Fujitsu Enterprise Postgres 14 SP1
on IBM LinuxONE

Manual Set

SP1

FUJITSU

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Fujitsu Enterprise Postgres 14 SP1 on IBM LinuxONE

Documentation Roadmap

SP1

Linux

FUJITSU

J2UL-2741-02ZLZ0(00)
September-2022

Preface

Purpose of this document

This document is intended for users of "FUJITSU Software Enterprise Postgres" (hereafter referred to as "FUJITSU Enterprise Postgres"), and explains how to read the manuals.

Structure of this document

The structure and content of this manual is shown below.

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Issue date and version

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Edition 2.0: September 2022
Edition 1.0: February 2022
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Contents

Chapter 1 How to Read the Manuals

The FUJITSU Enterprise Postgres manuals use certain notational conventions and rules. Pay attention to these conventions and rules when reading the FUJITSU Enterprise Postgres manuals.

1.1 Abbreviations of Manual Titles

The following tables list abbreviations of the titles of manuals for FUJITSU Enterprise Postgres as they appear in the manuals.

Formal manual title	Abbreviation in FUJITSU Enterprise Postgres manuals
FUJITSU Enterprise Postgres Release Notes	Release Notes
FUJITSU Enterprise Postgres General Description	General Description
FUJITSU Enterprise Postgres Installation and Setup Guide for Server	Installation and Setup Guide for Server
FUJITSU Enterprise Postgres Installation and Setup Guide for Client	Installation and Setup Guide for Client
FUJITSU Enterprise Postgres Installation and Setup Guide for Server Assistant	Installation and Setup Guide for Server Assistant
FUJITSU Enterprise Postgres Operation Guide	Operation Guide
FUJITSU Enterprise Postgres Cluster Operation Guide (Database Multiplexing)	Cluster Operation Guide (Database Multiplexing)
FUJITSU Enterprise Postgres Security Operation Guide	Security Operation Guide
FUJITSU Enterprise Postgres Application Development Guide	Application Development Guide
FUJITSU Enterprise Postgres Connection Manager User's Guide	Connection Manager User's Guide
FUJITSU Enterprise Postgres Reference	Reference
FUJITSU Enterprise Postgres Java API Reference	Java API Reference
FUJITSU Enterprise Postgres Glossary	Glossary
FUJITSU Enterprise Postgres Messages	Messages
PostgreSQL 14.0 Documentation	PostgreSQL Documentation

1.2 System of Manuals and How to Use the Manuals

This section describes the system of manuals for FUJITSU Enterprise Postgres.

1.2.1 System of Manuals

FUJITSU Enterprise Postgres manuals

The table below shows the manuals on FUJITSU Enterprise Postgres.

Use/Purpose	Manual title	Content	When to read
Deciding whether to upgrade the product.	Release Notes	Overview of upgraded features and incompatibility information.	When learning about features upgraded from earlier versions and incompatibility information.
Acquiring an overview of the product and the basic	General Description	Description of all available functions associated with each	When learning basic information and restrictions that system engineers and operators must

Use/Purpose	Manual title	Content	When to read
information required for work and operation.		intended purpose or use, and screenshots of operations.	know to actually operate the product.
Installing and setting up FUJITSU Enterprise Postgres correctly to enable its use.	Installation and Setup Guide for Server	Procedure for installing and setting up FUJITSU Enterprise Postgres.	When installing and setting up FUJITSU Enterprise Postgres.
Installing the FUJITSU Enterprise Postgres client function correctly to enable its use.	Installation and Setup Guide for Client	Installing the FUJITSU Enterprise Postgres client function.	When installing the FUJITSU Enterprise Postgres client function.
Installing and setting up the FUJITSU Enterprise Postgres Server Assistant.	Installation and Setup Guide for Server Assistant	Procedure for installing and setting up the FUJITSU Enterprise Postgres Server Assistant.	When installing and setting up the FUJITSU Enterprise Postgres Server Assistant.
Operating and managing FUJITSU Enterprise Postgres.	Operation Guide	Description of the tasks required in FUJITSU Enterprise Postgres management and operation.	When learning how to operate and manage the databases.
Performing switchover using database multiplexing mode.	Cluster Operation Guide (Database Multiplexing)	Description of the tasks required for database multiplexing operation.	When using database multiplexing mode to create operating environment for switchover and perform it.
Performing security operation.	Security Operation Guide	Description of the tasks required for security operations.	When using security features and performing security operation in FUJITSU Enterprise Postgres.
Applications using the interface provided by FUJITSU Enterprise Postgres.	Application Development Guide	Procedure for creating an application using embedded SQL, JDBC driver, ODBC driver.	When developing an application using the interface provided by FUJITSU Enterprise Postgres.
Performing high availability system using the Connection Manager feature.	Connection Manager User's Guide	Description of the features, setup, and usage of Connection Manager.	When using Connection Manager features by FUJITSU Enterprise Postgres.
Usage of FUJITSU Enterprise Postgres commands.	Reference	Description of the FUJITSU Enterprise Postgres commands expanded on from PostgreSQL.	When learning FUJITSU Enterprise Postgres command functions, options, and examples of use.
Learning the syntax of the JDBC API.	Java API Reference	Description of the syntax of the JDBC API.	When learning the syntax of the JDBC API.
Learning the meaning of the terms of FUJITSU Enterprise Postgres.	Glossary	Description of the terms used in the FUJITSU Enterprise Postgres manuals.	When checking the meaning of terms used in the FUJITSU Enterprise Postgres manuals.
Referring to messages from FUJITSU Enterprise Postgres and taking measures for them.	Messages	Description of each message and description of any measures to be taken for it.	When finding out the specific measures for dealing with messages from FUJITSU Enterprise Postgres.

PostgreSQL manual

The table below shows the manual on PostgreSQL-compatible features.

Use/Purpose	Manual title	Content	When to read
Learning about PostgreSQL features.	PostgreSQL Documentation	Official PostgreSQL documentation. Explains all features officially supported by the relevant version of PostgreSQL.	When learning how to use PostgreSQL.

1.2.2 Documentation Road Map

This section provides a documentation roadmap, broken down by user role.

Database administrator

The database administrator is a user who performs FUJITSU Enterprise Postgres installation and setup, and who operates and monitors the database.

Refer to the manuals in the table below, according to purpose:

	Purpose	Manual name
Required reading	To learn about upgraded features and incompatibility information	Release Notes
	To read an overview of the software	General Description
	To perform installation and setup	Installation and Setup Guide for Server
		Cluster Operation Guide (Database Multiplexing)
		Connection Manager User's Guide
	To install the Server Assistant	Installation and Setup Guide for Server Assistant
	To operate and monitor	Operation Guide
		Security Operation Guide
		Cluster Operation Guide (Database Multiplexing)
		Reference
	Using Connection Manager features	Connection Manager User's Guide
	Reference	Messages
		Glossary
Refer to as required	To learn about PostgreSQL features	PostgreSQL Documentation

Application developer

The application developer is a user who defines the database and develops applications.

Refer to the manuals in the table below, according to purpose:

	Purpose	Manual name
Required reading	To learn about upgraded features and incompatibility information	Release Notes
	To read an overview of the software	General Description
	To perform installation and setup	Installation and Setup Guide for Client
	To define a database	Operation Guide
	To develop applications	Application Development Guide
		Java API Reference
	Using Connection Manager features	Connection Manager User's Guide
	Reference	Messages
		Glossary
Refer to as required	To learn about PostgreSQL features	PostgreSQL Documentation

1.3 Notational Conventions in the Manuals

Manual titles and product names in the manual are abbreviated.

This section explains the notational conventions for abbreviations and platform-specific information in the manuals.

1.3.1 Abbreviation of Product Names

The following table lists abbreviations of the names of products related to FUJITSU Enterprise Postgres as they appear in the manuals.

Formal name	Abbreviation
Red Hat(R) Enterprise Linux(R) 8 (for IBM Z) and SUSE Linux Enterprise Server 15 (for IBM Z)	Linux
Red Hat(R) Enterprise Linux(R) 8 (for IBM Z)	RHEL8
SUSE Linux Enterprise Server 15 (for IBM Z)	SLES 15
Windows(R) 8.1, Windows(R) 8.1 Pro, Windows(R) 8.1 Enterprise, Windows(R) 10 Home, Windows(R) 10 Education, Windows(R) 10 Pro, Windows(R) 10 Enterprise, Windows(R) 11 Home, Windows(R) 11 Education, Windows(R) 11 Pro, Windows(R) 11 Enterprise, Microsoft(R) Windows Server(R) 2016 Datacenter, Microsoft(R) Windows Server(R) 2016 Standard, Microsoft(R) Windows Server(R) 2016 Essentials, Microsoft(R) Windows Server(R) 2019 Datacenter, Microsoft(R) Windows Server(R) 2019 Standard, Microsoft(R) Windows Server(R) 2019 Essentials, Microsoft(R) Windows Server(R) 2022 Datacenter,	Windows(R)

Formal name	Abbreviation
Microsoft(R) Windows Server(R) 2022 Standard and Microsoft(R) Windows Server(R) 2022 Essentials	
Microsoft(R) Edge	Edge
Java Naming and Directory Interface	JNDI
Java(TM) 2 SDK, Standard Edition, Java(TM) 2 Platform, Enterprise Edition, Java(TM) Platform, Standard Edition and Java(TM) Development Kit	JDK
Java(TM) 2 Runtime Environment, Standard Edition and Java(TM) Runtime Environment	JRE
FUJITSU Enterprise Postgres Advanced Edition (64bit)	AE or FUJITSU Enterprise Postgres Advanced Edition
IBM mainframe (z14)	IBM z14
IBM mainframe (z15)	IBM z15

Remarks: The symbols (R) and (TM) may be omitted in this manual.

1.3.2 FUJITSU Enterprise Postgres Conventions

The naming conventions for the FUJITSU Enterprise Postgres product names and functions used in the FUJITSU Enterprise Postgres manuals are shown below.

1.3.2.1 Server

The names used in the manuals in explanations regarding FUJITSU Enterprise Postgres functions are shown below.

Product name	Name used in manuals
FUJITSU Enterprise Postgres Advanced Edition (64bit)	64-bit product

1.3.2.2 Client

The names used in the manuals in explanations regarding FUJITSU Enterprise Postgres client functions are shown below.

Product name	Name used in manuals
FUJITSU Enterprise Postgres Client (64bit)	64-bit product

1.3.3 Symbol Convention

The symbols shown below are used in the manuals.

Symbol	Meaning
[ ]	These symbols indicate characters displayed in a window or dialog box or keyboard keys. Examples: [Setting] dialogue box, [File] menu, [Item name], [OK] button, [Enter] key.

1.4 Notes about Manuals

This section contains notes about the FUJITSU Enterprise Postgres operating environments and manuals.

- Images in figures

  The FUJITSU Enterprise Postgres manuals contain figures showing printouts for FUJITSU Enterprise Postgres to provide the reader an idea of what the printouts look like, but since the figures are only examples, they are incomplete.

- Explanatory examples

  Most of the examples of databases in the FUJITSU Enterprise Postgres manuals are modeled after inventory control databases of retail stores. The design and contents of the databases in the examples are fictitious and do not represent any real database.

- UNIX release version number

  This system conforms to UNIX System V Rel4.2MP.

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Fujitsu Enterprise Postgres 14 SP1 on IBM LinuxONE

Glossary

SP1

Linux

FUJITSU

J2UL-2757-02ZLZ0(00)
September-2022

Preface

Purpose of this document

This document explains FUJITSU Enterprise Postgres terminology.

Intended readers

This document is aimed at all users of FUJITSU Enterprise Postgres.

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Edition 2.0: September 2022
Edition 1.0: February 2022
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Contents

Glossary

Arbitration command

A user command called when an abnormality is detected using operating system/server heartbeat monitoring in database multiplexing mode.

Arbitration server

A dedicated server on which the Server Assistant program is installed.

Archive log

Contains the history of updates made to the database, and is used during recovery.

Backup data storage destination

The directory that stores the backup data.

Client command

A command that is executed from the client machine and used. Also known as a client application.

Connection Manager

The replication operation to continue without knowing where the application is connected.

The Connection Manager feature improves the availability.

Data storage destination

The directory that stores the database clusters.

Database cluster

The database storage area on the database storage disk. Database clusters are a collection of databases managed by an instance.

Data masking

A feature that can change the returned data for queries generated by applications, to prevent exposing actual data.

Database multiplexing

Mechanism in which a database is made redundant on multiple servers, by transferring transaction logs (WAL) via the network to enable application jobs to be continued.

Database superuser

A user defined in the database with access privileges for all database objects.

Encoding

Indicates the character set.

Fencing

A process that isolates a database server with an unstable status from the cluster system in database multiplexing mode. This process is implemented as a fencing command.

Fencing command

A user command that implements fencing in database multiplexing mode.

Global Meta Cache

The Global Meta Cache feature cache the informations about system catalogs information (catalog meta cache) in shared memory. The catalog meta cache on shared memory is called the Global Meta Cache (GMC).

Instance

A series of server processes for managing database clusters.

Instance administrator

The OS user account that owns the database cluster files and operates the database server processes.

Instance name

Indicates the instance name.

Local Meta Cache Limit

The ability to limit the size by removing the Local Meta Cache that has not been accessed for a long time.

Local Meta Cache is a meta cache (system catalog and table definition information) held in local memory.

Masking policy

A method of changing data under specific conditions when it is returned for a query from an application. You can configure masking target, masking type, masking condition and masking format.

Mirrored transaction log

The log that mirrors the transaction log at the backup data storage destination.

Mirroring Controller arbitration process

A process that performs arbitration and fencing on the arbitration server.

Mirroring Controller monitoring process

A process that performs heartbeat monitoring of the Mirroring Controller process. If the Mirroring Controller process returns no response or is down, the Mirroring Controller monitoring process is restarted automatically.

Mirroring Controller process

A process that performs operating system/server and process heartbeat monitoring and disk abnormality monitoring between database servers. Additionally, the process issues arbitration requests to the arbitration server and executes arbitration commands.

Pgpool-II connection pooling

The connection pooling feature of Pgpool-II supported by FUJITSU Enterprise Postgres.

This feature maintains the connection established with the database server and reuses that connection each time a new connection with the same properties (user name, database, and protocol version) arrives. By reducing the connection overhead for the database server, throughput of the whole system is improved.

Pgpool-II failover

The automatic failover feature of Pgpool-II supported by FUJITSU Enterprise Postgres.

If any of the database servers crashes or can no longer be reached, this feature disconnects the server and continues operation on the remaining servers. The streaming replication feature of PostgreSQL is combined with Pgpool-II to achieve a high-availability system.

Pgpool-II load balancing

The load balancing feature of Pgpool-II supported by FUJITSU Enterprise Postgres.

This feature distributes reference queries to multiple database servers, improving throughput of the whole system. The database multiplexing feature or PostgreSQL streaming replication feature is combined with Pgpool-II to reduce the load on the database server.

Pgpool-II server

A server for using the failover, connection pooling, and load balancing features of Pgpool-II. It is a dedicated server that has a server program installed for using these features.

Primary server

The server that processes the main database jobs during multiplexed database operation.

Server Assistant

A feature that objectively determines the status of database servers as a third party, and if necessary, isolates affected databases if the database servers are unable to accurately ascertain their mutual statuses in database multiplexing mode, such as due to a network error between database servers, or server instability.

Server Assistant program

A program to be installed on the arbitration server.

Server command

A command used on the database server. Also known as a server application.

Standby server

A server that generates a replicated database synchronized with the primary server, and that can run as an alternative server in case the primary server fails during multiplexed database operation.

State transition command

A user command called when Mirroring Controller performs a state transition of a database server in database multiplexing mode. State transition commands include the post-switch command, pre-detach command, and post-attach command.

Transaction log

Contains the history of updates made to the database by transactions. Also known as the WAL (Write-Ahead Log).

Transaction log storage destination

The directory that stores the transaction log.

VCI (Vertical Clustered Index)

An index with columnar data structure suitable for aggregation.

WAL (Write-Ahead Log)

Has the same meaning as 'transaction log'.

WebAdmin program

A GUI-based program installed on a database server or a dedicated WebAdmin server, used to manage database instances.

WebAdmin server

By using the WebAdmin program on a different server to the database server, instances on multiple database servers can be managed from a dedicated WebAdmin server on which the WebAdmin program is installed.

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Fujitsu Enterprise Postgres 14 SP1 on IBM LinuxONE

General Description

SP1

Linux

FUJITSU

J2UL-2744-02ZLZ0(00)
September-2022

Preface

Purpose of this document

This document explains the FUJITSU Enterprise Postgres concepts to those who are to operate databases using it.

This document explains the features of FUJITSU Enterprise Postgres.

Intended readers

This document is intended for people who are:

- Considering installing FUJITSU Enterprise Postgres
- Using FUJITSU Enterprise Postgres for the first time
- Wanting to learn about the concept of FUJITSU Enterprise Postgres
- Wanting to see a functional overview of FUJITSU Enterprise Postgres

Readers of this document are also assumed to have general knowledge of:

- Computers
- Jobs
- Linux

Structure of this document

This document is structured as follows:

Chapter 1 FUJITSU Enterprise Postgres Basics

Explains the features of FUJITSU Enterprise Postgres.

Appendix A List of Features

Lists the main features provided by FUJITSU Enterprise Postgres.

Appendix B OSS Supported by FUJITSU Enterprise Postgres

Explains the OSS supported by FUJITSU Enterprise Postgres.

Appendix C Features that can be Used on Servers Other than the Database Server

Explains features that can be used on servers other than the database server.

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Edition 2.0: September 2022
Edition 1.0: February 2022
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Chapter 1 FUJITSU Enterprise Postgres Basics

FUJITSU Enterprise Postgres maintains the operating methods, interfaces for application development and SQL compatibility of PostgreSQL, while providing expanded features for enhanced reliability and operability.

This chapter explains the functionality extended by FUJITSU Enterprise Postgres.

Refer to "Appendix A List of Features" for feature differences between editions.

Additionally, FUJITSU Enterprise Postgres supports various open source software (OSS). Refer to "Appendix B OSS Supported by FUJITSU Enterprise Postgres" for information on OSS supported by FUJITSU Enterprise Postgres.

FUJITSU Enterprise Postgres has the following features:

- Flexible database recovery
  Not only does FUJITSU Enterprise Postgres recover data to its most recent form when a failure occurs, which is essential for databases, but it can also recover to any point in time. Additionally, backup/recovery can be performed using any copy technology.

- Simple GUI-based installation and operation management
  FUJITSU Enterprise Postgres uses GUI to simplify cumbersome database operations, and allows databases to be used intuitively.

- High reliability by using database multiplexing
  Database multiplexing protects important data and enables highly reliable database operation.

- Seamless migration from Oracle databases
  FUJITSU Enterprise Postgres provides a compatibility feature with Oracle databases that localizes the correction of existing applications and allows easy migration to FUJITSU Enterprise Postgres.

- Storage Data Protection using Transparent Data Encryption
  Information can be protected from data theft by encrypting data to be stored in the database.

- Data masking for improved security
  The data masking feature changes the returned data for queries from applications, to prevent exposing actual data. This improves security for handling confidential data such as personal information.

- Audit logs for improved security
  Audit logs can be used to counter security threats such as unauthorized access and misuse of privileges for the database.

- Enhanced query plan stability
  The following features can control SQL statement query plans:

  - Optimizer hints
  - Locked statistics

  These features are used for curbing performance deterioration caused by changes in SQL statement query plans, such as with mission-critical jobs that emphasize performance stability over improved SQL statement processing performance.

- Increased aggregation performance using the in-memory feature
  The following features help speed up scans even when aggregating many rows.

  - Vertical Clustered Index (VCI)

  - In-memory data

- High-speed data load
  Data from files can be loaded at high speed into FUJITSU Enterprise Postgres tables using the high-speed data load feature.

- High availability by using Connection Manager
  With the Connection Manager features, replication operation can be continued without being aware of the connection destination of the applications.

- Memory usage reduction using Global Meta Cache
  The Global Meta Cache feature loads some of meta cahe information in shared memory. This reduces overall system memory usage.

- Memory usage reduction using Local Meta Cache Limit
  Reduce memory consumption by limiting the metacache that is kept in local memory.

- WAL compression for streaming replication
  Reduces network load by compressing streaming replication WAL transfers.

1.1 Flexible Database Recovery

Threats such as data corruption due to disk failure and incorrect operations are unavoidable in systems that use databases. The ability to reliably recover corrupted databases without extensive damage to users when such problems occur is an essential requirement in database systems.

FUJITSU Enterprise Postgres provides the following recovery features that flexibly respond to this requirement:

- Media recovery, which recovers up to the most recent point in time
- Point-in-time recovery, which can recover up to a specific point in time
- Backup/recovery that can integrate with various copy technologies

Media recovery, which recovers up to the most recent point in time

When a disk failure occurs, media recovery can recover data to how it was immediately before the failure.

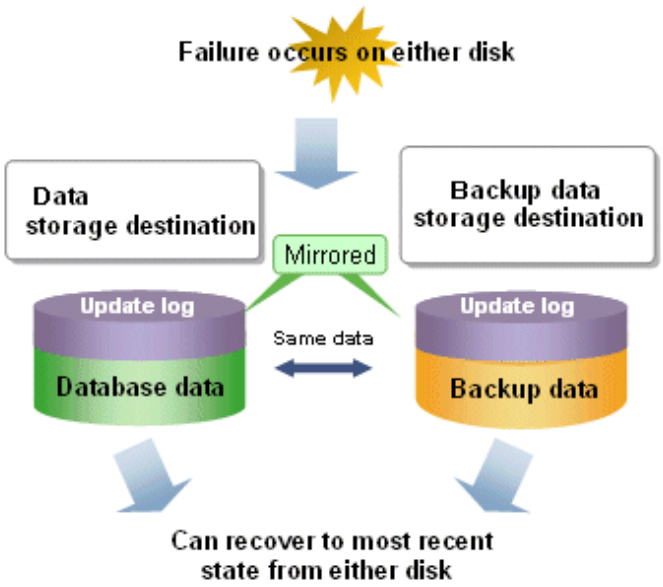
In order to recover the database, FUJITSU Enterprise Postgres accumulates a history of database update operations, such as data additions and deletions, as an update log.

FUJITSU Enterprise Postgres retains a duplicate (mirror image) of the update log after backup execution on the data storage destination and on the backup data storage destination. Therefore, the data on one disk can be used to recover to the most recent state of the database even if a disk failure has occurred on the other.

Media recovery is executed using either a GUI tool provided with FUJITSU Enterprise Postgres (WebAdmin) or server commands.

Information

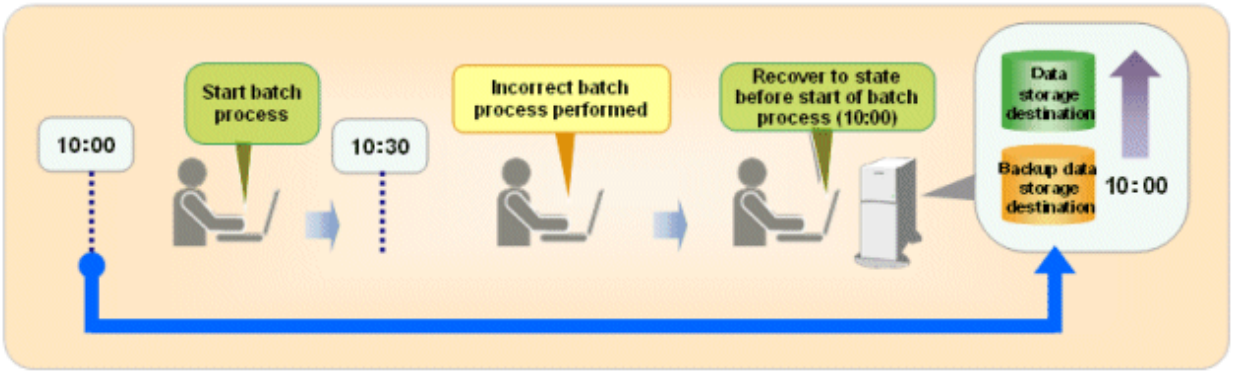
Recovery using WebAdmin requires less time and effort, since WebAdmin automatically determines the scope of the operation.



Point-in-time recovery, which can recover up to a specific point in time

Point-in-time recovery can be used to recover a database that has been updated by an incorrect operation, for example, by specifying any date and time before the incorrect operation.

Point-in-time recovery is executed using FUJITSU Enterprise Postgres server commands.



Backup data compression

Compressing and storing backup data reduces the amount of disk space required for backups.

It supports compression of backup data(database cluster and tablespace) and compression of archive logs in the update log.

Backup/recovery that can integrate with various copy technologies

It is possible to back up to the backup data storage destination, or to any backup destination using any copy technology implemented by user commands.

See

Refer to "Backup/Recovery Using the Copy Command" in the Operation Guide for information on backup/recovery using user commands.

1.2 Simple GUI-Based Installation and Operation Management

FUJITSU Enterprise Postgres provides WebAdmin, which is a GUI tool for a range of tasks, from database installation to operation management. This allows the databases to be used simply and intuitively.

WebAdmin can be used for FUJITSU Enterprise Postgres setup, creating and monitoring a streaming replication cluster, database backups, and for recovery. Depending on the configuration, WebAdmin can be used to manage FUJITSU Enterprise Postgres instances in a single server, or instances spread across multiple servers.

- Setup

  To perform setup using WebAdmin, you must create an instance. An instance is a set of server processes that manage a database cluster (database storage area on the data storage destination disk). Instances can be created easily and with only minimal required input, because the tool automatically determines the optimal settings for operation.

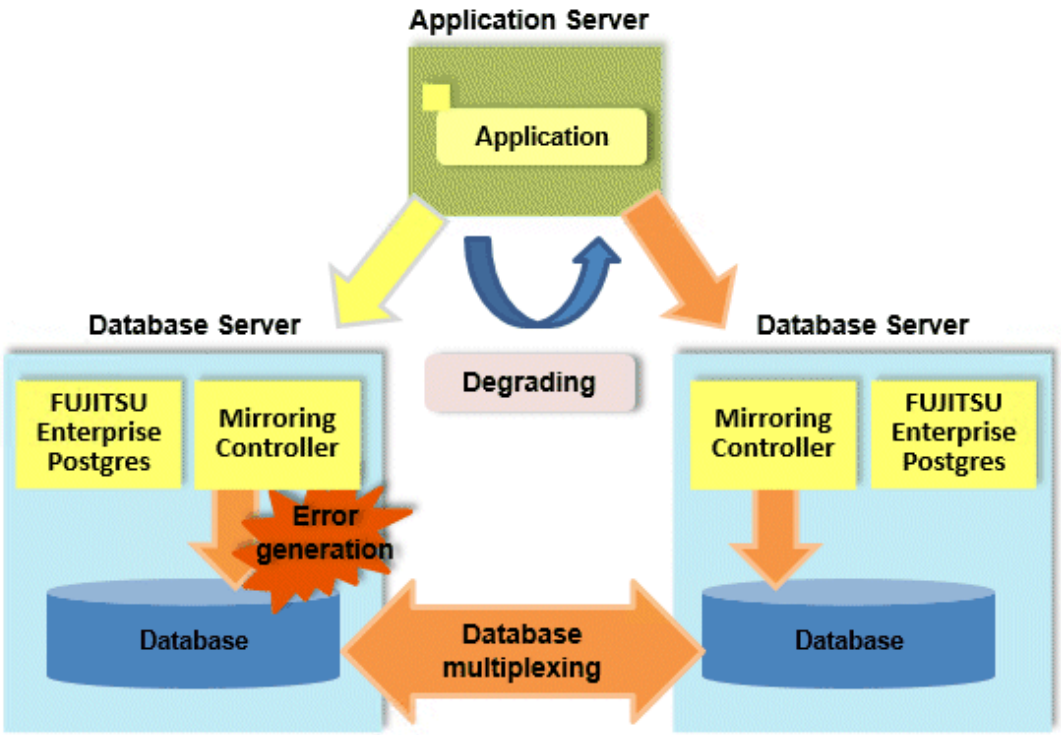
- Database backup/recovery

  Database backup and recovery can be performed using simple GUI operations.

  In particular, FUJITSU Enterprise Postgres can automatically identify and isolate the location of errors. This simplifies the recovery process and enables faster recovery.

1.3 High Reliability with Database Multiplexing

It is vital for systems that use databases to protect data from damage or loss caused by a range of factors such as hardware and software errors. Database multiplexing protects important data and enables highly reliable database operation.



FUJITSU Enterprise Postgres not only mirrors a database using the PostgreSQL streaming replication feature, but also provides simplified switchover and standby disconnection features as well as a feature to detect faults in elements that are essential for the continuity of database process, disk, network, and other database operations.

Even if a switchover is performed, the client automatically distinguishes between the primary and standby servers, so applications can be connected transparently regardless of the physical server.

The Mirroring Controller option enables the primary server (the database server used for the main jobs) to be switched automatically to the standby server if an error occurs in the former.

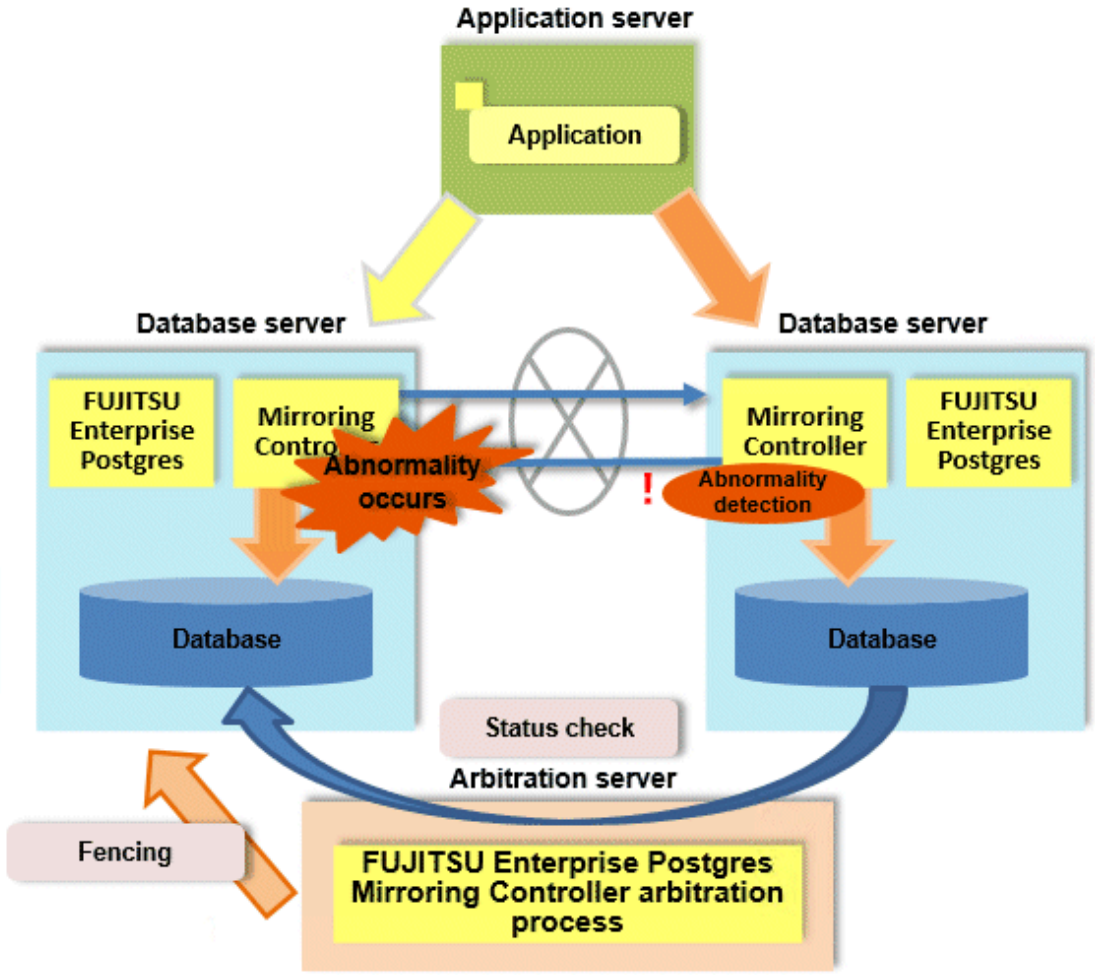
In addition, by using the data on the standby server, reference jobs such as data analysis and form output can be performed in parallel to the jobs on the primary server.

Operation using the arbitration server

Mirroring Controller may not be able to correctly determine the status of the other server if there is a network issue between database servers or a server is in an unstable state. As a result, both servers will temporarily operate as primary servers, so it may be possible to perform updates from either server.

The Server Assistant is a feature that objectively checks the status of database servers as a third party and isolates (fences) unstable servers in such cases.

In database multiplexing mode, the Server Assistant is made available by adding a new server (arbitration server) on which the Server Assistant is installed. Using an arbitration server can prevent the issue mentioned above (both servers temporarily operating as primary servers) and enables highly reliable operation.



See

- Refer to "Database Multiplexing Mode" in the Cluster Operation Guide (Database Multiplexing) for information on the database multiplexing.

1.4 Seamless Migration from Oracle Databases

FUJITSU Enterprise Postgres supports Orafce, to provide compatibility with Oracle databases.

Using the compatibility feature reduces the cost of correcting existing applications and results in easy database migration.

See

Refer to "Compatibility with Oracle Databases" in the Application Development Guide for information on compatible features.

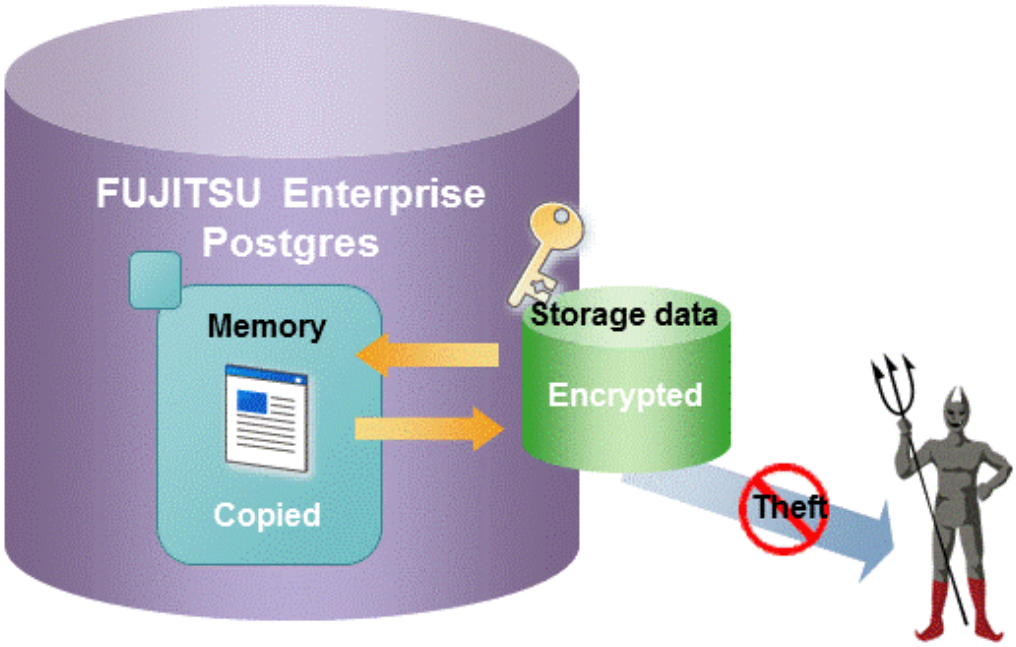
1.5 Storage Data Protection Using Transparent Data Encryption

The encryption of data to be stored in a database is essential under the following encryption requirements of PCI DSS (Payment Card Industry Data Security Standard), the data security standard of the credit industry:

- Confidential information (such as credit card numbers) can be encrypted.
- The encryption key and data are managed as separate entities.
- The encryption key is replaced at regular intervals.

To satisfy these requirements, FUJITSU Enterprise Postgres provides a transparent data encryption feature. Note that PostgreSQL uses an encryption feature called pgcrypto, which can also be used in FUJITSU Enterprise Postgres, but requires applications to be modified. Therefore, we recommend using FUJITSU Enterprise Postgres's transparent data encryption feature.

Key management in conjunction with the IBM Z hardware security module provides robust security.



The transparent data encryption feature also allows you to choose an external key management system as the storage location for your encryption keys.

See

Refer to "Protecting Storage Data Using Transparent Data Encryption" or "Using Transparent Data Encryption with Key Management Systems as Keystores" in the Operation Guide for information about transparent data encryption.

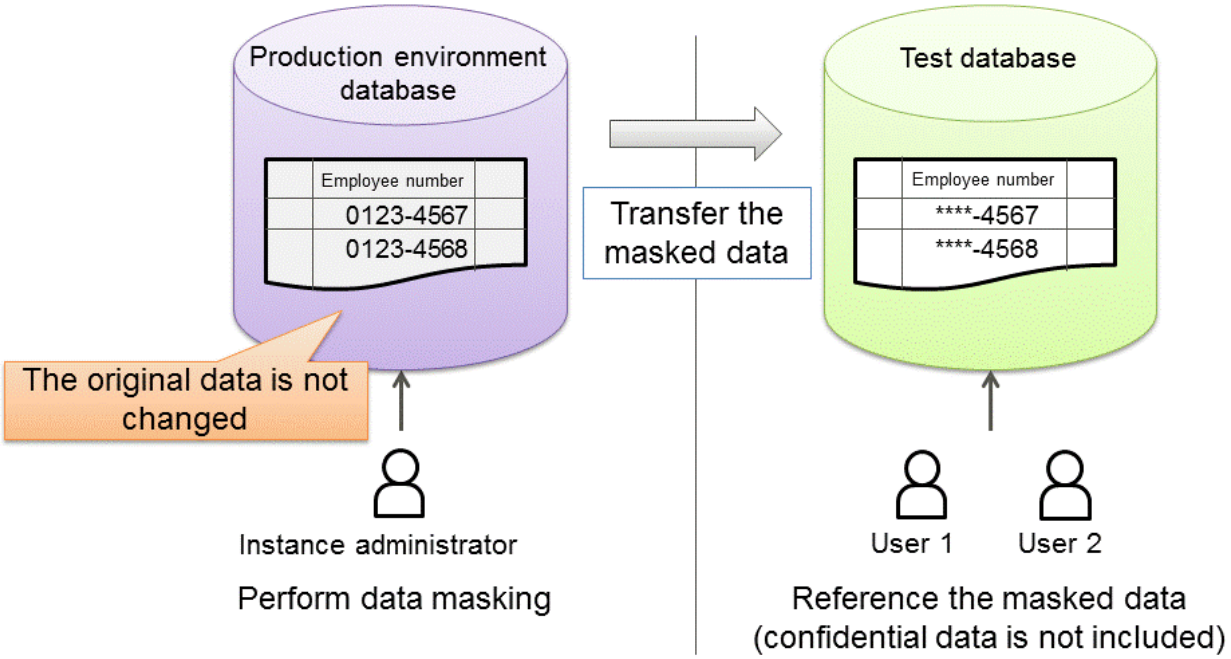
1.6 Data Masking for Improved Security

FUJITSU Enterprise Postgres provides a data masking feature that protects data to maintain security of data handled in systems.

The data masking feature changes the returned data for queries from applications and makes it available for reference without exposing the actual data.

For example, for a query of employee data, digits except the last four digits of an eight-digit employee number can be changed to "*" so that it can be used for reference.

Also, the data changed by the data masking feature can be transferred to a test database so that users who perform testing or development can reference the data. As production data should not be used in a test or development environment because of the risk of data leakage, this feature enables data that is similar to actual production data to be safely used in those environments.



See

Refer to "Data Masking" in the Operation Guide for information on data masking.

1.7 Security Enhancement Using Audit Logs

Details relating to database access can be retrieved in audit logs. The audit log feature can be used to counter security threats such as unauthorized access to the database and misuse of privileges.

In PostgreSQL, logs output as server logs can be used as audit logs by using the log output feature. There are, however, logs that cannot be analyzed properly, such as SQL runtime logs, which do not output the schema name. Additionally, because the output conditions cannot be specified in detail, log volumes can be large, which may lead to deterioration in performance.

The audit log feature of FUJITSU Enterprise Postgres enables retrieval of details relating to database access as an audit log by extending the feature to pgaudit. Additionally, audit logs can be output to a dedicated log file or server log. This enables efficient and accurate log monitoring.

See

Refer to "Audit Log Feature" in the Security Operation Guide for details.

1.8 Enhanced Query Plan Stability

FUJITSU Enterprise Postgres estimates the cost of query plans based on SQL statements and database statistical information, and selects the least expensive query plan. However, like other databases, FUJITSU Enterprise Postgres does not necessarily select the most suitable query plan. For example, it may suddenly select unsuitable query plan due to changes in the data conditions.

In mission-critical systems, stable performance is more important than improved performance, and changes in query plans case to be avoided. In this situation, the following features can stabilize query plans:

- Optimizer hints

  You can use pg_hint_plan to specify a query plan in each individual SQL statement.

- Locked statistics

  You can use pg_dbms_stats to lock statistical information per object, such as a database, schema, or table.

 See

Refer to "Optimizer Hints" in the Application Development Guide for information on optimizer hints.

Refer to "Locked Statistics" in the Application Development Guide or information on locked statistics.

 Note

Use the features provided when FUJITSU Enterprise Postgres is installed for optimizer hints and locked statistical information. FUJITSU Enterprise Postgres does not support other similar open-source features.

1.9 Increased Aggregation Performance Using the In-memory Feature

FUJITSU Enterprise Postgres provides the in-memory feature, which uses columnar index and memory-resident data. This reduces disk I/Os and enhances aggregation performance.

Columnar index

Many aggregation processes may require a large portion of data in a particular column. However, traditional row data structure reads unnecessary columns, resulting in inefficient use of memory and CPU cache, and slower processing. FUJITSU Enterprise Postgres provides a type of columnar index, VCI (Vertical Clustered Index). This addresses the above issues, and enhances aggregation performance.

VCI provides the following benefits:

- Minimizes impact on existing jobs, and can perform aggregation using job data in real time.
- Provided as an index, so no application modification is required.
- Stores data also on the disk, so aggregation jobs can be quickly resumed using a VCI even if a failure occurs (when an instance is restarted).
- If the amount of memory used by VCI exceeds the set value, aggregation can still continue by using VCI data on the disk.

It also provides the features below:

- Disk compression
  Compresses VCI data on the disk, minimizing required disk space. Even if disk access is required, read overhead is low.
- Parallel scan
  Enhances aggregation performance by distributing aggregation processes to multiple CPU cores and then processing them in parallel.

In-memory data

The following features keep VCI data in memory and minimize disk I/Os on each aggregation process.

- Preload feature
  Ensures stable response times by loading VCI data to memory before an application scans it after the instance is restarted.
- Stable buffer feature
  Reduces disk I/Os by suppressing VCI data eviction from memory by other job data.

Purposes of this feature

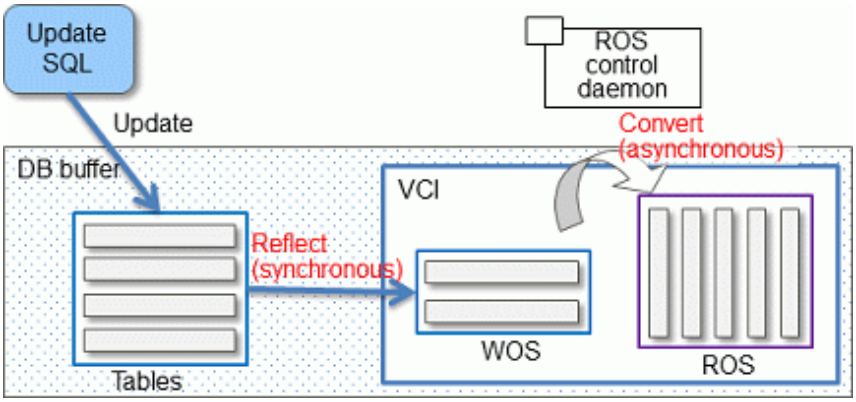
This feature has a data structure that can efficiently use the newly added resources, and aims to enhance the existing aggregation processing in normal operations to be faster than parallel scan. It shares the same purpose of enhancing aggregation performance with the parallel scan feature that is provided separately, but differs in that it speeds up nightly batch processes by utilizing available resources.

VCI architecture

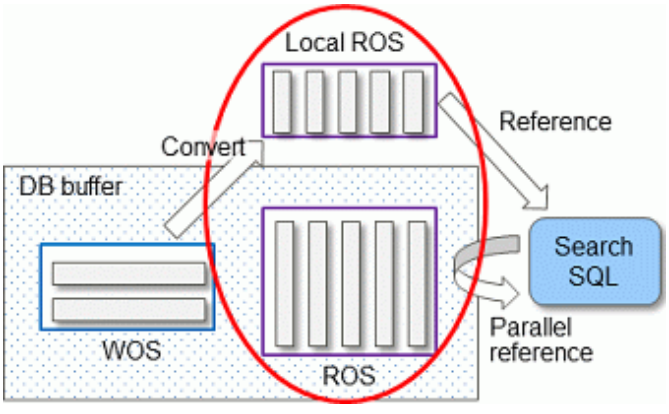
This section briefly explains VCI architecture as it contains basic terminology required, for example, when setting parameters.

Update and aggregation operations to enable real time use of job data are described.

VCI has write buffer row-based WOS (Write Optimized Store) in addition to the columnar data structure ROS (Read Optimized Store). Converting each update into a columnar index has a significant impact on the update process response times. Therefore, data is synchronously reflected to the row-based WOS when updating. After a certain amount of data is stored in WOS, the ROS control daemon asynchronously converts it to ROS. As above, the entire VCI is synchronized with the target table column, minimizing update overhead.



The same scan results can be obtained without a VCI by using WOS in conjunction with ROS. More specifically, WOS is converted to Local ROS in local memory for each aggregation process, and aggregated with ROS.



See

Refer to "Installing and Operating the In-memory Feature" in the Operation Guide for information on installation and operation of VCI.

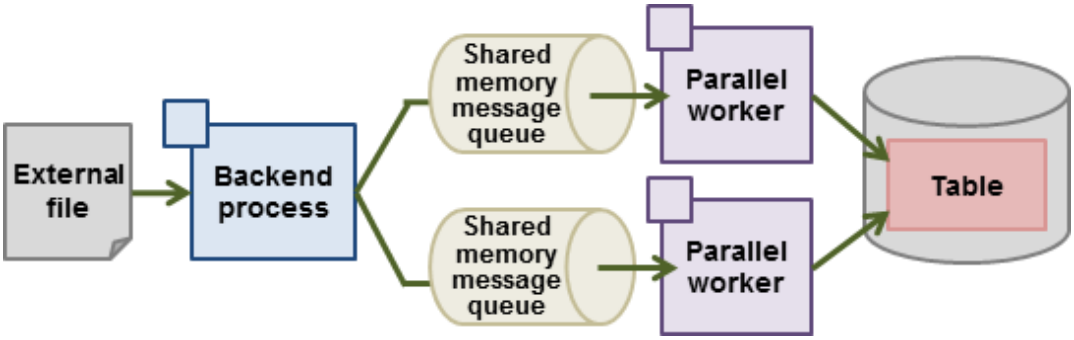
Refer to "Scan Using a Vertical Clustered Index (VCI)" in the Application Development Guide for information on scan using a VCI.

1.10 High-Speed Data Load

High-speed data load executes COPY FROM commands using multiple parallel workers. Because conversion of data from the external file to the appropriate internal format, table creation, and index creation are performed in parallel, it is possible to load large volumes of data at high speed.

Architecture of high-speed data load

High-speed data load is required for parameter setting and resource estimation, so a brief description of its architecture is provided below.



High-speed data load uses a single backend process collaborating with multiple parallel workers to perform data load in parallel. Data is exchanged between the backend process and parallel workers via shared memory message queues. The backend process distributes the loaded data of external files to multiple parallel workers. Each parallel worker then converts the data loaded from the shared memory message queue into the appropriate internal format, and inserts it into the table. If the table has indexes, their keys are extracted and inserted into the index page.

See

Refer to "High-Speed Data Load" in the Operation Guide for details.

1.11 High availability by using Connection Manager

The Connection Manager provides the following features. You can use these features to increase system availability.

Heartbeat monitoring feature

Detects kernel panics between the server running the client and the server running the instance, physical server failures, and inter-server network link downs, and notifies the client or instance. The client is notified as an error event through the SQL connection, and the instance will be notified in the form of a force collection of SQL connections with clients that are out of service.

Transparent connection support feature

When an application wants to connect to an instance of an attribute (Primary/Standby) configured with replication, it can do so without knowing which server the instance is running on.

Information

The available client drivers for Connection Manager are libpq (C language library), ECPG (embedded SQL in C), ODBC driver and JDBC driver.

See

Refer to the Connection Manager User's Guide for details.

1.12 Memory Usage Reduce with Meta cache Reduction and Limit

When executing SQL, you must refer to the definition of the table or index you want to access. These definitions are cached in the local memory of the backend process separately from the shared memory buffer of the database on shared_buffers because they are referenced each time SQL is executed. The direct definition is a tuple of system catalogs. The cache for this tuple is called "Catalog Cache". A structure that makes the definition easy to use is called a "Relations Cache". And in FUJITSU Enterprise Postgres, these two are collectively called "Meta Cache".

The meta cache will be kept indefinitely for performance reasons. In a large database, a single backend process accesses a large number of tables and so on, which results in a large meta-cache for the backend process. As a result, the sum of the local memory of the backend process may exceed the realistic memory size.

On the other hand, the feature to reduce the meta cache for the entire instance by sharing the meta cache between backend processes is the Global Meta Cache feature. The current Global Meta Cache feature only shares the catalog cache. Therefore, the metacache in Global Meta Cache now refers to the catalog cache.

What you still cannot share using the current Global Meta Cache feature and need to keep in local memory is the information (Meta cache header) and relation cache to access Global Meta Cache in shared memory. If you do not use the Global Meta Cache feature, keep the catalog and relation caches in local memory. The meta cache held in local memory is called the "Local Meta Cache". The feature to limit the size of a Local Meta Cache by removing it if it has not been accessed for a long time is the Local Meta Cache limit feature.

The Global Meta Cache feature and the Local Meta Cache limit feature can be used together to provide the strictest control over memory consumption. Of course, you can use only one or the other.

However, the Global Meta Cache feature has several percent overhead to access shared memory. The Local Meta Cache limit feature also causes the overhead of reholding the metacache because it may discard the previously held metacache. Therefore, consider using these features when your estimates do not allow for memory consumption.

1.12.1 Memory Usage Reduction Using Global Meta Cache

The Global Meta Cache feature cache the meta cache in shared memory. The meta cache on shared memory is called the Global Meta Cache (GMC).

Without this feature, the meta cache was cached in per-process memory. Therefore, there was a problem increase in memory usage in environments with large databases and large numbers of connections. The Global Meta Cache feature enables sharing of meta caches on shared memory, thereby reducing overall system memory usage.

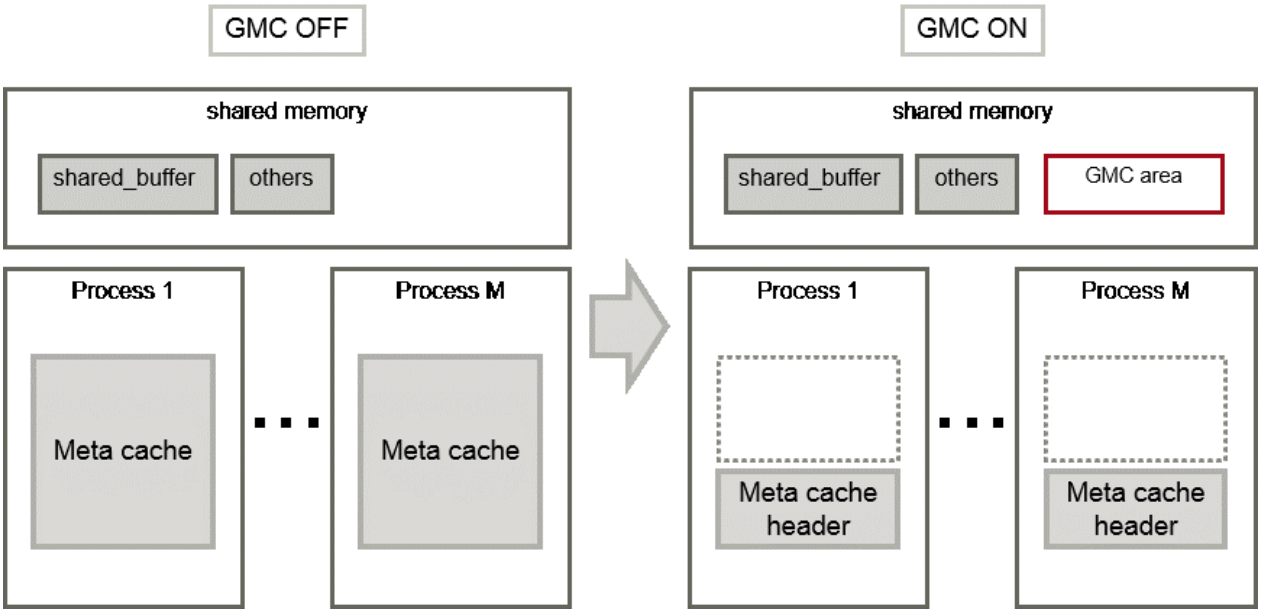
Meta cache

Processing a query involves parsing the query, creating the plan, executing the plan, and so on. PostgreSQL process accesses the system catalog to perform these steps. Once accessed, the system catalog tuples are cached in per-process memory. The direct definition is one tuple of system catalogs. Each process performs faster query processing by searching the meta cache instead of searching for the required tuples in the system catalog each time.

The meta cache usage increases in proportion to the number of tables and columns accessed. It is cached on a per-process basis, so the system's overall meta cache usage increases in proportion to the number of connections.

Architecture of Global Meta Cache feature

Describes the architecture of the Global Meta Cache feature.



When the GMC feature is on, the per-process meta cache is cached in the GMC area on shared memory. Reference to the GMC area and process-specific work information is cached in the memory of each process. PostgreSQL process searches the meta cache for each process and accesses the GMC based on the reference information. If there is no reference information in the process's memory, it searches the GMC area. If the GMC area also does not have a corresponding meta cache, it accesses the system catalog to create meta cache.

Also, sharing the meta cache does not cause any loss of data consistency. If the system catalog or table definition changes while a transaction is running, the cache deletion or creation does not affect outside of the process running the transaction. After the transaction commits, the GMC area cache is deleted or created. If other transactions are referencing the cache when GMC is tried to be deleted, the deletion is deferred until there are no more references. After a commit, a new transaction sees the new cache instead of the old one.

See

Global Meta Cache feature is disabled by default. Refer to "Global Meta Cache" in the Operation Guide for information how to decide whether introduce it or not and usage.

1.12.2 Memory Usage Reduction Using Local Meta Cache Limit

Local Meta Cache Limit feature limits the size of a Local Meta Cache by removing it if it has not been accessed for a long time.

Of the definitions that SQL accesses, the main factors that make the Local Meta Cache bloat are tables and indexes. In addition, table column definitions are also maintained as a catalog cache.

For example, in a system where one long-lived connection is shared by various businesses, one connection (that is, backend process) will access many tables. If there are 3,000 such connections, and each connection accesses a table of 50,000, the total amount of memory consumed by the 3,000 backend processes may be a few terabytes.

In such a case, using this feature may reduce it to about several tens of gigabytes.

Architecture of Local Meta Cache Limit feature

When this feature is enabled, the caching strategy is to keep the cache as long as possible within the specified upper limit. If holding a new cache exceeds the limit, consider locality of reference and delete the cache from the one with the longest unreferenced time.

However, because the cache used by active transactions cannot be deleted, if a transaction uses a large number of caches, the cache may be held above the limit. In this case, delete the cache at the end of the transaction.

See

Local Meta Cache limit feature is disabled by default. Refer to "Local Meta Cache Limit" in the Operation Guide for information how to decide whether introduce it or not and usage.

1.13 WAL Compression for Streaming Replication

WAL that is transferred by Streaming Replication can be compressed. This reduces the amount of data transferred for streaming replication and reduces the network load. This function can be used to increase throughput in cases where the network load is high due to Database aggregation, etc., or in environments where the network transfer speed is slow such as disaster prevention environments.

Using zEnterprise Data Compression(zEDC) for compression / decompression speeds up compression / decompression. Therefore, performance can be stabilized using zEDC.

See

Refer to "WAL Compression for Streaming Replication" in the Operation Guide for information on the WAL compression for streaming replication.

Refer to the IBM documentation for information on configuring the zEDC.

Appendix A List of Features

The following table lists the main features provided by FUJITSU Enterprise Postgres.

Category	Feature
Fujitsu-developed software technology	WebAdmin (Rapid setup, One-click recovery)
Improved reliability and availability	Database multiplexing
	Backup/recovery using user commands
	Backup data compression
	Connection Manager
	WAL compression for streaming replication
Application development	Embedded SQL integration Java integration ODBC integration
	Features compatible with Oracle databases
Security	Transparent data encryption
	Data masking
	Audit log
Performance	In-memory feature
	High-speed data load
	Global Meta Cache
	Local Meta Cache Limit
Performance tuning	Optimizer hints
	Fixed statistical information

Appendix B OSS Supported by FUJITSU Enterprise Postgres

The OSS supported by FUJITSU Enterprise Postgres is listed below.

OSS name	Version and level	Description	Reference
PostgreSQL	14.0	Database management system	PostgreSQL Documentation
orafce	3.17.0	Oracle-compatible SQL features	"Compatibility with Oracle Databases" in the Application Development Guide
Pgpool-II	4.2.6	Failover, connection pooling, load balancing, etc.	"Pgpool-II" in the Installation and Setup Guide for Server
oracle_fdw	2.4.0	Connection to the Oracle database server	"oracle_fdw" in the Installation and Setup Guide for Server
pg_statsinfo	13.0	Collection and accumulation of statistics	"pg_statsinfo" in the Installation and Setup Guide for Server
pg_hint_plan	13.1.3.7	Tuning (statistics management, query tuning)	- "pg_hint_plan" in the Installation and Setup Guide for Server - "Optimizer Hints" in the Application Development Guide
pg_dbms_stats	1.5.0		- "pg_dbms_stats" in the Installation and Setup Guide for Server - "Locked Statistics" in the Application Development Guide
pg_repack	1.4.7	Table reorganization	"pg_repack" in the Installation and Setup Guide for Server
pg_rman	1.3.13	Backup and restore management	"pg_rman" in the Installation and Setup Guide for Server
pgBadger	11.6	Log analysis	"pgBadger" in the Installation and Setup Guide for Server
pg_bigm	1.2	Full-text search (multibyte)	"pg_bigm" in the Installation and Setup Guide for Server
PostgreSQL JDBC driver	42.2.23	JDBC driver	"JDBC Driver" in the Application Development Guide
psqlODBC	13.02.0000	ODBC driver	"ODBC Driver" in the Application Development Guide

Appendix C Features that can be Used on Servers Other than the Database Server

This chapter explains the configuration and operating environment of features to be installed and used on servers other than the database server when used in conjunction with the FUJITSU Enterprise Postgres database server.

In this chapter, FUJITSU Enterprise Postgres programs are referred to as server programs.

Below are features to be installed and used on servers other than the database server:

- WebAdmin
- Server Assistant
- Pgpool-II (failover, connection pooling, and load balancing)

C.1 WebAdmin

If there is only one database server, WebAdmin is normally installed on the same server as the database (the WebAdmin program can be installed at the same time as the server program).

If there are multiple database servers, database server instances can be managed collectively if a dedicated WebAdmin server is used. In this case, the WebAdmin program is installed on the WebAdmin server, and the server program and WebAdmin program are installed on the database server.

 See

- Refer to "1.2 Simple GUI-Based Installation and Operation Management" for information on WebAdmin.
- Refer to "Determining the Preferred WebAdmin Configuration" in the Installation and Setup Guide for Server for information on the server configuration when using WebAdmin.
- Refer to "Required Operating System" in the Installation and Setup Guide for Server for information on the operating environment of WebAdmin.

C.2 Server Assistant

To use the Server Assistant, the Server Assistant program is installed on a dedicated server (arbitration server).

 See

- Refer to "Overview of Database Multiplexing Mode" in the Cluster Operation Guide (Database Multiplexing) for information on the Server Assistant and the server configuration.
- Refer to "Required Operating System" in the Installation and Setup Guide for Server Assistant for information on the operating environment of the Server Assistant.

C.3 Failover, Connection Pooling, and Load Balancing Features of Pgpool-II

Pgpool-II is software that is placed between the database server and database client to relay the connection.

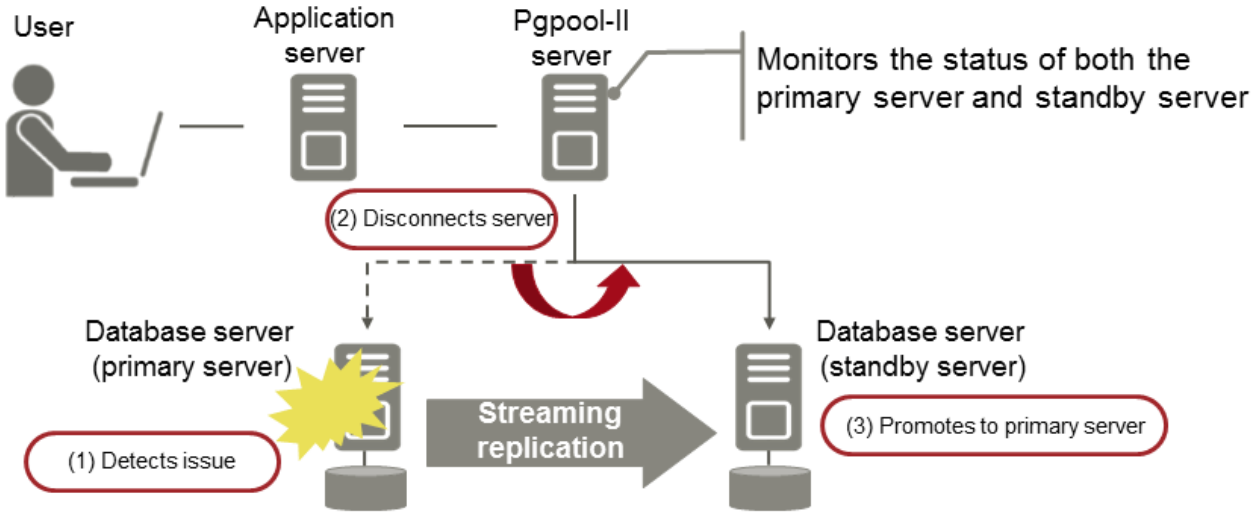
Pgpool-II provides the failover, connection pooling, and load balancing features for use during streaming replication.

Failover

In PostgreSQL, a database can be made redundant (building a high availability system) using synchronous streaming replication.

If the database server of either the primary server or standby server fails or is no longer accessible when using synchronous streaming replication, jobs will stop.

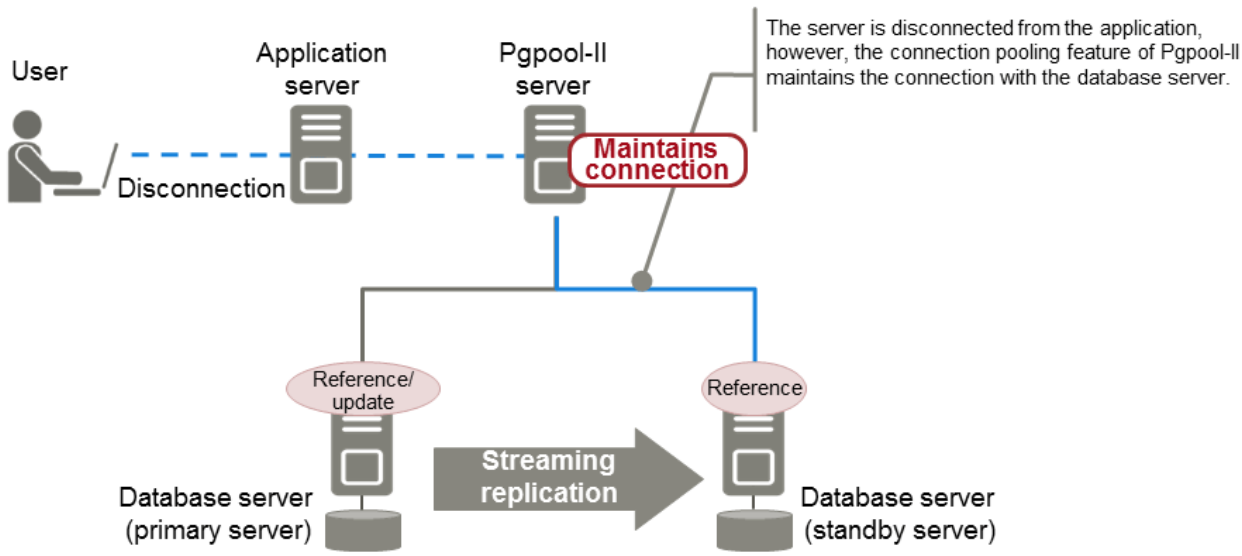
Failover monitors the status of each database and automatically disconnects the server when an error occurs. As a result, jobs can continue uninterrupted on the remaining server.



Connection pooling

This feature maintains (pools) the connection established with the database server, and reuses that connection each time a new connection with the same properties (user name, database, and protocol version) arrives.

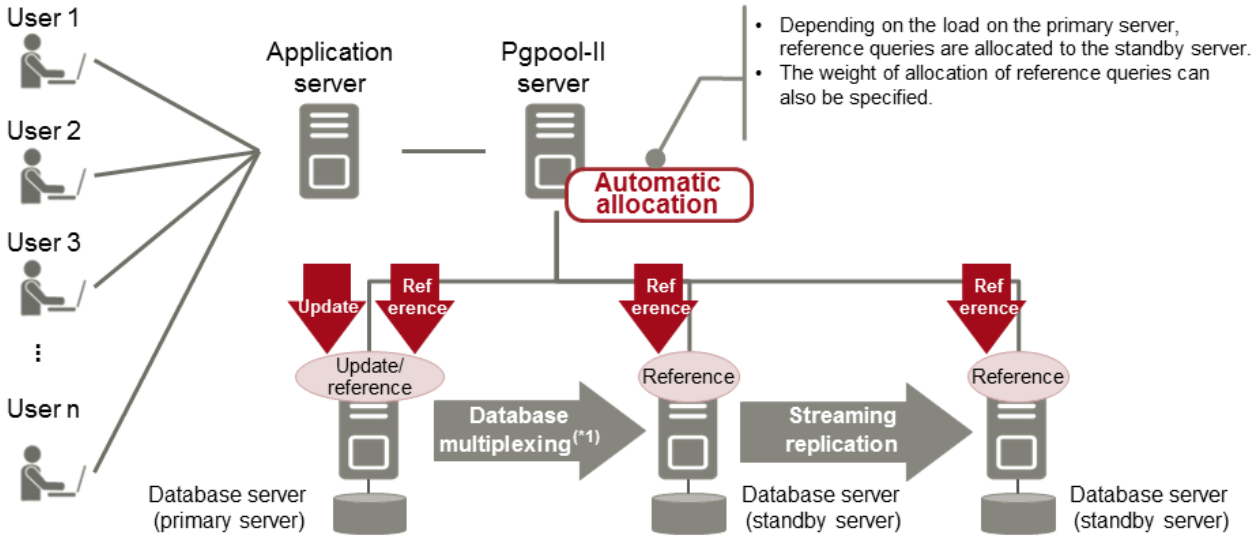
Connection pooling reduces the connection overhead for the database server, improving throughput of the whole system.



Load balancing

This feature distributes reference queries to multiple database servers, improving throughput of the whole system.

By combining load balancing with the FUJITSU Enterprise Postgres database multiplexing feature or the PostgreSQL streaming replication feature, load on the database server is reduced.



*1: The arbitration server used during database multiplexing has been omitted from this document.

See

- Refer to "System configuration when using Pgpool-II" in the Installation and Setup Guide for Server for information on the server configuration when using Pgpool-II.
- Refer to "Required Operating System" in the Installation and Setup Guide for Server for information on the operating environment of Pgpool-II.

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Fujitsu Enterprise Postgres 14 SP1 on IBM LinuxONE

Release Notes

SP1

Linux

FUJITSU

J2UL-2742-02ZLZ0(00)
September-2022

Preface

Purpose of this document

This document provides release information for FUJITSU Enterprise Postgres.

Structure of this document

This document is structured as follows:

Chapter 1 New Features and Improvements

Explains the new features and improvements in this version.

Chapter 2 Compatibility Information

Provides information regarding compatibility.

Export restrictions

Exportation/release of this document may require necessary procedures in accordance with the regulations of your resident country and/or US export control laws.

Issue date and version

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Edition 2.0: September 2022
Edition 1.0: February 2022
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Contents

Chapter 1 New Features and Improvements

This chapter explains FUJITSU Enterprise Postgres new features and improvements added in this version.

Table 1.1 New features and improvements

Version and level	Classification	Feature
14 SP1	Security	Support for KMIP(Key Management Interoperability Protocol)
14	Operation	Connection Manager
	OSS	PostgreSQL Rebase
		Update of OSS Provided
	Platform enhancement	Additional Operating System Support for Server Feature
		Additional Operating System Support for Client Feature
		Additional Operating System Support for Server Assistant Feature

1.1 Features Added in 14 SP1

This section explains new features and improvements in FUJITSU Enterprise Postgres 14 SP1.

1.1.1 Security

This section explains the new features and improvements related to security:

- Support for KMIP(Key Management Interoperability Protocol)

1.1.1.1 Support for KMIP(Key Management Interoperability Protocol)

KMIP(Key Management Interoperability Protocol) is supported.

You can use an encryption key stored in a key management system that supports KMIP as the master encryption key for transparent data encryption. This eliminates the need for backup operations of encryption keys, which were previously performed with the transparent data encryption feature.

See

Refer to "Using Transparent Data Encryption with Key Management Systems as Keystores" in the Operation Guide for details.

1.2 Features Added in 14

This section explains new features and improvements in FUJITSU Enterprise Postgres 14.

1.2.1 Operation

This section explains the new features and improvements related to operation:

- Connection Manager

1.2.1.1 Connection Manager

Connection Manager is now available to the following client drivers:

- ODBC driver
- JDBC driver

See

Refer to Connection Manager User's Guide for details.

1.2.2 OSS

This section explains the new feature related to OSS:

- PostgreSQL rebase
- Update of OSS provided

1.2.2.1 PostgreSQL Rebase

The PostgreSQL version that FUJITSU Enterprise Postgres is based on is 14.0.

See

Refer to "PostgreSQL Version Used for FUJITSU Enterprise Postgres" in the Installation and Setup Guide for Server for details.

1.2.2.2 Update of OSS Provided

The OSS provided by FUJITSU Enterprise Postgres have been updated.

See

Refer to "OSS Supported by FUJITSU Enterprise Postgres" in the General Description for details.

1.2.3 Platform enhancement

This section explains the new features related to platform enhancement:

- Additional operating system support for server
- Additional operating system support for client
- Additional operating system support for server assistant

1.2.3.1 Additional Operating System Support for Server Feature

The following additional operating system is supported:

- SLES 15 SP3

See

Refer to "Required Operating System" in the Installation and Setup Guide for Server for details.

1.2.3.2 Additional Operating System Support for Client Feature

The following additional operating system is supported:

- SLES 15 SP3

See

Refer to "Required Operating System" in the Installation and Setup Guide for Server for details.

1.2.3.3 Additional Operating System Support for Server Assistant Feature

The following additional operating system is supported:

- SLES 15 SP3

See

Refer to "Required Operating System" in the Installation and Setup Guide for Server Assistant for details.

Chapter 2 Compatibility Information

This chapter explains incompatible items and actions required when migrating from an earlier version to FUJITSU Enterprise Postgres 14 SP1. Check compatibility before migrating and take the appropriate action.

2.1 Installation/Setup Incompatibility

Item	Pre-migration version				
	11	12	12 SP1	13	14
Removing Operating System Support	Y	Y	Y	N	N
Changing kernel parameter settings when an instance is created with WebAdmin	Y	Y	Y	N	N
Removing Operating System Support	Y	Y	N	N	N
Changing the way OSS is set up	Y	N	N	N	N
Modifying Pgpool-II Installation Handling	Y	N	N	N	N
Changing Core and Log File Paths when Instance is Created with WebAdmin	Y	N	N	N	N
Renaming WebAdmin Services	Y	N	N	N	N

Y: Incompatibility exists

N: Incompatibility does not exist

2.1.1 Removing Operating System Support

Incompatibility

In FUJITSU Enterprise Postgres 13 or later, the following operating systems have been removed.

- RHEL7.7 and later minor version
- RHEL8.1

Action method

None.

2.1.2 Changing kernel parameter settings when an instance is created with WebAdmin

Incompatibility

For FUJITSU Enterprise Postgres 13 and later, changes kernel parameter settings for WebAdmin instance creation.

FUJITSU Enterprise Postgres 12 SP1 or earlier

Kernel Parameters	Value	Calculated Value
SHMMAX	If *currentValue* < *calculatedValue*, configure the calculated value	`((1800 + 270 * max_locks_per_transaction) * max_connections + (1800 + 270 * max_locks_per_transaction) * autovacuum_max_workers + (770 + 270 * max_locks_per_transaction) * max_prepared_transactions +`

Kernel Parameters	Value	Calculated Value
		(shared_buffer) + (16 * 1024 * 1024) + (770 * 1024)) * 1.05
SHMALL	Specify *currentValue* + *calculatedValue*	(SHMMAX / PAGESIZE) + 1 PAGESIZE = 4K
SEMMNI	Specify *currentValue* + *calculatedValue*	ceil((max_connections + autovacuum_max_workers + 4) / 16)
SEMMNS	Specify *currentValue* + *calculatedValue*	ceil((max_connections + autovacuum_max_workers + 4) / 16) * 17

FUJITSU Enterprise Postgres 13 or later

Kernel Parameters	Value	Calculated Value
SHMMAX	Do not change value	-
SHMALL	Do not change value	-
SEMMNI	Specify *currentValue* + *calculatedValue*	- For instances of FUJITSU Enterprise Postgres 11: ceil((max_connections + autovacuum_max_workers + max_worker_processes + 5) / 16) - For Fujitsu Enterprise Postgres 12 and later instances: ceil((max_connections + autovacuum_max_workers + max_wal_senders + max_worker_processes + 5) / 16)
SEMMNS	Specify *currentValue* + *calculatedValue*	- For instances of FUJITSU Enterprise Postgres 11: ceil((max_connections + autovacuum_max_workers + max_worker_processes + 5) / 16) * 17 - For Fujitsu Enterprise Postgres 12 and later instances: ceil((max_connections + autovacuum_max_workers + max_wal_senders + max_worker_processes + 5) / 16) * 17

Action method

None.

2.1.3 Removing Operating System Support

Incompatibility

In FUJITSU Enterprise Postgres 12 SP1 or later, the following operating systems have been removed.

- SLES 12 SP4

Action method

None.

2.1.4 Changing the Way OSS is Set Up

Incompatibility

FUJITSU Enterprise Postgres 12 or later do not place OSS extension modules in the executable directory. The OSS extension modules must be placed in the executable directory when you set up OSS.

Refer to "Setting Up and Removing OSS" in the Installation and Setup Guide for Server for details.

Action method

None.

2.1.5 Modifying Pgpool-II Installation Handling

Incompatibility

For FUJITSU Enterprise Postgres 12 or later, Pgpool-II is not automatically installed when you install the server. Therefore, if you want to take advantage of Pgpool-II, install it separately from the server installation.

The extension modules required for the database server are shipped with the server program. You should set up Pgpool-II on the database server side, even if Pgpool-II is to be used on a different server than the database server.

Refer to "Setting Up and Removing OSS" in the Installation and Setup Guide for Server for details.

Action method

None.

2.1.6 Changing Core and Log File Paths when Instance is Created with WebAdmin

Incompatibility

In FUJITSU Enterprise Postgres 12 or later, change the core and log file paths when creating an instance in WebAdmin.

FUJITSU Enterprise Postgres 11

Log File Path: /var/tmp/fsep_*version*/*instanceAdminUser_instanceNamePortNumber*/log

Core File Path: /var/tmp/fsep_*version*/*instanceAdminUser_instanceNamePortNumber*/core

version: product version_edition_architecture

［Example］

Log File Path: /var/tmp/fsep_110_AE_64/naomi_myinst27599/log

Core File Path: /var/tmp/fsep_110_AE_64/naomi_myinst27599/core

FUJITSU Enterprise Postgres 12

Log File Path: /var/tmp/fsep_*version*/*instanceAdminUser_instanceNamePortNumber*/log

Core File Path: /var/tmp/fsep_*version*/*instanceAdminUser_instanceNamePortNumber*/core

version: product version_WA_architecture

［Example］

Log File Path: /var/tmp/fsep_120_WA_64/naomi_myinst27599/core

Core File Path: /var/tmp/fsep_120_WA_64/naomi_myinst27599/log

Action method

None.

2.1.7 Renaming WebAdmin Services

Incompatibility

In FUJITSU Enterprise Postgres 12 or later, change the service name registered when you set up WebAdmin.

FUJITSU Enterprise Postgres 11

fsep_*x*SP*z*_*edition*_64_WebAdmin_Port1

fsep_*x*SP*z*_*edition*_64_WebAdmin_Port2

FUJITSU Enterprise Postgres 12 or later

fsep_xSPz_WA_64_WebAdmin_Port1

fsep_xSPz_WA_64_WebAdmin_Port2

Action method

None.

2.2 Application Migration Incompatibility

Item	Pre-migration version				
	11	12	12 SP1	13	14
Changing the display result when data masking is applied to NaN, infinity, -infinity	Y	Y	Y	Y	N
Changing the Valid Range of Identifiers Defined by the DECLARE STATEMENT statement	Y	Y	Y	Y	N
Changing Precompile Results	Y	Y	Y	Y	N
Changing the Trigger Replacement Process	Y	Y	Y	Y	N
Removing Java Support	Y	Y	Y	N	N
Changed to Error when Running an Operator or Function that Returns non Data Types for Masking Type	Y	N	N	N	N

Y: Incompatibility exists

N: Incompatibility does not exist

2.2.1 Changing the display result when data masking is applied to NaN, infinity, -infinity

Incompatibility

In FUJITSU Enterprise Postgres 14, the display result when data masking is applied to NaN, infinity, and -infinity will be changed.

FUJITSU Enterprise Postgres 13 or earlier

If the float type NaN, infinity, and -infinity are partially masking with (9,1,2), the following will be displayed.

```
NaN : 99
Infinity : 99
-Infinity : 99
```

FUJITSU Enterprise Postgres 14 or later

If the float type NaN, infinity, and -infinity are partially masking with (9,1,2), the following will be displayed.

```
NaN : NaN
Infinity : Infinity
-Infinity : -Infinity
```

Action method

If the application is analyzing the SQL masking output result, please consider the non-numeric output result and correct it.

2.2.2 Changing the Valid Range of Identifiers Defined by the DECLARE STATEMENT statement

Incompatibility

In FUJITSU Enterprise Postgres 14 will change the valid range of identifiers defined by a DECLARE STATEMENT statement in ecpg/ecobpg.

FUJITSU Enterprise Postgres 13 or earlier

The valid range is now per process.

FUJITSU Enterprise Postgres 14 or later

The valid range is now per file.

Action method

None.

2.2.3 Changing Precompile Results

Incompatibility

In FUJITSU Enterprise Postgres 14 removed the ECPGdeclare/ECPGopen function. Therefore, results precompiled from earlier versions of FUJITSU Enterprise Postgres will not be available in FUJITSU Enterprise Postgres 14.

Action method

Rebuild the application.

2.2.4 Changing the Trigger Replacement Process

Incompatibility

In FUJITSU Enterprise Postgres 14 will change restricted triggers to not be supported by replace operations (OR REPLACE).

FUJITSU Enterprise Postgres 13 or earlier

You can replace a constraint trigger.

[Example]

```
=# CREATE OR REPLACE CONSTRAINT TRIGGER my_constraint_trigger AFTER DELETE ON my_table
-# FOR EACH ROW
-# EXECUTE PROCEDURE funcA();
CREATE TRIGGER
```

FUJITSU Enterprise Postgres 14 or later

It does not support replacing a constraint trigger.

[Example]

```
=# CREATE OR REPLACE CONSTRAINT TRIGGER my_constraint_trigger AFTER DELETE ON my_table
-# FOR EACH ROW
-# EXECUTE PROCEDURE funcA();
ERROR:  CREATE OR REPLACE CONSTRAINT TRIGGER is not supported
```

Action method

None.

2.2.5 Removing Java Support

Incompatibility

In FUJITSU Enterprise Postgres 13 or later, the following Java have been removed.

- Java SE 6

Also, the JDBC driver file 'postgresql-jdbc4.jar' for JDK 6 or JRE 6 isn't installed.

Action method

None.

2.2.6 Changed to Error when Running an Operator or Function that Returns non Data Types for Masking Type

Incompatibility

In FUJITSU Enterprise Postgres 12, changed to error when running an operator or function that returns non Data Types for Masking type.

FUJITSU Enterprise Postgres 11

In the following cases, the operator or function in 3) may be executed without masking.

This is an incorrect result because the data containing the masking column is performed without masking.

1) Create a Masking policy. and

2) Execute a SELECT statement. and

3) Execute an operator or function in the SELECT statement of 2). and

4) The operator or function argument of 3) includes a subquery. and

5) The operator or function argument of 3) contains the column to be protected created in 1). and

6) The operator or function of 3) returns a type not listed in "Data Types for Masking" in "Operation Guide".

FUJITSU Enterprise Postgres 12 or later

Operator or function results of 3) in the following error.

```
ERROR:  The output data type is incompatible with the confidential policy.
HINT:  Data type of the result value(s) produced by expression/function using confidential columns
is not supported by Data masking module. Consider removing confidential columns from such
expressions/functions.
```

This is correct because the operator or function returns a data type not listed in "Data Types for Masking" in "Operation Guide".

Action method

Do one of the following to ensure that the results are identical to those of FUJITSU Enterprise Postgres 11:

1) Modify the Masking policy to prevent masking from being performed for the user executing the SQL.

2) Modify SQL to not use operators or functions that return types not listed in "Data Types for Masking" in "Operation Guide".

2.3 Operation Migration Incompatibility

Item	Pre-migration version				
	11	12	12 SP1	13	14
Changing the Output of the Status Mode of the cm_ctl Command	Y	Y	Y	Y	N
Rename column "master_pid" in pgx_loader_state to "leader_pid"	Y	Y	Y	Y	N
Adding a Message to Output when the Database Server watchdog detects that the Connection Manager is down	N	Y	Y	Y	N
Change the Error Information when the Connection Manager re-executes SQL on the Failed Connection	N	Y	Y	Y	N
Changing the Value of the Category Column in the pg_settings view	Y	Y	Y	N	N
Changing pgx_stat_lwlock of the Statistics View	Y	Y	Y	N	N
Changing the Behavior of pgx_rcvall	Y	Y	Y	N	N
Mirroring Controller no longer retries to monitor database processes when they are detected as down	Y	N	N	N	N
Changing the Name and Parameter Name of the Mirroring Controller Post-Promote Command	Y	N	N	N	N
Changing Mirroring Controller User Command Input Values	Y	N	N	N	N

Y: Incompatibility exists

N: Incompatibility does not exist

2.3.1 Changing the Output of the Status Mode of the cm_ctl Command

Incompatibility

Changes the display of the output of the status mode of the cm_ctl command.

(If it has been modified by the P number PH21029, and you have applied an urgent fix that includes it, FUJITSU Enterprise Postgres 14 will work.)

When the cm_ctl command was executed in status mode, there was omission of the output of the header "pid" displayed in "application_information" which outputs the information of the application.

Correct the following in PH21029.

- Add ':' to 'application_information' to output application information
  Output "application_information:"

- Add the header "pid" output to "application_information"
  Outputs "pid" whose header information is missing.
- Changes the number of digits in the numeric portion of connected_time
  Change the display start position of the date and time connected to the conmgr process to correct the gap between the start position of the header and the numeric part. (5 digits backward)

This fix causes the following incompatibilities when running the cm_ctl command in status mode:

- Add ":" to the display of "application_information"
- Display the header "pid" in "application_information"
- Change the output start position of the "connected_time" header of "application_information"
- Change the start of the date and time output of "connected_time" in "application_information" to 5 digits later.

FUJITSU Enterprise Postgres 13 or earlier

```
application_information
addr         port  connected_time
10.xxx.x.xx  99999 21655 2021-10-20 09:18:51
```

FUJITSU Enterprise Postgres 14

```
application_information:
addr         port  pid       connected_time
10.xxx.x.xx  99999 21655     2021-10-20 09:18:51
```

When analyzing the output of the cm_ctl command in status mode in a batch or shell script, it may not work correctly if the header is referenced and the third is "connected_time".

For example, when identifying a row of data (numeric part), a string up to the header "addr", "port", and "connected_time" one row before is searched for and identified.

Action method

If you are using a batch or shell script to parse the output of the cm_ctl command in status mode, modify it to take into account the number of digits in the header and numeric part of the output.

2.3.2 Rename column "master_pid" in pgx_loader_state to "leader_pid"

Incompatibility

In FUJITSU Enterprise Postgres 14 renames column "master_pid" to "leader_pid" in the pgx_loade_state table.

Action method

None.

2.3.3 Adding a Message to Output when the Database Server watchdog detects that the Connection Manager is down

Incompatibility

In FUJITSU Enterprise Postgres 13 SP1, when using the Connection Manager, if the database server watchdog detects that the Connection Manager is down, it will output a message to the database server.

Incompatibilities may occur if:

1) The application server is using the Connection Manager. and

2) The database server is running the watchdog process. and

3) 1) Application server or Connection Manager goes down.

FUJITSU Enterprise Postgres 13 or earlier

If the database server watchdog detects that the Connection Manager is down, the following message is not output.

```
WARNING:  watchdog: error in heartbeat connection (20331): host=xxx.xxx.xxx.xxx port=xxxxx
pid=xxxxx
```

FUJITSU Enterprise Postgres 14

If the database server watchdog detects that the Connection Manager is down, the following message may be output.

```
WARNING:  watchdog: error in heartbeat connection (20331): host=xxx.xxx.xxx.xxx port=xxxxx
pid=xxxxx
```

Action method

If you are monitoring the database log for watchdog messages, change the monitoring setting to one that takes into account the possible output of these messages.

2.3.4 Change the Error Information when the Connection Manager re-executes SQL on the Failed Connection

Incompatibility

In FUJITSU Enterprise Postgres 13 SP1 allows an application using the Connection Manager to change the error information when attempting to execute SQL again on a connection that the Connection Manager has determined to be in error due to a database error.

The changed error information is included in the error presented in "Errors when an Application Connection Switch Occurs and Corresponding Actions" for each client driver in "Application Development Guide".

Incompatibilities may occur if the following conditions are met:

1) The application uses one of the following drivers. and

-libpq (C Library)

-ECPG (Embedded SQL in C)

2) You are using the Connection Manager. and

3) The database server to which the application in 1) was connected goes down. and

4) The Connection Manager notifies the application in 1) of an error when the database is down in 3). and

5) The application in 1) does not disconnect from the database server that is down, but executes SQL using the connection.

FUJITSU Enterprise Postgres 13 or earlier

The error information returned depends on the actual database server error condition.

FUJITSU Enterprise Postgres 14

The following error information is returned:

- For libpq (C Library): CONNECTION_BAD (PQstatus () return value)
- For ECPG (Embedded SQL in C): 57P02 (SQLSTATE return value)

Action method

Consider that the above error may be returned during the SQL error determination process.

Also, if you encounter an error about switching application destinations as described in "Errors when an Application Connection Switch Occurs and Corresponding Actions" for each client driver in "Application Development Guide", you should explicitly disconnect and reconnect or rerun the application.

2.3.5 Changing the Value of the Category Column in the pg_settings view

Incompatibility

For FUJITSU Enterprise Postgres 13, change the value of the category column in the pg_settings view.

FUJITSU Enterprise Postgres 12 SP1 or earlier

Original value	wrong value
Preset Options	Fujitsu Enterprise Postgres Parameters
Customized Options	Preset Options
Developer Options	Customized Options

This is an incorrect result because it is different from the original value.

FUJITSU Enterprise Postgres 13 or later

The correct value is the category column in the pg_settings view.

Action method

Replaces the category column in the pg_settings view with the values before migration, so that the results are the same as before migration.

2.3.6 Changing pgx_stat_lwlock of the Statistics View

Incompatibility

In FUJITSU Enterprise Postgres 13, change the wait event name displayed in the lwlock_name column of the statistics view pgx_stat_lwlock.

Wait Event Name

FUJITSU Enterprise Postgres 12 SP1 or earlier	FUJITSU Enterprise Postgres 13
clog (*1)	XactBuffer
commit_timestamp (*1)	CommitTSBuffer
subtrans (*1)	SubtransBuffer
multixact_offset (*1)	MultiXactOffsetBuffer
multixact_member (*1)	MultiXactMemberBuffer
async (*1)	NotifyBuffer
oldserxid (*1)	SerialBuffer
wal_insert (*1)	WALInsert
buffer_content (*1)	BufferContent
buffer_io (*1)	BufferIO
replication_origin (*1)	ReplicationOriginState
replication_slot_io (*1)	ReplicationSlotIO
proc (*1)	LockFastPath
buffer_mapping (*1)	BufferMapping
lock_manager (*1)	LockManager

FUJITSU Enterprise Postgres 12 SP1 or earlier	FUJITSU Enterprise Postgres 13
predicate_lock_manager (*1)	PredicateLockManager
parallel_hash_join (*1)	ParallelHashJoin
parallel_query_dsa (*1)	ParallelQueryDSA
session_dsa (*1)	PerSessionDSA
session_record_table (*1)	PerSessionRecordType
session_typmod_table (*1)	PerSessionRecordTypmod
shared_tuplestore (*1)	SharedTupleStore
tbm (*1)	SharedTidBitmap
parallel_append (*1)	ParallelAppend
serializable_xact (*2)	PerXactPredicateList
shared_mcxt (*2)	SharedMcxt
meta_cache_map (*2)	MetaCacheMap
global_metacache (*2)	GlobalCatcache
cached_buf_tranche_id (*2)	CachedBufTranche

*1）Events added in FUJITSU Enterprise Postgres 11.

*2）Events added in FUJITSU Enterprise Postgres 12.

Action method

None.

2.3.7 Changing the Behavior of pgx_rcvall

Incompatibility

In FUJITSU Enterprise Postgres 13, change the pgx_rcvall command to fail if the -e option of the pgx_rcvall command specifies a future time or if the -n option specifies a list appointment that does not exist.

FUJITSU Enterprise Postgres 12 SP1 or earlier

All archived WALs are applied for recovery if the -e option of the pgx_rcvall command specifies a time in the future, or if the -n option specifies a list appointment that does not exist.

FUJITSU Enterprise Postgres 13 or later

The pgx_rcvall command fails if the -e option of the pgx_rcvall command specifies a time in the future, or if the -n option specifies a list appointment that does not exist.

Action method

Specify recovery objectives correctly, if necessary.

2.3.8 Mirroring Controller no Longer Retries to Monitor Database Processes when they are Detected as Down

Incompatibility

For the FUJITSU Enterprise Postgres Mirroring Controller, change the heartbeat monitoring of the database process so that it does not retry monitoring when it detects down.

Action method

None.

2.3.9 Changing the Name and Parameter Name of the Mirroring Controller Post-Promote Command

Incompatibility

In the FUJITSU Enterprise Postgres 12 Mirroring Controller, change the name of the post-promote command, which is the state transition command, and the parameter name in the server configuration file that specifies the post-promote command.

FUJITSU Enterprise Postgres 11

- Command Name

  post-promote command

- The parameter name in the server configuration file that specifies the post-promote command

  post_promote_command

FUJITSU Enterprise Postgres 12 or later

- Command Name

  post-switch command

- The parameter name in the server configuration file that specifies the post-promote command

  post_switch_command

Action method

The post_promote_command parameter in the server configuration file continues to be available in FUJITSU Enterprise Postgres 12 or later.If specified in the server configuration file, it acts as a post-switch command.You cannot specify the post_promote_command and post_switch_command parameters at the same time.

2.3.10 Changing Mirroring Controller User Command Input Values

Incompatibility

Arguments (Fixed value: primarycenter) have been added to the following user commands:

- Fencing command of the database server
- Arbitration command
- Post-switch command
- Pre-detach command
- Post-attach command

Action method

If you are checking the number of arguments in a user command, increase the number of arguments by one.

2.4 JDBC Drive Incompatibility

Item	Pre-migration version				
	11	12	12 SP1	13	14
Changing the targetServerType Value	Y	Y	Y	N	N

Y: Incompatibility exists

N: Incompatibility does not exist

2.4.1 Changing the targetServerType Value

Incompatibility

In FUJITSU Enterprise Postgres 13, the value of targetServerType specified in the connection string was changed. Therefore, the previously used values are no longer available.

Action method

If you specified a value for targetServerType, change the value as follows:

Table 2.1 Specified values for the target server

Server Selection Order	FUJITSU Enterprise Postgres 12 SP1 or earlier	FUJITSU Enterprise Postgres 13
Primary Server	master	primary
Standby Server	slave	secondary
Prefer Standby Server	preferSlave	preferSecondary
Any	any	any

2.5 ODBC Drive Incompatibility

Item	Pre-migration version				
	11	12	12 SP1	13	14
Cannot specify prefer-read for target_session_attrs	Y	Y	Y	Y	Y

Y: Incompatibility exists

N: Incompatibility does not exist

2.5.1 Cannot specify prefer-read for target_session_attrs

Incompatibility

FUJITSU Enterprise Postgres 14 users will not see the "prefer-read" radio button in the "Target_Session_Attrs" item of the data source option selection screen.

Action method

Select prefer-standby.

2.6 C Library (libpq) Migration Incompatibility

Item	Pre-migration version				
	11	12	12 SP1	13	14
Changing when "prefer-read" is Specified for the target_session_attrs Parameter	Y	Y	Y	Y	N

Y: Incompatibility exists

N: Incompatibility does not exist

2.6.1 Changing when "prefer-read" is Specified for the target_session_attrs Parameter

Incompatibility

In FUJITSU Enterprise Postgres 14 changes the attach server priority if any of the following servers are specified simultaneously with "prefer-read" as the target_session_attrs parameter:

- Primary server (default_transaction_read_only = ON)
- Standby server

FUJITSU Enterprise Postgres 13 or earlier

The primary server (default_transaction_read_only = ON) and standby servers have the same priority.

FUJITSU Enterprise Postgres 14 or later

Standby servers connect in preference to primary servers (default_transaction_read_only = ON).

Action method

None.

2.7 oracle_fdw Incompatibility

Item	Pre-migration version				
	11	12	12 SP1	13	14
Changing the Oracle Client Version	Y	N	N	N	N

Y: Incompatibility exists

N: Incompatibility does not exist

2.7.1 Changing the Oracle Client Version

Incompatibility

FUJITSU Enterprise Postgres 12 change the version of the Oracle client used to build oracle_fdw to 11.2.

Action method

Use Oracle client version 11.2 or later.

Also,if a file named libclntsh.so.11.1 does not exist in OCI library, create a symbolic link named libclntsh.so.11.1.

2.8 pgaudit Incompatibility

Item	Pre-migration version				
	11	12	12 SP1	13	14
Changing to Output Extra NEW and OLD Values in the Audit Log when the Trigger Function Executes	Y	Y	Y	N	N

Y: Incompatibility exists

N: Incompatibility does not exist

2.8.1 Changing to Output Extra NEW and OLD Values in the Audit Log when the Trigger Function Executes

Incompatibility

In FUJITSU Enterprise Postgres 13, the trigger function additionally outputs NEW and OLD values to the audit log when the pgaudit.log_parameter is set to on.

FUJITSU Enterprise Postgres 12 SP1 or earlier

The following (18) does not output the values of NEW, OLD.

[Example]

```
AUDIT: SESSION,WRITE,2020-09-03 07:07:39 UTC,
        (1)    (2)   (3)
[local],9775,psql,k5user,postgres,3/536, 1, 2, INSERT, ,
(4)     (5)  (6)  (7)    (8)      (9)   (10)(11)(12)(13)
TABLE,public.trig_audit, ,
(14)  (15)    (16)
 "INSERT INTO trig_audit SELECT 'U', now(), user, OLD.*, NEW.*",
(17)
trig_audit AFTER ROW UPDATE 92027 trig_test trig_test public 0  f aaaa
(18)
```

FUJITSU Enterprise Postgres 13 or later

NEW, OLD values are output.

[Example]

```
AUDIT: SESSION,WRITE,2020-09-03 07:07:39 UTC,
[local],9775,psql,k5user,postgres,3/536,1,2,INSERT,,TABLE,public.
trig_audit,,
"INSERT INTO trig_audit SELECT 'U', now(), user, OLD.*, NEW.*",
(bbb) (aaa) trig_audit AFTER ROW UPDATE 92027 trig_test trig_test
public 0  f aaaa
```

Action method

If you are using an application that works by monitoring the string that the trigger function output to the audit log, modify the application to work with the NEW and OLD values.

2.9 WebAdmin Incompatibility

Item	Pre-migration version				
	11	12	12 SP1	13	14
Cannot specify prefer-read for target_session_attrs	Y	Y	Y	Y	N

Y: Incompatibility exists

N: Incompatibility does not exist

2.9.1 Cannot specify prefer-read for target_session_attrs

Incompatibility

FUJITSU Enterprise Postgres 14 will no longer allow prefer-read to target_session_attrs as a connection method to an upstream server that is specified when creating an instance of a standby server.

Action method

Specify prefer-standby.

2.10 Connection Manager Incompatibility

Item	Pre-migration version			
	12	12 SP1	13	14
Behavior change when "read-write" is specified for the target_session_attrs parameter	Y	Y	Y	N

Y: Incompatibility exists

N: Incompatibility does not exist

2.10.1 Behavior change when "read-write" is specified for the target_session_attrs parameter

Incompatibility

FUJITSU Enterprise Postgres 13 or earlier

May be connected to primary server (default_transaction_read_only = ON).

FUJITSU Enterprise Postgres 14 or later

It is not connected to the primary server (default_transaction_read_only = ON).

Action method

For FUJITSU Enterprise Postgres 13 and earlier, specify "primary" for the target_session_attrs parameter.

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Fujitsu Enterprise Postgres 14 SP1 on IBM LinuxONE

Program Updates

SP1

Linux

FUJITSU

J2UL-2743-02ZLZ0(00)
September-2022

Preface

This document explains the updates that have been fixed at this version.

The contents of this document are subject to change without notice.

Notations

The status for each edition is shown in the following table.

P number	Update summary
Number that uniquely identifies the update	Summary of update details

Export restrictions

Exportation/release of this document may require necessary procedures in accordance with the regulations of your resident country and/or US export control laws.

Issue date and version

```
Edition 2.0: September 2022
Edition 1.0: February 2022
```

Copyright

Chapter 1 Program Updates

This version incorporates the updates implemented in PostgreSQL 14.

See

Refer to the PostgreSQL Global Development Group website for information on the updates implemented in the following releases:

[PostgreSQL 14]

```
https://www.postgresql.org/docs/14/release-14.html
```

In addition, issues that occurred in previous versions are also fixed.

Refer to the following for details of the program fixes included in this version and level.

- FUJITSU Enterprise Postgres 14 SP1 Program Updates
- FUJITSU Enterprise Postgres 14 Program Updates

FUJITSU Enterprise Postgres 14 SP1 Program Updates

P number	Update summary
PH21794	There is a column "parallel_scan" that is not mentioned in the manual, such as in pg_stat_all_tables in the stats view.
PH22045	Executing CREATE INDEX CONCURRENTLY or REINDEX CONCURRENTLY may corrupt the index.
PH22064	In the status mode of cm_ctl, the IP address may not be displayed in addr of instance_information.
PH22065	There may be an error in the syntax error message when starting the conmgr process.
PH22169	FUJITSU Enterprise Postgres will reflect the security bug fixes absorbed in PostgreSQL JDBC Driver 42.2.25.
PH22179	Malicious applications using the JDBC driver may cause SQL injection when using cursors.
PH21526	When using the data masking function, the original data to be masked may be overwritten with the revised data.
PH22232	The bug fixes absorbed by Apache Log4j 2.18.0 are reflected in WebAdmin of FUJITSU Enterprise Postgres.
PH22260	The bug fixes absorbed by Apache Tomcat 9.0.65 are reflected in WebAdmin of FUJITSU Enterprise Postgres.

FUJITSU Enterprise Postgres 14 Program Updates

P number	Update summary
PH15298	On the WebAdmin client authentication setting screen, you may be able to make settings that do not meet the PostgreSQL specifications.
PH17555	WebAdmin may fail to start Mirroring Controller.
PH19280	The language of error messages displayed in WebAdmin may not match the language selected in WebAdmin.
PH19888	When displaying the instance information with WebAdmin, "Please wait" may be displayed and no response may occur.
PH20077	About 1.25 times more memory had been acquired than the value specified for shared_buffers. As a result, memory may not be secured when the instance is started and the startup may fail.
PH20741	When executing the pgx_loader command, the pgx_loader command may crash if the COPY statement specified with the -c option contains illegal characters.
PH21022	Provides a module for using JIT compilation for LLVM11.
PH21028	Failed to build libpq C library application using PQcmSocket().
PH21029	The application_information header "pid" does not appear when running the status mode of the cm_ctl command.
PH21246	Database startup might fail if zEDC compression is specified for the archive_command parameter.

Fujitsu Enterprise Postgres 14 SP1 on IBM LinuxONE

Installation and Setup Guide for Server

SP1

Linux

FUJITSU

J2UL-2745-02ZLZ0(00)
September-2022

Preface

Purpose of this document

The FUJITSU Enterprise Postgres database system extends the PostgreSQL features and runs on the Linux platform.

This document describes how to install and set up "FUJITSU Enterprise Postgres".

Intended readers

This document is intended for those who install and operate FUJITSU Enterprise Postgres.

Readers of this document are assumed to have general knowledge of:

- PostgreSQL
- SQL
- Linux

Structure of this document

This document is structured as follows:

Chapter 1 Overview of Installation

Describes the installation types and procedures

Chapter 2 Operating Environment

Describes the operating environment required to use FUJITSU Enterprise Postgres

Chapter 3 Installation

Describes how to perform a new installation of FUJITSU Enterprise Postgres

Chapter 4 Setup

Describes the setup to be performed after installation

Chapter 5 Uninstallation

Describes how to uninstall FUJITSU Enterprise Postgres

Appendix A Recommended WebAdmin Environments

Describes the recommended WebAdmin environment.

Appendix B Setting Up and Removing WebAdmin

Describes how to set up and remove WebAdmin

Appendix C WebAdmin Disallow User Inputs Containing Hazardous Characters

Describes characters that are not allowed in WebAdmin.

Appendix D Configuring Parameters

Describes FUJITSU Enterprise Postgres parameters.

Appendix E Estimating Database Disk Space Requirements

Describes how to estimate database disk space requirements

Appendix F Estimating Memory Requirements

Describes the formulas for estimating memory requirements

Appendix G Quantitative Limits

Describes the quantity range

Appendix H Configuring Kernel Parameters

Describes the settings for kernel parameters

Appendix I Determining the Preferred WebAdmin Configuration

Describes the two different configurations in which WebAdmin can be used and how to select the most suitable configuration

Appendix J System Configuration when using Pgpool-II

Describes the system configuration when using Pgpool-II.

Appendix K Supported contrib Modules and Extensions Provided by External Projects

Lists the PostgreSQL contrib modules and the extensions provided by external projects supported by FUJITSU Enterprise Postgres.

Appendix L Procedure when Modifying the JRE Installation

Describes the procedures to follow when modifying the JRE installation.

Export restrictions

Exportation/release of this document may require necessary procedures in accordance with the regulations of your resident country and/or US export control laws.

Issue date and version

```
Edition 2.0: September 2022
Edition 1.0: February 2022
```

Copyright

Revision History

Changes	Place of Change	Edition
Added an article about KMIP (Key Management Interoperability Protocol) support.	2.10 Key Management System Requirements	Edition 2.1

Contents

Chapter 1 Overview of Installation

This chapter provides an overview of FUJITSU Enterprise Postgres installation.

1.1 Features that can be Installed

Each FUJITSU Enterprise Postgres feature is installed on the machine that was used to build the database environment.

The basic features of FUJITSU Enterprise Postgres (server feature, client feature) can be installed.

1.2 Installation Types

The following installation types are available for FUJITSU Enterprise Postgres:

- New installation
- Reinstallation
- Multi-version installation

1.2.1 New Installation

In initial installation, FUJITSU Enterprise Postgres is installed for the first time.

1.2.2 Reinstallation

Perform reinstallation to repair installed program files that have become unusable for any reason.

1.2.3 Multi-Version Installation

FUJITSU Enterprise Postgres products can be installed on the same server if the product version (indicated by "*x*" in "*x* SP*z*") is different from that of any version of the product that is already installed.

1.3 Uninstallation

Uninstallation removes the system files of the installed FUJITSU Enterprise Postgres.

Chapter 2 Operating Environment

This chapter describes the operating environment required to use FUJITSU Enterprise Postgres.

See

Refer to "Operating Environment" in the Installation and Setup Guide for Client when installing the FUJITSU Enterprise Postgres client feature at the same time.

2.1 Required Operating System

One of the operating systems shown below is required in order to use FUJITSU Enterprise Postgres. Check and use minor version, which is certified and currently supported by Red Hat or SUSE for the target IBM z / Linux One hardware.

- RHEL8.2 or later minor version
- SLES 15 SP3

Note

The sepgsql module, which is a PostgreSQL extension, can be used in RHEL8.

Information

- The following packages are required for operations on RHEL8.

Package name	Remarks
alsa-lib	-
audit-libs	-
cyrus-sasl-lib	-
pcp-system-tools	Required when using parallel scan.
glibc	-
libnsl	-
libicu	Provides collation support. Install 60.x.
libgcc	-
libmemcached	Required when using Pgpool-II.
libstdc++	-
libtool-ltdl	Required when using ODBC drivers.
llvm	Versions 11.0.x, 10.0.x, or 9.0.x of llvm is required to run SQL with runtime compilation (just-in-time compilation). Install the package that contains libLLVM-11.so, libLLVM-10.so, or libLLVM-9.so. For example, version 11.0.x of "llvm-libs" published with Application Streams includes libLLVM-11.so. By default, version 11.0.x is used.

Package name	Remarks
	If you use a version other than 11.0.x, specify the version you want to use in the jit_provider parameter in postgresql.conf. For example, use llvmjit-vsn10 when using version 10.0.x. FUJITSU Enterprise Postgres uses runtime compilation by default. If you do not want to use runtime compilation, turn off the jit parameter in postgresql.conf.You do not need to install llvm if you turn off the jit parameter. Failure to install llvm without turning off the jit parameter may result in an error when executing SQL. For more information about runtime compilation, see "Just-in-Time Compilation (JIT)" in the PostgreSQL Documentation. Note: If JIT compilation using LLVM is performed on RHEL8, a verbose server message is logged one or more times on first query execution, for each associated database connection. <Message> ORC error: No callback manager available for s390x-ibm-linux This error message results from a known deficiency in one of the features of the LLVM library for IBM Z, but this feature is not used by the server and the error does not otherwise affect LLVM operation. To prevent this message from being logged, JIT compilation may be disabled, by setting the value "off" to the configuration variable "jit".
lz4-libs	-
ncurses-libs	-
net-tools	-
nss-softokn-freebl	-
opencryptoki	Required if transparent data encryption is used in conjunction with a hardware security module. Install 3.12.1 or later into default directory.
pam	Required when using PAM authentication.
perl-libs	Required when using PL/Perl. Install 5.26.
protobuf-c	Required if using the Transparent Data Encryption feature when using a key management system as a keystore. Install 1.3.0.
python3	Required when using PL/Python based on Python 3. Install 3.6.x.
redhat-lsb	-
libselinux	Required for sepgsql.
tcl	Required when using PL/Tcl. Install 8.6.
unzip	-
xz-libs	-
zlib	-

Package name	Remarks
java-1.8.0-openjdk	Required when using the database multiplexing and WebAdmin. Use build 1.8.0.242.b08 or later for s390x architecture.

- The following packages are required for operations on SLES 15.

Package name	Remarks
alsa-lib	-
audit-libs	-
dstat	Required when using parallel scan.
glibc	-
libgcc	-
libicu	Provides collation support. Install 52.
liblz4-1	-
libmemcached	Required when using Pgpool-II.
libstdc++	-
libtool-ltdl	Required when using ODBC drivers.
llvm	Install version 7.0.x of llvm to run SQL with runtime compilation (just-in-time compilation) and add the directory where the shared library libLLVM -*.so is located to the environment variable LD_LIBRARY_PATH. FUJITSU Enterprise Postgres 14 uses runtime compilation by default. If you do not want to use runtime compilation, turn off the jit parameter in postgresql.conf. You do not need to install llvm if you turn off the jit parameter. Failure to install llvm without turning off the jit parameter may result in an error when executing SQL. For more information about runtime compilation, see "Just-in-Time Compilation (JIT)" in the PostgreSQL Documentation.
LLVM-libs	Install version 7.0.x.
ncurses-libs	-
net-tools	-
nss-softokn-freebl	-
opencryptoki	Required if transparent data encryption is used in conjunction with a hardware security module. Install 3.10 or later into default directory.
pam	Required when using PAM authentication.
perl-libs	Required when using PL/Perl. Install 5.18.
protobuf-c	Required if using the Transparent Data Encryption feature when using a key management system as a keystore. Install 1.3.2.
python3	Required when using PL/Python based on Python 3. Install 3.7.x.
sysstat	Required when using pgx_fjqssinf command. Set up the sar command after installation.

Package name	Remarks
tcl	Required when using PL/Tcl. Install 8.6.
xz-libs	-
zlib	-
java-1_8_0-openjdk	Required when using the database multiplexing and WebAdmin. Use build 1.8.0.302 or later for s390x architecture.

2.2 Related Software

There is no exclusive Software.

The following table lists client that can be connected to the FUJITSU Enterprise Postgres server feature.

Table 2.1 Connectable client

OS	Product name
Linux	FUJITSU Software Enterprise Postgres Client 14 or later

Note

The connection from a client product of a different version to this server function depends on the compatibility of each function included in the client product with PostgreSQL, so some functions may not be available.

The following table lists server assistant that can be connected to the FUJITSU Enterprise Postgres server feature.

Table 2.2 Connectable server assistant

OS	Product name
Linux	FUJITSU Software Enterprise Postgres Advanced Edition 14 or 14 SP1

2.3 Excluded Software

There are no exclusive products.

2.4 Required Patches

There are no required patches.

2.5 Hardware Environment

The following hardware is required to use FUJITSU Enterprise Postgres.

Memory

At least 512 MB of memory is required.

Hardware security module

If transparent data encryption is used in conjunction with a hardware security module, the IBM Z Crypto Express Adapter Card must support either the CCA coprocessor or the EP11 coprocessor.

Note

In z/VM, the virtual cryptographic devices which are available to transparent data encryption must be only dedicated("APDED").

2.6 Disk Space Required for Installation

The following table shows the disk space requirements for new installation of FUJITSU Enterprise Postgres. If necessary, increase the size of the file system.

Table 2.3 Disk space required for installation

Directory	Required disk space (Unit: MB)
/etc	1
Installation destination of the server	443
Installation destination of WebAdmin	284
Installation destination of the client	114
Installation destination of PgPool	18

2.7 Supported System Environment

This section describes the supported system environment.

2.7.1 TCP/IP Protocol

FUJITSU Enterprise Postgres supports version 4 and 6 (IPv4 and IPv6) of TCP/IP protocols.

Note

Do not use link-local addresses if TCP/IP protocol version 6 addresses are used.

2.7.2 File System

All file systems with a POSIX-compliant interface are supported.

However, for stable system operation, the disk where the database is deployed must use a highly reliable file system. Consider this aspect when selecting the file system to be used.

The recommended file system is "ext4".

2.8 PostgreSQL Version Used for FUJITSU Enterprise Postgres

FUJITSU Enterprise Postgres is based on PostgreSQL 14.0.

2.9 Notes on Using Streaming Replication

To use streaming replication, build the primary server and all standby servers using the same FUJITSU Enterprise Postgres version (*1).

*1: The product version is indicated by "*x*" in the notation "*x* SP*z*".

Note

Streaming replication cannot be used in combination with Open Source PostgreSQL.It should also be used between instances running on same architecture (i.e. an instance running on Intel64 should not be used to stream instance running on s390x)

2.10 Key Management System Requirements

If you use a key management system as a keystore to use the Transparent Data Encryption feature, the following conditions must be met.

Protocol

Key management systems must use the Key Management Interoperability Protocol (KMIP) Version 1.4 protocol.

Encryption Key

The encryption key used must be able to be created or brought into the KMIP server under the following conditions.

- AES 256 bit symmetric key

  A Managed Object that meets the following criteria:

  - Cryptographic Algorithm : AES
  - Cryptographic Length : 256

- Key not wrapped

Operation

The following operations using the KMIP protocol must be supported:

- Get operation

  Encryption keys can be returned in Key Format Type: Raw format.

Client authentication

You must be able to authenticate and authorize clients in the following ways:

- The registered client certificate can authenticate the client and authorize access to the encryption key.

Quantitative Limits

FUJITSU Enterprise Postgres can receive a maximum response size of 8192 bytes from a key management system. Any further response results in an error.

Chapter 3 Installation

This chapter explains each of the installation procedures of FUJITSU Enterprise Postgres.

3.1 Pre-installation Tasks

Check the system environment below before installing FUJITSU Enterprise Postgres.

Check the disk space

Ensure that there is sufficient disk space to install FUJITSU Enterprise Postgres.

Refer to "2.6 Disk Space Required for Installation" for information on the required disk space.

Reconfigure the disk partition if disk space is insufficient.

Set JAVA_HOME

Ensure that Open JRE 8 is installed, and export the JAVA_HOME environment variable.

```
#export JAVA_HOME="OpenJre8InstallDir"
```

Refer to "Appendix L Procedure when Modifying the JRE Installation" for information on modifying JRE after installation.

Executable Users

Installation and uninstallation is performed by superuser.

On the system, run the following command to become superuser.

```
$ su -
Password:******
```

Determine the preferred WebAdmin configuration

WebAdmin can be installed in two configurations:

- Single-server
- Multiserver

See

Refer to "Appendix I Determining the Preferred WebAdmin Configuration" for details.

Determining the Pgpool-II System Configuration

The system configuration when using Pgpool-II is as follows:

- Place on database server
- Place on application server
- Place on dedicated server

See

Refer to "Appendix J System Configuration when using Pgpool-II".

3.2 Run Installation

Install according to the following procedure:

Note

- The following characters can be used as input values:

  Alphanumeric characters, hyphens, commas and forward slashes

- When reinstalling the product, back up the following folder in which the WebAdmin instance management information is stored:

  webAdminInstallFolder/data/fepwa

  Follow the procedure below to perform the backup.

  1. Stop the WebAdmin server. Refer to "B.1.3 Stopping the Web Server Feature of WebAdmin" for details.
  2. Back up the following folder:

     webAdminInstallFolder/data/fepwa

  Replace the above folder with the backed up folder when the reinstallation is complete.

1. Stop applications and programs

If the installation method is the following, all applications and programs that use the product must be stopped:

- Reinstallation

Before starting the installation, stop the following:

- Applications that use the product
- Connection Manager
- Instance
- Web server feature of WebAdmin

  Execute the WebAdminStop command to stop the Web server feature of WebAdmin.

  Example

  If WebAdmin is installed in /opt/fsepv<*x*>webadmin:

  ```
  # cd /opt/fsepv<x>webadmin/sbin
  # ./WebAdminStop
  ```

- Mirroring Controller

  Execute the mc_ctl command with the stop mode option specified and stop the Mirroring Controller.

  Example

  ```
  $ mc_ctl stop -M /mcdir/inst1
  ```

- pgBadger
- Pgpool-II

2. Mount the DVD drive

Insert the server program DVD into the DVD drive, and run the command given below.

Example

```
# mount -t iso9660 -r -o loop /dev/dvd /media/dvd
```

Here /dev/dvd is the device name for the DVD drive (which may vary depending on your environment), and /media/dvd is the mount point (which may need to be created before calling the command).

Note

If the DVD was mounted automatically using the automatic mount daemon (autofs), "noexec" is set as the mount option, so the installer may fail to start. In this case, use the mount command to remount the DVD correctly, and then run the installation. Note that the mount options of a mounted DVD can be checked by executing the mount command without any arguments.

3. Run the installation

Select and install the following packages (rpm) with the rpm command.

Feature Name	Operating System	Package (Path)
Server	RHEL8	SERVER/Linux/packages/r80s390x/FJSVfsep-SV-*.rpm
	SLES 15	SERVER/Linux/packages/SUSE15s390x/FJSVfsep-SV-*.rpm
WebAdmin	RHEL8	WEBADMIN/Linux/packages/r80s390x/FJSVfsep-WAD-*.rpm
	SLES 15	WEBADMIN/Linux/packages/SUSE15s390x/FJSVfsep-WAD-*.rpm
Client	RHEL8	CLIENT64/Linux/packages/r80s390x/FJSVfsep-CL-*.rpm
	SLES 15	CLIENT64/Linux/packages/SUSE15s390x/FJSVfsep-CL-*.rpm
Pgpool-II	RHEL8	PGPOOL2/Linux/packages/r80s390x/FJSVfsep-POOL2-*.rpm
	SLES 15	PGPOOL2/Linux/packages/SUSE15s390x/FJSVfsep-POOL2-*.rpm

*is the version, OS, etc.

Example

In the following example, /media/dvd is the name of the mount point where the DVD is mounted.

Below is an example of new installation on RHEL8.

```
# cd /media/dvd/SERVER/Linux/packages/r80s390x
# rpm -ivh FJSVfsep-SV-14-1401-0.el8.s390x.rpm
```

Below is an example of new installation on SLES 15.

```
# cd /media/dvd/SERVER/Linux/packages/SUSE15s390x
# rpm -ivh FJSVfsep-SV-14-1401-0.s15.s390x.rpm
```

Below is an example of reinstallation on RHEL8.

```
# cd /media/dvd/SERVER/Linux/packages/r80s390x
# rpm -ivh --replacepkgs FJSVfsep-SV-14-1401-0.el8.s390x.rpm
```

Below is an example of reinstallation on SLES 15.

```
# cd /media/dvd/SERVER/Linux/packages/SUSE15s390x
# rpm -ivh --replacepkgs FJSVfsep-SV-14-1401-0.s15.s390x.rpm
```

Note

If you perform reinstallation, and an installation prefix (in the --prefix option of the rpm command) was used for the new installation, you must use the same prefix.

4. Setting Up WebAdmin

When using WebAdmin, use the WebAdminSetup command to set up WebAdmin. Refer to "B.1 Setting Up WebAdmin" for information on the WebAdmin setup procedure.

5. Set the installation environment to be used by Mirroring Controller

When using Database Multiplexing, use the mc_update_jre_env command to set the installation environment to be used by Mirroring Controller.

Example

```
# export JAVA_HOME="OpenJRE8InstallDir"
# /opt/fsepv<x>server64/bin/mc_update_jre_env
```

Chapter 4 Setup

This chapter describes the setup procedures to be performed after installation completes.

4.1 Operating Method Types and Selection

This section describes how to operate FUJITSU Enterprise Postgres.

There are two methods of managing FUJITSU Enterprise Postgres operations - select one that suits your purposes:

The Operation Guide describes the operating method using WebAdmin, and the equivalent operating method using the server commands.

Simple operation management using a web-based GUI tool (WebAdmin)

Suitable when using frequently used basic settings and operations for operation management.

This method allows you to perform simple daily tasks such as starting the system before beginning business, and stopping the system when business is over, using an intuitive operation.

Usage method

Usage is started by using WebAdmin to create the instance.

By using an external scheduler and the pgx_dmpall command, periodic backups can be performed, which can then be used in recovery using WebAdmin.

Note

Do not use a server command other than pgx_dmpall and pgx_keystore or a server application. Operation modes that use server commands and server applications cannot be used in conjunction with WebAdmin. If used, WebAdmin will not be able to manage the instances correctly.
In addition, to perform a backup by copy command from the pgx_dmpall command, select the operating method using the server commands.
To compress the backup in WebAdmin operations, use the pgx_dmpall command.
Refer to Reference and the PostgreSQL Documentation for information on server commands and server applications.

Advanced operation management using server commands

An overview of the operating method using the GUI, and its relationship with the operating method using the server commands, are shown below.

Refer to the Operation Guide for details.

Operation		Operation with the GUI	Operation with commands
Setup	Creating an instance	WebAdmin is used. The server machine capacity, and the optimum parameter for operations using WebAdmin, are set automatically.	The configuration file is edited directly using the initdb command.
	Creating a standby instance	WebAdmin is used. WebAdmin performs a base backup of the source instance and creates a standby instance.	A standby instance is created using the pg_basebackup command.
	Changing the configuration files	WebAdmin is used.	The configuration file is edited directly.
Starting and stopping an instance		WebAdmin is used.	The pg_ctl command is used.

Operation		Operation with the GUI	Operation with commands
Creating a database		None.	This is defined using the psql command or the application after specifying the DDL statement.
Backing up the database		WebAdmin, or the pgx_dmpall command, is used.	It is recommended that the pgx_dmpall command be used. Recovery to the latest database can be performed.
Database recovery		WebAdmin is used.	To use the backup that was performed using the pgx_dmpall command, the pgx_rcvall command is used.
Monitoring	Database errors	The status in the WebAdmin window can be checked.	The messages that are output to the database server log are monitored.
	Disk space	The status in the WebAdmin window can be checked. A warning will be displayed if the free space falls below 20%.	This is monitored using the df command of the operating system, for example.
	Connection status	None.	This can be checked referencing pg_stat_activity of the standard statistics view from psql or the application.

See

Refer to "Periodic Operations" and "Actions when an Error Occurs" in the Operation Guide for information on monitoring and database recovery.

4.2 Preparations for Setup

This section describes the preparation required before setting up FUJITSU Enterprise Postgres.

4.2.1 Creating an Instance Administrator

Decide which OS user account will be assigned the instance administrator role. You can assign it to a new user or to an existing one, but you cannot assign it to the OS superuser (root).

The following example shows an OS user account with the name "fsepuser" being assigned the instance administrator role.

Example

```
# useradd fsepuser
# passwd fsepuser
```

Note

The following note applies if using WebAdmin for operations:

- If the password is changed for the user account of the instance administrator, set the changed password using ALTER ROLE WITH ENCRYPTED PASSWORD.

The following note applies if using Transparent data Encryption in Hardware-based Keystores:

- OS user account who is assigned the instance administrator role must belong to the 'pkcs11' group since FUJITSU Enterprise Postgres runs as Cryptoki application in order to work in conjunction with the IBM Z Hardware Security Module.
  When using WebAdmin, OS user account who logs in to WebAdmin must belong to the 'pkcs11' group as effective group.

4.2.2 Preparing Directories for Resource Deployment

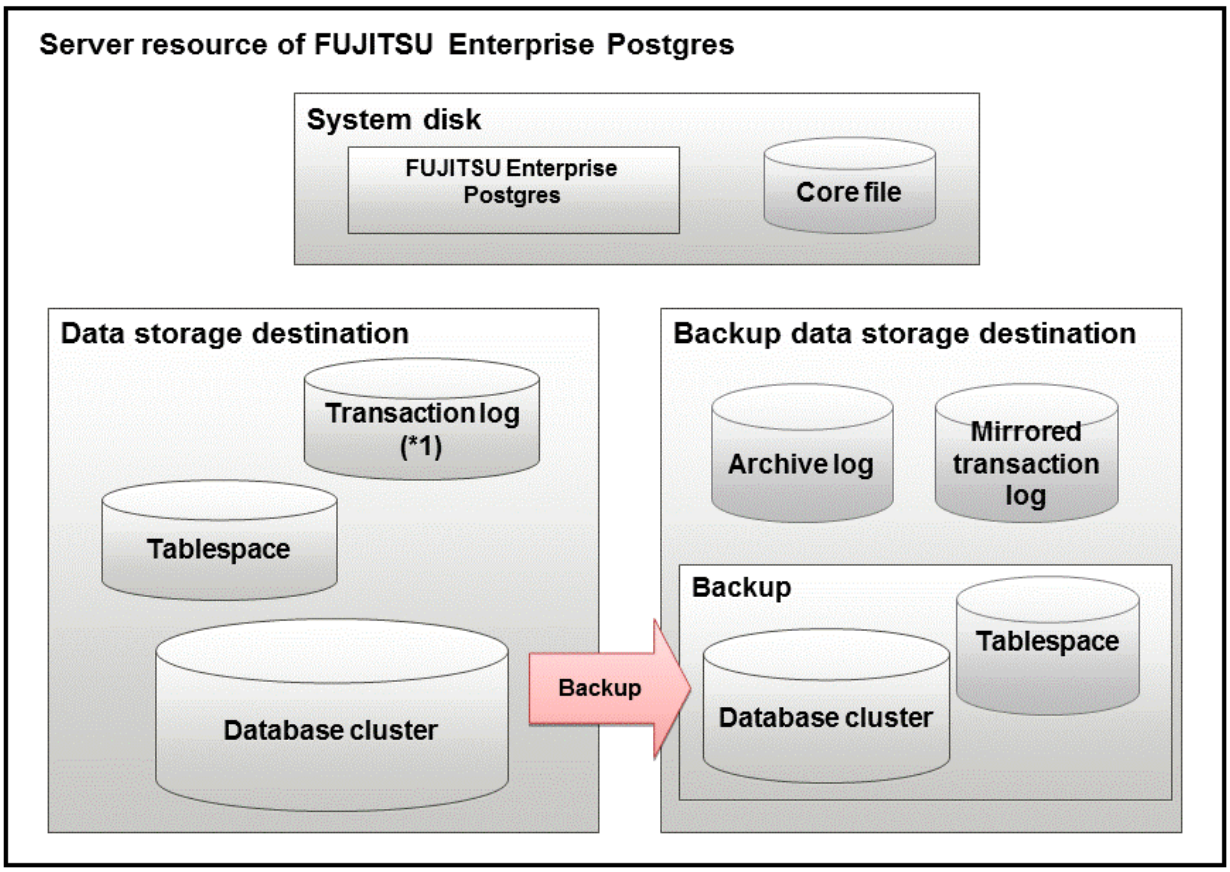
Prepare the directories required when creating instances.

Considerations when deploying resources

The disk configuration on the resource deployment destination is important, because it affects not only recovery following disk corruption, but normal operation as well. The points for determining the disk configuration are as follows:

1. If the backup data storage destination and the data storage destination are both lost, it will not be possible to recover the data, so deploy them to separate disks.
2. To shorten the recovery time following a single disk fault, deploy the system disk and data storage destination to separate disks.
3. The backup data storage destination requires at least double the capacity of the data storage destination, so deploy it to the disk with the most space available.
4. When large amounts of data are updated, the write-to load for the data storage destination, transaction log storage destination, and backup data storage destination (mirrored transaction log) will also be great. For this reason, deploy them to separate disks, out of consideration for performance.

When using the volume manager provided by the operating system, be aware of which physical disk the file system has been created on, for example, by deploying the data storage destination and the backup data storage destination to separate disks.



*1: To distribute the I/O load, place the transaction log on a different disk from the data storage destination.

Resource	Role
Database cluster	The area where the database is stored. It is a collection of databases managed by an instance.
Tablespace	Stores table files and index files in a separate area from the database cluster. Specify a space other than that under the database cluster.
Transaction log	Stores log information in preparation for a crash recovery or rollback. This is the same as the WAL (Write Ahead Log).
Archive log	Stores log information for recovery
Mirrored transaction log (mirrored WAL)	Enables a database cluster to be restored to the state immediately before an error even if both the database cluster and transaction log fail when performing backup/recovery operations using the pgx_dmpall command or WebAdmin.
Corefile	FUJITSU Enterprise Postgres process corefile output when an error occurs with a FUJITSU Enterprise Postgres process.

Examples of disk deployment

The following are examples of disk deployment:

Number of disks	Disk	Deployment
3	System disk	FUJITSU Enterprise Postgres program
		Corefile

Number of disks	Disk	Deployment
	Connected physical disk	Data storage destination, transaction log storage destination
	Connected physical disk	Backup data storage destination
2	System disk	FUJITSU Enterprise Postgres program
		Corefile
		Data storage destination, transaction log storage destination
	Connected physical disk	Backup data storage destination

Proposal for disk deployment using WebAdmin

To generate an instance using WebAdmin, we recommend an optimum deployment that takes into account the status of all disks at the time of instance generation, and items 1 to 3 in the "Considerations when deploying resources" subheading above, based on the limitations below (note that a different deployment can also be specified).

- The mount point does not include national characters
- The instance administrator has the proper permissions to read and write on the mount point

Preparing directories

The directories to be prepared depend on the way that you create the instances.

The following shows the directories that need to be prepared:

Directory to be prepared	Using WebAdmin	Using the initdb command
Data storage destination	Y (*1)	Y
Backup data storage destination	O (*1) (*4)	O
Transaction log storage destination	O (*1) (*2)	O
Corefile output destination	N (*3)	O

Y: Required
O: Optional
N: Not required

*1: WebAdmin automatically creates a directory

*2: The default is to create in a directory in the data storage destination. When it is necessary to distribute the I/O load for the database data and the transaction log, consider putting the transaction log storage destination on a different disk from the data storage destination

*3: The corefile path is as follows:

`/var/tmp/fsep_`*`version`*`/`*`instanceAdminUser`*`_`*`instanceNamePortNumber`*`/core`

version: product version_WA_architecture

Note: The product version is normally the version of WebAdmin used to create the instance. For example, WebAdmin 14 allows a user to create a FUJITSU Enterprise Postgres 11 instance on a database server having WebAdmin 11. In this case, because WebAdmin 11 is used to create the instance, the product version will be "11".

instanceAdminUser: operating system user name

PortNumber: port number specified when creating the instance

Example:

/var/tmp/fsep_140_WA_64/naomi_myinst27599/core

Note that resources placed in /var/tmp that have not been accessed for 30 days or more will be deleted by the default settings of the operating system. Consider excluding them from deletion targets or changing the output destination in the operating system settings.

To change the output destination, configure the core_directory and the core_contents parameters in postgresql.conf. Refer to "Parameters" in the Operation Guide for information on the settings for these parameters.

*4: This directory is required when instance backup is enabled.

Note

- The directories must meet the following conditions:
  - The directory owner must be the OS user account that you want to be the instance administrator
  - The directory must have write permission
  - The directory must be empty
- If you use WebAdmin, you cannot use directories mounted over the network.
  Examples include NFS (Network File System) and CIFS (Common Internet File System).
  Also, even if you are not using WebAdmin, do not use these directories unless you are creating tablespaces on a storage device on your network.

Example

The following example shows the OS superuser creating /database/inst1 as the directory for storing the database data and changing the owner of the directory to the OS user account "fsepuser".

```
# mkdir -p /database/inst1
# chown -R fsepuser:fsepuser /database/inst1
# chmod 700 /database/inst1
```

4.2.3 Estimating Resources

Estimate the resources to be used on the FUJITSU Enterprise Postgres.

Refer to "Appendix E Estimating Database Disk Space Requirements" for information on estimating database disk space requirements.

Refer to "Parameters automatically set by WebAdmin according to the amount of memory" when creating multiple instances with WebAdmin.

Refer to "Appendix F Estimating Memory Requirements" when creating instances with the initdb command, to estimate memory usage.

4.2.4 Configuring Corefile Names

If a process crashes, a corefile for the process will be generated by the operating system. If a corefile is generated with the same name as an existing corefile generated for a different process, the newly-generated corefile will overwrite the previously dumped corefile. To prevent this, configure a unique corefile name for each crash by appending the process ID, program name, and datetime.

Corefile names can be configured using the "kernel.core_pattern" and "kernel.core_uses_pid" kernel parameters.
Refer to the "man page" in "core(5)" for information on how to use these parameters.

Note that with regard to the location for storing corefiles, the operating system settings take precedence over the core_directory parameter of postgresql.conf.

If you specify systemd-coredump as the core_pattern, the core file is not placed in the location specified by the core_directory parameter.See the systemd-coredump (8) man page for the location of core files.

Use coredumpctl to retrieve core files.For more information about using coredumpctl, see the coredumpctl (1) man page.

4.3 Creating Instances

There are two methods that can be used to create an instance:

- 4.3.1 Using WebAdmin
- 4.3.2 Using the initdb Command

Creating multiple instances

Multiple instances can be created.

The memory allocated needs to be adjusted when multiple instances are created with WebAdmin (refer to "Parameters automatically set by WebAdmin according to the amount of memory" for details).

Features that cannot be set up using WebAdmin

The "Storage data protection using transparent data encryption" feature cannot be set up using WebAdmin.

To set up this feature in an instance created by WebAdmin, perform the additional setup tasks detailed in "Storage Data Protection using Transparent Data Encryption" in the Operation Guide.

Note

- Instances created using the initdb command (command line instances) can be managed using WebAdmin, however, they must first be imported into WebAdmin. Refer to "4.3.1.4 Importing Instances" for details.
- Always use WebAdmin to delete instances that were created or imported using WebAdmin. Because WebAdmin management information cannot be deleted, WebAdmin will determine that the instance is abnormal.
- Databases with the names 'template0' and 'template1' are automatically created when an instance is created.
  These databases are used as the templates for databases created later. Furthermore, a default database with the name 'postgres' is automatically created, which will be used with FUJITSU Enterprise Postgres commands. It is important that you do not delete these databases created by default.

4.3.1 Using WebAdmin

This section describes how to create an instance using WebAdmin.

WebAdmin must be set up correctly before it can be used. Refer to "B.1 Setting Up WebAdmin" for details. Additionally, if WebAdmin needs to be configured to use an external repository database, refer to "B.3 Using an External Repository for WebAdmin" for details.

It is recommended to use the following browsers with WebAdmin:

- Microsoft Edge (Build41 or later)

WebAdmin will work with other browsers, such as Firefox and Chrome, however, the look and feel may be slightly different.

Configure your browser to allow cookies and pop-up requests from the server on which FUJITSU Enterprise Postgres is installed.

Refer to "Appendix A Recommended WebAdmin Environments" for information on how to change the pop-up request settings and other recommended settings.

Note

- WebAdmin does not run in Windows(R) safe mode.
- If the same instance is operated from multiple WebAdmin windows, it will not work correctly.
- If the same instance is operated from multiple WebAdmin versions, it will not work correctly. Always use the latest version of WebAdmin for instance operations.
- For efficient use of WebAdmin, it is recommended not to use the browser [Back] and [Forward] navigation buttons, the [Refresh] button, and context-sensitive menus, including equivalent keyboard shortcuts.
- Copying and pasting the WebAdmin URLs are not supported. Additionally, bookmarking of WebAdmin URLs is not supported.
- It is recommended to match the language between the instance server locale and WebAdmin.

- WebAdmin supports only one language: English.
- It is recommended to change the WebAdmin language setting from the instance details page only.
- It is recommended to operate WebAdmin using the WebAdmin launcher.
- WebAdmin uses the labels "Data storage path", "Backup storage path" and "Transaction log path" to indicate "data storage destination", "backup data storage destination" and "transaction log storage destination" respectively. In this manual these terms are used interchangeably.
- If the browser was not operated for a fixed period (about 30 minutes), the session will time out and the login page will be displayed again for the next operation.
- Port access permissions
  If a port is blocked (access permissions have not been granted) by a firewall, enable use of the port by granting access. Refer to the vendor document for information on how to grant port access permissions.
  Consider the security risks carefully when opening ports.
- When creating or importing an instance in WebAdmin, set the log_directory parameter in postgresql.conf to '/var/tmp/fsep_*version*/*instanceAdminUser_instanceNamePortNumber*/log'. Note that resources placed in /var/tmp that have not been accessed for 30 days or more will be deleted by the default settings of the operating system. Therefore, consider excluding instances created using WebAdmin from deletion targets in the operating system settings if you need to stop those instances for a long time.

4.3.1.1 Logging in to WebAdmin

This section describes how to log in to WebAdmin.

Startup URL for WebAdmin

In the browser address bar, type the startup URL of the WebAdmin window in the following format:

```
http://hostNameOrIpAddress:portNumber/
```

- *hostNameOrIpAddress*: Host name or IP address of the server where WebAdmin is installed.
- *portNumber*: Port number of WebAdmin. The default port number is 27515.

The startup screen is displayed. From this window you can log in to WebAdmin or access the product documentation.

Logging in to WebAdmin

Click [Launch WebAdmin] in the startup URL window to start WebAdmin and display the login window. Enter the instance administrator user ID (operating system user account name) and password, and log in to WebAdmin. User credential (instance administrator user ID and password) should not contain hazardous characters. Refer to "Appendix C WebAdmin Disallow User Inputs Containing Hazardous Characters".

4.3.1.2 Creating an Instance

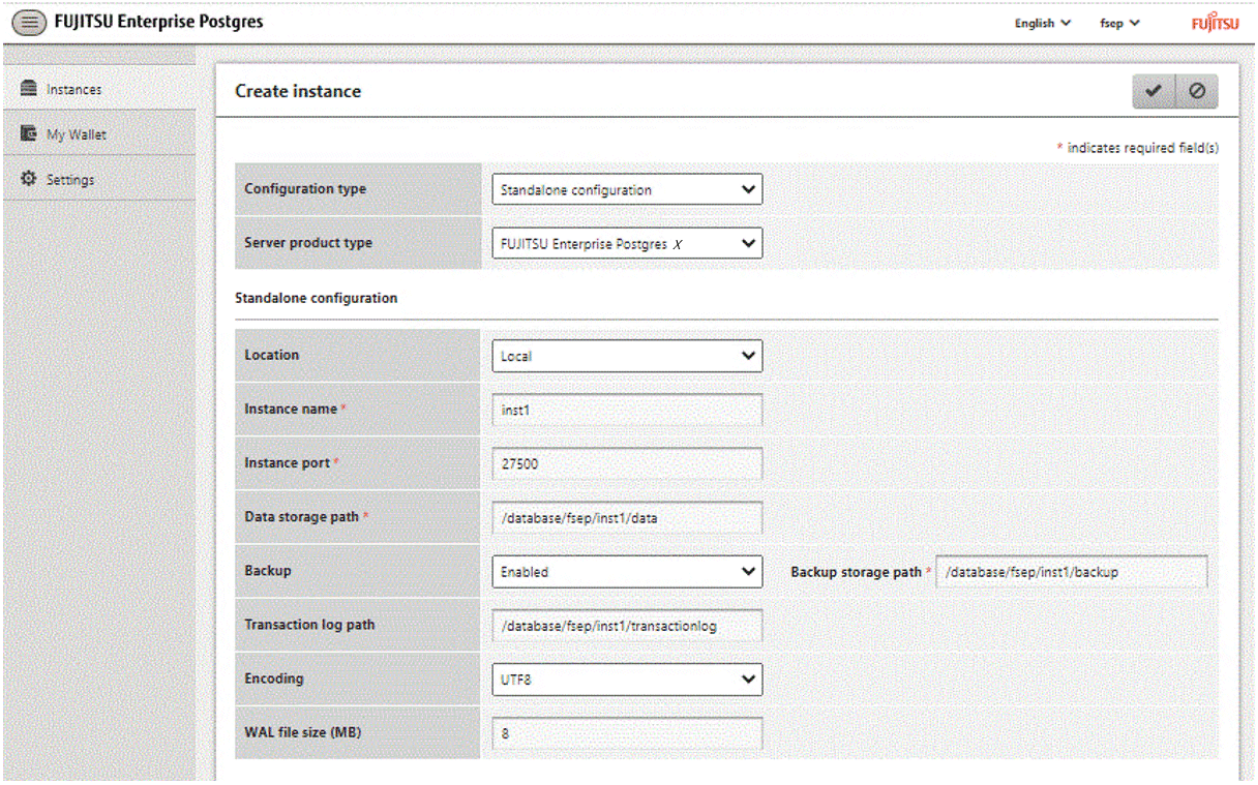
This section describes how to create an instance.

Information

WebAdmin calculates values using the formula indicated in "Managing Kernel Resources" under "Server Administration" in the PostgreSQL Documentation, and configures these in the kernel parameters. Refer to "Appendix H Configuring Kernel Parameters" for information on configuring parameter names.
Refer to "Appendix D Configuring Parameters" for information on the postgresql.conf values required to derive the set values.

1. Start WebAdmin, and log in to the database server.
2. In the [Instances] tab, click  .

3. Enter the information for the instance to be created.



Enter the following items:

- [Configuration type]: Whether to create a standalone instance or an instance that is part of a cluster.
- [Server product type]: Sets which of the following instances to create:
  - FUJITSU Enterprise Postgres 11 Instances
  - FUJITSU Enterprise Postgres 12 Instances
  - FUJITSU Enterprise Postgres 13 Instances
  - FUJITSU Enterprise Postgres 14 Instances

  The default is "FUJITSU Enterprise Postgres 14".
  WebAdmin can create and manage instances compatible with the following, but new functionality in FUJITSU Enterprise Postgres 14 may not support the instance or it may be disabled.
  - FUJITSU Enterprise Postgres 11
  - FUJITSU Enterprise Postgres 12
  - FUJITSU Enterprise Postgres 13
- [Location]: Whether to create the instance in the server that the current user is logged into, or in a remote server. The default is "Local", which will create the instance in the server machine where WebAdmin is currently running.
- [Instance name]: Name of the database instance to manage

  The name must meet the conditions below:
  - Maximum of 16 characters
  - The first character must be an ASCII alphabetic character
  - The other characters must be ASCII alphanumeric characters
- [Instance port]: Port number of the database server

- [Data storage path]: Directory where the database data will be stored
- [Backup]: Whether to enable or disable the WebAdmin backup feature. The default is "Enabled". Select "Disabled" to disable all backup and restore functionality for the instance. If "Enabled" is selected, enter the following item:
  - [Backup storage path]: Directory where the database backup will be stored
- [Transaction log path]: Directory where the transaction log will be stored
- [Encoding]: Database encoding system
- [WAL file size]: Allow the WAL file size to be set when creating an instance. The default is 16 MB if the field is blank. The size specified must be a power of 2 between 1 and 1024. This option is not available for standby instances.

If "Remote" is selected for [Location], enter the following additional items:

- [Host name]: Name of the host where the instance is to be created
- [Operating system credential]: Operating system user name and password for the remote machine where the instance is to be created
- [Remote WebAdmin port for standalone]: Port in which WebAdmin is accessible in the remote machine

Note

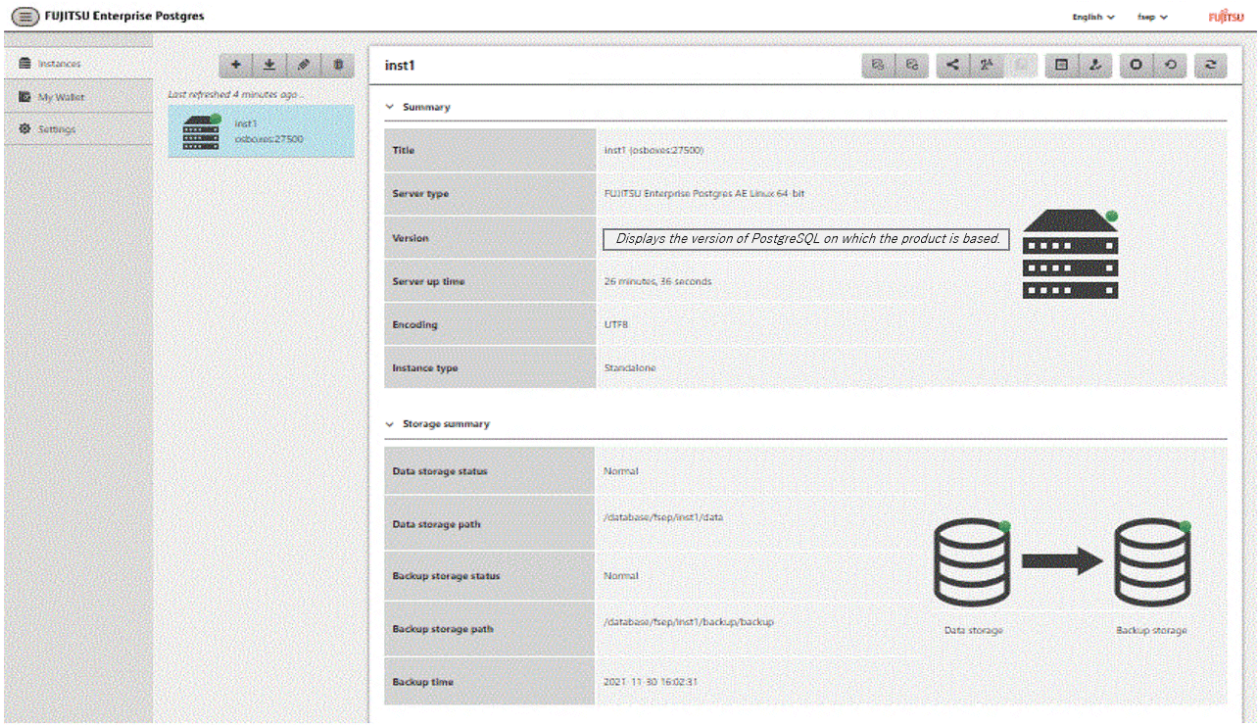
- Refer to "4.2.2 Preparing Directories for Resource Deployment" - "Considerations when deploying resources" for information on points to consider when determining the data storage path, backup storage path, and transaction log path.
- The following items can be modified after the instance has been created.
  - Instance name
  - Port number
  - Backup storage path

  Refer to "Editing instance information" for details.
- Do not specify directories that include symbolic link or multibyte characters when specifying the data storage destination or backup data storage destination.
- In the instance that is created using WebAdmin, the locale of the character set to be used in the database, and the locale of the collating sequence, are fixed using C.
- For enhanced security, WebAdmin encrypts the superuser password using SCRAM-SHA-256 authentication.
- Host name and Operating system credential (Operating system user name and password) should not contain hazardous characters. Refer to "Appendix C WebAdmin Disallow User Inputs Containing Hazardous Characters".

4. Click  to create the instance.

   If the instance is created successfully, a message indicating the same will be displayed.

5. The instance will be started when it is created successfully.



6. Back up the basic information that was set

   Back up the WebAdmin management information periodically to ensure operational continuity when a fault occurs on the system disk. Follow the procedure below to perform the backup.

   a. Stop the WebAdmin server. Refer to "B.1.3 Stopping the Web Server Feature of WebAdmin" for details.

   b. Back up the following directory:

      webAdminInstallDir/data/fepwa

4.3.1.3 Changing Instance Settings

You can change the information that is set when an instance is created.

Change the following settings to suit the operating and management environment for FUJITSU Enterprise Postgres.

- Instance configuration
  - Character encoding
  - Communication
  - SQL options
  - Memory
  - Streaming replication
- Changing client authentication information
- Editing instance information

Information

These settings are the same as the parameters that can be set in the files shown below. Refer to "Appendix D Configuring Parameters" for information on the equivalence relationship between the item name and the parameter.

- postgresql.conf

- pg_hba.conf

Note

The files shown below can also be modified directly, however if a parameter not described in "Appendix D Configuring Parameters" was edited by mistake, WebAdmin may not run correctly.

- postgresql.conf
- pg_hba.conf

You can also modify the following files directly, but WebAdmin may not work correctly if the records span multiple lines. Therefore, change the record to a single row.

- pg_hba.conf
- pg_ident.conf

Instance configuration

1. Start WebAdmin and log in to the database server.
2. In the [Instances] tab, click  .
3. Click  to change the configuration.
4. Click  to save your changes.

See

Select a client-side encoding system that can be converted to/from the database encoding system. Refer to "Automatic Character Set Conversion Between Server and Client" in "Server Administration" in the PostgreSQL Documentation for information on the encoding system combinations that can be converted.

Changing client authentication information

1. Start WebAdmin and log in to the database server.
2. In the [Instances] tab, click  .

   Click  to register new authentication information.

   To change authentication information, select the information, and then click  .

   To delete authentication information, select the information, and then click  .

Note

When creating the instance, do not delete the entry below, because it is a connection required for WebAdmin to monitor the operational status of the database:
Type=local, Database=all, User=all, and Method=md5

Editing instance information

Use the [Edit instance] page to modify the following items for an instance:

- Instance name
- Port number

- Backup storage path

1. In the [Instances] tab, click  . The [Edit instance] page is displayed.
2. Modify the relevant items.

   If [Backup storage path] is changed, [Backup management] is enabled. Select the required option:

   Retain existing backup: Create a backup in [Backup storage path] and retain the existing backup in its original location.

   Copy existing backup to new path: Copy the existing backup to [Backup storage path]. A new backup will not be created. The existing backup will be retained in its original location.

   Move existing backup to new path: Move the existing backup to [Backup storage path]. A new backup will not be created.

   Remove existing backup: Create a backup in [Backup storage path]. The existing backup will be removed.
3. Click  to save your changes.

- The [Edit instance] page is also displayed when the user selects 'Navigate to the "Edit instance" page' from the [Anomaly Error] dialog box. Refer to "Anomaly Detection and Resolution" in the Operation Guide for information on what takes place when an anomaly is detected.
- When [Instance name] or [Instance port] is modified, the log_directory and core_directory parameters in postgresql.conf are updated. Also, the specified directories are created if they do not exist.

  Refer to "4.3.1.4 Importing Instances" for information on the format of these directories.

4.3.1.4 Importing Instances

Instances can be created using WebAdmin, or via the command line using the initdb command. Instances created using the initdb command (command line instances) can be managed using WebAdmin, however, they must first be imported into WebAdmin.

This section explains how to import command line instances into WebAdmin.

1. In the [Instances] tab, click  . The [Import instance] page is displayed.
2. Enter the information for the instance being imported. Refer to "4.3.1.2 Creating an Instance" for information on the items that need to be entered.
3. Click  to import the instance.

- Importing neither starts nor stops the instance.
- The following restrictions apply to instance import:
  - Any instance already managed by WebAdmin cannot be imported again.
  - The postgresql.conf file must be located in the same directory as [Data storage path].
  - Read/write permissions are required for [Data storage path].
  - The location specified in postgresql.conf for the following files must not have been changed:
    - hba_file
    - ident_file
  - If the following file contains records that span multiple lines, change the record to a single line before importing.
    - pg_hba.conf
    - pg_ident.conf

- If the instance is part of a cluster that is monitored by Mirroring Controller, WebAdmin will be unable to detect the Mirroring Controller settings.
- Instances making use of Mirroring Controller functionality should not be imported, because subsequent operations on those instances may cause unexpected and undesirable side-effects.
- It is not possible to import and operate an instance that uses a directory mounted by Network File System (NFS).
- You must make the following changes to the parameters in postgresql.conf prior to importing the instance in WebAdmin.

Parameter	Requirements
port	The port parameter should be uncommented.

The log_directory and core_directory parameters in postgresql.conf are updated during import. Also, the specified directories are created if they do not exist.

The format of these directories is as follows:

log_directory: '/var/tmp/fsep_*version*/*instanceAdminUser*_*instanceNamePortNumber*/log'

core_directory: '/var/tmp/fsep_*version*/*instanceAdminUser*_*instanceNamePortNumber*/core'

version: product version_WA_architecture

instanceAdminUser: operating system user name

PortNumber: port number specified when creating the instance

Examples:

log_directory: '/var/tmp/fsep_140_WA_64/naomi_myinst27599/log'

core_directory: '/var/tmp/fsep_140_WA_64/naomi_myinst27599/core'

- When a standby instance is imported, a valid entry, using the IP address of the standby instance, must exist in the pg_hba.conf file of the master instance to allow the standby instance to connect to the master instance.
- When a standby instance is imported, the value for "host" in the primary_conninfo parameter of postgresql.auto.conf should match the host name of the master instance.
- When a standby instance is imported, you cannot specify "passfile" in the primary_conninfo parameter of postgresql.auto.conf. Be sure to specify "password".
- Instances created by other operating systems cannot be imported.
- If a instance is being imported while it is running, WebAdmin will encrypt the superuser password using SCRAM-SHA-256 authentication.

4.3.2 Using the initdb Command

This section describes the procedure to create an instance using the initdb command.

Note

If a port is blocked (access permissions have not been granted) by a firewall, enable use of the port by granting access. Refer to the vendor document for information on how to grant port access permissions.
Consider the security risks carefully when opening ports.

4.3.2.1 Editing Kernel Parameters

Refer to "Appendix H Configuring Kernel Parameters" prior to editing these settings.

After the settings are complete, check the command specifications of the relevant operating system and restart the system if required.

4.3.2.2 Creating an Instance

Create an instance, with the database cluster storage destination specified in the PGDATA environment variable or in the -D option. Furthermore, the user that executed the initdb command becomes the instance administrator.

Note

- Instances created using the initdb command (command line instances) can be managed using WebAdmin, however, they must first be imported into WebAdmin. Refer to "4.3.1.4 Importing Instances" for details.
- If creating multiple instances, ensure that there is no duplication of port numbers or the directories that store database clusters.

See

Refer to "initdb" in "Reference" in the PostgreSQL Documentation for information on the initdb command.

The procedure to create an instance is described below.

1. Use the OS user account that you want as the instance administrator.

   Connect with the server using the OS user account that you want as the instance administrator.

   You cannot use the OS superuser (root).

   The following example shows the OS superuser connected to the server being changed to the OS user account "fsepuser".

   Example

   ```
   # su fsepuser
   ```

2. Configure the environment variables

   Configure the environment variables in the server with the newly created instance.

   Set the following environment variables:

   - PATH environment variables

     Add the installation directory "/bin".

   - MANPATH environment variables

     Add the installation directory "/share/man".

   - LD_LIBRARY_PATH environment variables

     Add the installation directory "/lib".

   Example

   The following example configures environment variables when the installation directory is "/opt/fsepv<*x*>server64".

   Note that "<*x*>" indicates the product version.

   sh, bash

   ```
   $ PATH=/opt/fsepv<x>server64/bin:$PATH ; export PATH
   $ MANPATH=/opt/fsepv<x>server64/share/man:$MANPATH ; export MANPATH
   $ LD_LIBRARY_PATH=/opt/fsepv<x>server64/lib:$LD_LIBRARY_PATH ; export LD_LIBRARY_PATH
   ```

   csh, tcsh

   ```
   $ setenv PATH /opt/fsepv<x>server64/bin:$PATH
   $ setenv MANPATH /opt/fsepv<x>server64/share/man:$MANPATH
   $ setenv LD_LIBRARY_PATH /opt/fsepv<x>server64/lib:$LD_LIBRARY_PATH
   ```

Note

If you execute any command other than FUJITSU Enterprise Postgres (OS commands, etc.) after LD_LIBRARY_PATH is set, remove the installation directory/lib from LD_LIBRARY_PATH.

3. Create a database cluster

   Create the database cluster with the initdb command, specifying the storage destination directory.

   Specify the transaction log storage destination and the locale setting option as required.

   Example

   ```
   $ initdb -D /database/inst1 --waldir=/transaction/inst1 --lc-collate="C" --lc-ctype="C" --
   encoding=UTF8
   ```

Point

In some features, instance names are requested, and those names are required to uniquely identify the instance within the system. These features allow names that conform to WebAdmin naming conventions, so refer to the following points when determining the names:

- Maximum of 16 characters
- The first character must be ASCII alphabetic character
- The other characters must be ASCII alphanumeric characters

Note

- To balance I/O load, consider deploying the transaction log storage destination to a disk device other than the database cluster storage destination and the backup data storage destination.
- Specify "C" or "POSIX" for collation and character category. Performance deteriorates if you specify a value other than "C" or "POSIX", although the behavior will follow the rules for particular languages, countries and regions. Furthermore, this may need to be revised when running applications on systems with different locales.
  For example, specify as follows:

  ```
  initdb --locale="C" --lc-messages="C"
  initdb --lc-collate="C" --lc-ctype="C"
  ```

- Specify the same string in the LANG environment variable of the terminal that starts FUJITSU Enterprise Postgres as was specified in lc-messages of initdb (lc_messages of postgresql.conf). If the same string is not specified, messages displayed on the terminal that was started, as well as messages output to the log file specified in the -l option of the pg_ctl command or the postgres command used for startup, may not be output correctly.
- Specify an encoding system other than SQL_ASCII for the database. If SQL_ASCII is used, there is no guarantee that the encryption system for data in the database will be consistent, depending on the application used to insert the data.

See

Refer to "Locale Support" in "Localization" in "Server Administration" in the PostgreSQL Documentation for information on locales.

4. Set port number.

   Specify a port number in the port parameter of postgresql.conf. Ensure that the specified port number is not already used for other software. If a port number is not specified, "27500" is selected.

Register the specified port numbers in the /etc/services file if WebAdmin is used to create other instances. WebAdmin uses the /etc/services file to check if port numbers specified as available candidates have been duplicated.

Register any name as the service name.

5. Set the corefile output destination.

   Specify the output destination of the corefile, which can later be used to collect information for investigation, by setting the core_directory and core_contents parameters of postgresql.conf.

   See

   Refer to "Parameters" in the Operation Guide for information on the settings for these parameters.

6. Set the backup storage destination.

   Specify the backup data storage destination and other backup settings when backup is to be performed as a provision against database errors.

   See

   Refer to "Backup Methods" in the Operation Guide for information on specifying backup settings.

7. Start an instance.

   Start with the start mode of the pg_ctl command.

   If either of the following conditions are met, the message "FATAL:the database system is starting up(11189)" may be output.

   - An application, command, or process connects to the database while the instance is starting
   - An instance was started without the -W option specified

   This message is output by the pg_ctl command to check if the instance has started successfully.
   Therefore, ignore this message if there are no other applications, commands, or processes that connect to the database.

   Example

   ```
   $ pg_ctl start -D /database/inst1
   ```

   See

   Refer to "pg_ctl" in "Reference" in the PostgreSQL Documentation for information on the pg_ctl command.

   Note

   If the -W option is specified, the command will return without waiting for the instance to start. Therefore, it may be unclear as to whether instance startup was successful or failed.

4.4 Configuring Remote Connections

This section describes the settings required when connecting remotely to FUJITSU Enterprise Postgres from a database application or a client command.

4.4.1 When an Instance was Created with WebAdmin

Settings related to connection

The default is to accept connections from remote computers to the database.

Change "listen_addresses" in postgresql.conf to modify the default behavior.

Refer to "Appendix D Configuring Parameters" for information on postgresql.conf.

Client Authentication Information settings

The following content is set by default when WebAdmin is used to create an instance.

- Authentication of remote connections from local machines is performed.

When changing Client Authentication Information, select [Client Authentication] from [Setting], and then change the settings.

4.4.2 When an Instance was Created with the initdb Command

Connection settings

The default setting only permits local connections from the client to the database. Remote connections are not accepted.

Change "listen_addresses" in postgresql.conf to perform remote connection.

All remote connections will be allowed when changed as shown below.

Example

```
listen_addresses = '*'
```

Also, configure the parameters shown below in accordance with the applications and number of client command connections.

Parameter name	Parameter description
superuser_reserved_connections	Number of connections reserved for database maintenance, for example backup or index rebuilding. If you need to simultaneously perform a large number of processes that exceed the default value, change this value accordingly.
max_connections	Set the value as: *numberOfSimultaneousConnectionsToInstance* + superuser_reserved_connections

Client authentication information settings

When trying to connect from a client to a database, settings are required to determine whether the instance permits connections from the client - if it does, then it is possible to make settings to determine if authentication is required.

 See

Refer to "The pg_hba.conf File" in "Server Administration" in the PostgreSQL Documentation for details.

4.5 Other Settings

This section describes settings that are useful for operations.

4.5.1 Error Log Settings

This section explains the settings necessary to monitor errors in applications and operations, and to make discovering the causes easier.

Make error log settings only when instances are created with the initdb command.

When creating instances with WebAdmin, these settings are already made and hence do not need to be set.

Furthermore, some parameters are used by WebAdmin, and if changed, may cause WebAdmin to no longer work properly. Refer to "Appendix D Configuring Parameters" for details.

Note

Set the output destination for the system log to the server log so that it cannot be viewed by administrators of other instances.

Application errors are output to the system log or server log. The output destination directory for the system log and server log should have access permissions set so that they cannot be viewed by people other than the instance administrator.

Edit the following parameters in postgresql.conf:

Parameter name	Parameter description	How to enable the settings
syslog_ident	Used to specify labels to attach to messages, so that these can be identified when output to the system log if more than one FUJITSU Enterprise Postgres is used.	reload option of the pg_ctl mode
logging_collector	Specify "on" to ensure that messages are output by FUJITSU Enterprise Postgres to the server log file. The server log file is created in the log directory in the database cluster.	restart option of the pg_ctl mode
log_destination	Specify "stderr,syslog" to output messages from FUJITSU Enterprise Postgres to the screen and either the system log or the event log.	reload option of the pg_ctl mode
log_line_prefix	Specify information to be added at the start of messages output by an instance. This information is useful for automatic monitoring of messages. You can output the SQLSTATE value, output time, executing host, application name, and user ID. Refer to "What To Log" in the PostgreSQL Documentation for details. Example: log_line_prefix = '%e: %t [%p]: [%l-1] user = %u,db = %d,remote = %r app = %a '	reload option of the pg_ctl mode

Point

- If you want fewer application errors being output to the system log, refer to "When To Log" and "What To Log" in the PostgreSQL Documentation for information on how to reduce the output messages.
- If you want to separate errors output from other software, refer to "Where To Log" in the PostgreSQL Documentation to change the output destination to the server log file rather than the system log.

4.5.2 Configuring Automatic Start and Stop of an Instance

You can automatically start or stop an instance when the operating system on the database server is started or stopped.

Use the following procedure to configure automatic start and stop of an instance.

Note that, if an instance is started in a failover operation, the cluster system will control the start or stop, therefore this feature should not be used. Also, when performing database multiplexing, refer to "Enabling Automatic Start and Stop of Mirroring Controller and Multiplexed Instances" in the Cluster Operation Guide (Database Multiplexing).

Note that "<*x*>" in paths indicates the product version.

Note

You should wait for time correction, network setup, and so on.

1. Create a unit file

   Copy the unit file sample stored in the directory below, and revise it to match the target instance.

   fujitsuEnterprisePostgresInstallDir/share/fsepsvoi.service.sample

   Example

   In the following example, the installation directory is "/opt/fsepv<*x*>server64", and the instance name is "inst1".

   ```
   # cp /opt/fsepv<x>server64/share/fsepsvoi.service.sample /usr/lib/systemd/system/
   fsepsvoi_inst1.service
   ```

   Revise the underlined portions of the options below in the unit file.

Section	Option	Specified value	Description
Unit	Description	FUJITSU Enterprise Postgres *instanceName*	Specifies the feature overview. Specifies the name of the target instance. (*1)
Service	ExecStart	/bin/bash -c '*installDir*/bin/pgx_symstd start *installDir dataStorageDestinationDir*'	Command to be executed when the service is started.
	ExecStop	/bin/bash -c '*installDir*/bin/pgx_symstd stop *installDir dataStorageDestinationDir*'	Command to be executed when the service is stopped.
	ExecReload	/bin/bash -c '*installDir*/bin/pgx_symstd reload *installDir dataStorageDestinationDir*'	Command to be executed when the service is reloaded
	User	User	OS user account of the instance administrator.
	Group	Group	Group to which the instance administrator user belongs.

   *1: The instance name should be as follows:

   If WebAdmin is used to create the instance: *instanceName*

   If the initdb command is used to create the instance: *nameThatIdentifiesTheInstance*
   The naming conventions for the instance name or for identifying the instance are as follows:

   - Up to 16 bytes
   - The first character must be an ASCII alphabetic character
   - The other characters must be ASCII alphanumeric characters

2. Enable automatic start and stop

   As the OS superuser, use the systemctl command to enable automatic start and stop.

   Example

   ```
   # systemctl enable fsepsvoi_inst1.service
   ```

4.5.3 Settings when Using the Features Compatible with Oracle Databases

To use the features compatible with Oracle databases, create a new instance and execute the following command for the "postgres" and "template1" databases:

```
CREATE EXTENSION oracle_compatible;
```

Features compatible with Oracle databases are defined as user-defined functions in the "public" schema created by default when database clusters are created, so they can be available for all users without the need for special settings.

For this reason, ensure that "public" (without the double quotation marks) is included in the list of schema search paths specified in the search_path parameter.

There are also considerations for use the features compatible with Oracle databases. Refer to " Precautions when Using the Features Compatible with Oracle Databases" in the Application Development Guide for details.

4.6 Setting Up and Removing OSS

This section explains how to set up OSS supported by FUJITSU Enterprise Postgres.

If you want to use OSS supported by FUJITSU Enterprise Postgres, follow the setup procedure.

If you decide not to use the OSS supported by FUJITSU Enterprise Postgres, follow the removing procedure.

To build and use OSS obtained from the web, etc., instead of OSS supported by FUJITSU Enterprise Postgres, see "4.6.10 Build with PGXS".

Information

- In this section, the applicable database that enables the features of each OSS is described as "postgres".
- Execute CREATE EXTENSION for the "template1" database also, so that each OSS can be used by default when creating a new database.

Refer to "OSS Supported by FUJITSU Enterprise Postgres" in the General Description for information on OSS other than those described below.

4.6.1 oracle_fdw

4.6.1.1 Setting Up oracle_fdw

1. Add the path of the OCI library to the environment variable. The available version of the OCI library is 11.2 or later.
   Add the installation path of the OCI library to the LD_LIBRARY_PATH environment variable.
2. As superuser, run the following command:

```
$ su -
Password:******
# cp -r /opt/fsepv<x>server64/OSS/oracle_fdw/* /opt/fsepv<x>server64
```

3. If a file named libclntsh.so.11.1 does not exist in your OCI library, create a symbolic link with the name libclntsh.so.11.1 to libclntsh.so.xx.1 (xx is the version of the OCI library).

```
# ln -s libclntsh.so.12.1 libclntsh.so.11.1
```

4. Restart FUJITSU Enterprise Postgres.
5. Execute CREATE EXTENSION for the database that will use this feature.
   Use the psql command to connect to the "postgres" database.

```
postgres=# CREATE EXTENSION oracle_fdw;
CREATE EXTENSION
```

Information

- If the OCI library is not installed on the server, install it using the Oracle client or Oracle Instant Client.
  Refer to the relevant Oracle manual for information on the installation procedure.
- If the version of the OCI library is updated, change the path of the OCI library in the LD_LIBRARY_PATH environment variable to the updated path. Also, re-create the symbolic link named libclntsh.so.11.1 if necessary.

Note

This feature cannot be used on instances created in WebAdmin. It can only be used via server commands.

4.6.1.2 Removing oracle_fdw

1. Execute DROP EXTENSION for the database that will use this feature.
   Use the psql command to connect to the "postgres" database.

```
postgres=# DROP EXTENSION oracle_fdw CASCADE;
DROP EXTENSION
```

2. As superuser, run the following command:

```
$ su -
Password:******
# rm -rf /opt/fsepv<x>server64/filesCopiedDuringSetup
```

Information

The files copied during setup can be checked below.

```
# find /opt/fsepv<x>server64/OSS/oracle_fdw
```

4.6.2 pg_bigm

4.6.2.1 Setting Up pg_bigm

1. Set the postgresql.conf file parameters.
   Add "pg_bigm" to the shared_preload_libraries parameter.

2. As superuser, run the following command:

```
$ su -
Password:******
# cp -r /opt/fsepv<x>server64/OSS/pg_bigm/* /opt/fsepv<x>server64
```

3. Restart FUJITSU Enterprise Postgres.

4. Execute CREATE EXTENSION for the database that will use this feature.
   Use the psql command to connect to the "postgres" database.

```
postgres=# CREATE EXTENSION pg_bigm;
CREATE EXTENSION
```

4.6.2.2 Removing pg_bigm

1. Execute DROP EXTENSION for the database that will use this feature.
   Use the psql command to connect to the "postgres" database.

```
postgres=# DROP EXTENSION pg_bigm CASCADE;
DROP EXTENSION
```

2. As superuser, run the following command:

```
$ su -
Password:******
# rm -rf /opt/fsepv<x>server64/filesCopiedDuringSetup
```

Information

The files copied during setup can be checked below.

```
# find /opt/fsepv<x>server64/OSS/pg_bigm
```

3. Set the postgresql.conf file parameters.
   Delete "pg_bigm" to the shared_preload_libraries parameter.
4. Restart FUJITSU Enterprise Postgres.

4.6.3 pg_hint_plan

4.6.3.1 Setting Up pg_hint_plan

1. Set the postgresql.conf file parameters.
   Add "pg_hint_plan" to the "shared_preload_libraries" parameter.
2. As superuser, run the following command:

```
$ su -
Password:******
# cp -r /opt/fsepv<x>server64/OSS/pg_hint_plan/* /opt/fsepv<x>server64
```

3. Restart FUJITSU Enterprise Postgres.
4. Run CREATE EXTENSION for the database that uses this feature.
   The target database is described as "postgres" here.
   Use the psql command to connect to the "postgres" database.

```
postgres=# CREATE EXTENSION pg_hint_plan;
CREATE EXTENSION
```

See

Refer to " Optimizer Hints" in the Application Development Guide for details.

4.6.3.2 Removing pg_hint_plan

Note

Unsetting pg_hint_plan will cause hints registered in the hint_plan.hints table to be lost. Therefore, it is recommended that pg_dump back up the hint_plan.hints table for each database if it is likely that pg_hint_plan will be used again later.

1. Execute DROP EXTENSION for the database that will use this feature.
   Use the psql command to connect to the "postgres" database.

```
postgres=# DROP EXTENSION pg_hint_plan CASCADE;
DROP EXTENSION
```

2. As superuser, run the following command:

```
$ su -
Password:******
# rm -rf /opt/fsepv<x>server64/filesCopiedDuringSetup
```

Information

The files copied during setup can be checked below.

```
# find /opt/fsepv<x>server64/OSS/pg_hint_plan
```

3. Set the postgresql.conf file parameters.
   Delete "pg_hint_plan" to the shared_preload_libraries parameter.

4. Restart FUJITSU Enterprise Postgres.

4.6.4 pg_dbms_stats

4.6.4.1 Setting Up pg_dbms_stats

1. Set the postgresql.conf file parameter.
   Add "pg_dbms_stats" to the "shared_preload_libraries" parameter.

2. As superuser, run the following command:

```
$ su -
Password:******
# cp -r /opt/fsepv<x>server64/OSS/pg_dbms_stats/* /opt/fsepv<x>server64
```

3. Restart FUJITSU Enterprise Postgres.

4. Run CREATE EXTENSION for the database that will use this feature.
   The target database is described as "postgres" here.
   Use the psql command to connect to the "postgres" database.

```
postgres=# CREATE EXTENSION pg_dbms_stats;
CREATE EXTENSION
```

See

Refer to "Optimizer Hints" in the Application Development Guide for details.

4.6.4.2 Removing pg_dbms_stats

Note

Unsetting pg_dbms_stats causes statistics managed by pg_dbms_stats to be lost. Therefore, it is recommended that you back up each table in the dbms_stats folder of each database in binary format if you may want to use pg_dbms_stats again later.

```
postgres > # COPY <dbms_stats Schema's table name> TO '<Filename>' FORMAT binary;
```

1. Execute DROP EXTENSION for the database that will use this feature.
   Use the psql command to connect to the "postgres" database.

```
postgres=# DROP EXTENSION pg_dbms_stats CASCADE;
DROP EXTENSION
```

2. As superuser, run the following command:

```
$ su -
Password:******
# rm -rf /opt/fsepv<x>server64/filesCopiedDuringSetup
```

Information

The files copied during setup can be checked below.

```
# find /opt/fsepv<x>server64/OSS/pg_dbms_stats
```

3. Set the postgresql.conf file parameters.
   Delete "pg_dbms_stats" to the shared_preload_libraries parameter.

4. Restart FUJITSU Enterprise Postgres.

4.6.5 pg_repack

4.6.5.1 Setting Up pg_repack

1. As superuser, run the following command:

```
$ su -
Password:******
# cp -r /opt/fsepv<x>server64/OSS/pg_repack/* /opt/fsepv<x>server64
```

2. Execute CREATE EXTENSION for the database that will use this feature.
   Use the psql command to connect to the "postgres" database.

```
postgres=# CREATE EXTENSION pg_repack;
CREATE EXTENSION
```

4.6.5.2 Removing pg_repack

1. Execute DROP EXTENSION for the database that will use this feature.
   Use the psql command to connect to the "postgres" database.

```
postgres=# DROP EXTENSION pg_repack CASCADE;
DROP EXTENSION
```

2. As superuser, run the following command:

```
$ su -
Password:******
# rm -rf /opt/fsepv<x>server64/filesCopiedDuringSetup
```

Information

The files copied during setup can be checked below.

```
# find /opt/fsepv<x>server64/OSS/pg_repack
```

4.6.6 pg_rman

4.6.6.1 Setting Up pg_rman

1. As superuser, run the following command:

```
$ su -
Password:******
# cp -r /opt/fsepv<x>server64/OSS/pg_rman/* /opt/fsepv<x>server64
```

2. Restart FUJITSU Enterprise Postgres.

Information

Before initialization of the backup catalog, it is recommended to set the parameters below in postgresql.conf. Refer to the pg_rman manual (http://ossc-db.github.io/pg_rman/index-ja.html) for details.

- log_directory
- archive_mode
- archive_command

Note

This feature cannot be used on instances created in WebAdmin. It can only be used via server commands.

4.6.6.2 Removing pg_rman

1. As superuser, run the following command:

```
$ su -
Password:******
# rm -rf /opt/fsepv<x>server64/filesCopiedDuringSetup
```

   ### Information

   The files copied during setup can be checked below.

```
# find /opt/fsepv<x>server64/OSS/pg_rman
```

2. Restart FUJITSU Enterprise Postgres.

4.6.7 pg_statsinfo

4.6.7.1 Setting Up pg_statsinfo

1. Set the postgresql.conf file parameters.
   - Add "pg_statsinfo" to the shared_preload_libraries parameter.
   - Specify the log file name for the log_filename parameter.
2. As superuser, run the following command:

```
$ su -
Password:******
# cp -r /opt/fsepv<x>server64/OSS/pg_statsinfo/* /opt/fsepv<x>server64
```

3. Restart FUJITSU Enterprise Postgres.

Information

Note that pg_statsinfo forcibly overwrites the settings below.

- log_destination

  "csvlog" is added and "stderr" is deleted.

- logging_collector

  "on" is set.

Note

This feature cannot be used on instances created in WebAdmin. It can only be used via server commands.

4.6.7.2 Removing pg_statsinfo

1. As superuser, run the following command:

```
$ su -
Password:******
# rm -rf /opt/fsepv<x>server64/filesCopiedDuringSetup
```

   Information

   The files copied during setup can be checked below.

```
# find /opt/fsepv<x>server64/OSS/pg_statsinfo
```

2. Set the postgresql.conf file parameters.

   - Delete "pg_statsinfo" to the shared_preload_libraries parameter.
   - Delete the log file name for the log_filename parameter.

3. Restart FUJITSU Enterprise Postgres.

4.6.8 pgBadger

4.6.8.1 Setting Up pgBadger

1. Set the postgresql.conf file parameters.
   Set the parameters so that the information required for analysis is output to the server log.
   Refer to "Documentation" in the pgBadger website (https://pgbadger.darold.net/) for details.
   The pgBadger material is stored under /opt/fsepv<x>server64/OSS/pgbadger.

2. Restart FUJITSU Enterprise Postgres.

4.6.8.2 Removing pgBadger

1. Set the postgresql.conf file parameters.
   Restores information you specified during Setup.

2. Restart FUJITSU Enterprise Postgres.

4.6.9 Pgpool-II

4.6.9.1 Setting Up Pgpool-II

1. As superuser, run the following command:

```
$ su -
Password:******
# cp -r /opt/fsepv<x>server64/OSS/Pgpool-II/* /opt/fsepv<x>server64
```

2. Execute CREATE EXTENSION for the database that will use this feature.
   Use the psql command to connect to the "postgres" database.

```
postgres=# CREATE EXTENSION pgpool_recovery;
CREATE EXTENSION
```

3. Set the postgresql.conf file parameters.
   Specify the path to pg_ctl for the pgpool.pg_ctl parameter.

4. Restart FUJITSU Enterprise Postgres.

Note

The online recovery feature of Pgpool-II cannot be used on instances created in WebAdmin. It can only be used via server commands.

4.6.9.2 Removing Pgpool-II

1. Execute DROP EXTENSION for the database that will use this feature.
   Use the psql command to connect to the "postgres" database.

```
postgres=# DROP EXTENSION pgpool_recovery CASCADE;
DROP EXTENSION
```

2. As superuser, run the following command:

```
$ su -
Password:******
# rm -rf /opt/fsepv<x>server64/filesCopiedDuringSetup
```

Information

The files copied during setup can be checked below.

```
# find /opt/fsepv<x>server64/OSS/Pgpool-II
```

3. Set the postgresql.conf file parameters.
   Delete the pg_ctl path for the pgpool.pg_ctl parameter.

4. Restart FUJITSU Enterprise Postgres.

4.6.10 Build with PGXS

Many PostgreSQL extensions are built using a build base for extensions called PGXS. Building with PGXS also generates files related to llvm. Depending on which version of llvm you are using, follow these steps:

4.6.10.1 Using the Default Version of llvm

The default version of llvm is described in "2.1 Required Operating System". If you want to use the default version of llvm, use the OSS documentation to build and install OSS.

4.6.10.2 Using a Non-Default Version of llvm

1. As superuser, copy the Makefile.global corresponding to the version of llvm you want to use. The following is an example of using version 9 of llvm. Makefile.global is overwritten when an emergency fix is applied or removed from Fujitsu Enterpise Postgres, this procedure should be performed each time a build is performed.

```
$ su -
Password:******
```

```
# cp /opt/fsepv<x>server64/lib/pgxs/src/Makefile.global-vsn9 /opt/fsepv<x>server64/lib/pgxs/src/
Makefile.global
```

2. Follow the OSS documentation to build and install OSS.
3. As superuser, run the following command:. The following is an example of using version 9 of llvm:.

```
$ su -
Password:******
# mv /opt/fsepv<x>server64/lib/bitcode/<OSS名>* /opt/fsepv<x>server64/lib/bitcode-vsn9/
```

4.6.10.3 Without llvm

If you do not use llvm, use the with _ llvm = no option when performing the build, as shown below. For other options, follow the OSS documentation.

```
# make USE_PGXS=1 with_llvm=no
```

4.7 Integration with Message-Monitoring Software

To monitor messages output by FUJITSU Enterprise Postgres using software, configure the product to monitor SQLSTATE, instead of the message text - this is because the latter may change when FUJITSU Enterprise Postgres is upgraded.

Configure FUJITSU Enterprise Postgres to output messages in a format that can be read by the message-monitoring software by specifying "%e" in the log_line_prefix parameter of postgresql.conf to output the SQLSTATE value.

A setting example is shown below - it outputs the output time, executing host, application name, and user ID, in addition to the SQLSTATE value.

Example

```
log_line_prefix = '%e: %t [%p]: [%l-1] user = %u,db = %d,remote = %r app = %a '
```

See

Refer to "What To Log" in the PostgreSQL Documentation for information on how to configure the settings.

4.8 Deleting Instances

This section explains how to delete an instance.

- 4.8.1 Using WebAdmin
- 4.8.2 Using Server Commands

Note

- Always use WebAdmin to delete instances that were created or imported using WebAdmin. Because WebAdmin management information cannot be deleted, WebAdmin will determine that the instance is abnormal.
- If you have set automatic start and stop of the instance, execute the following commands to disable the script and cancel registration.

  ```
  systemctl disable nameOfUnitFileThatPerformsAutomaticStartAndStop
  rm /usr/lib/systemd/system/nameOfUnitFileThatPerformsAutomaticStartAndStop
  ```

  Example

  ```
  # systemctl disable fsepsvoi_inst1.service
  # rm /usr/lib/systemd/system/fsepsvoi_inst1.service
  ```

4.8.1 Using WebAdmin

This section explains how to delete an instance using WebAdmin.

Use the following procedure to delete an instance.

1. Stop the instance

   In the [Instances] tab, select the instance to stop and click  .

2. Back up files.

   Before deleting the instance, back up any required files under the data storage destination, the backup data storage destination, and the transaction log storage destination.

3. Delete the instance

   In the [Instances] tab, select the instance to delete and click  .

Note

Deleting an instance deletes only the following lowest-level directories. If they are not required, delete them manually.

- Data storage destination
- Backup data storage destination
- Transaction log storage destination (if different from the data storage destination)

4.8.2 Using Server Commands

This section explains how to delete an instance using server commands.

Use the following procedure to delete an instance.

1. Stop the instance

   Execute the stop mode of the pg_ctl command.

   An example is shown below:

   Example

   ```
   $ pg_ctl stop -D /data/inst1
   ```

2. Back up files.

   Before deleting the instance, back up any required files under the data storage destination, the backup data storage destination, and the transaction log storage destination.

3. Delete the instance

   Use a standard UNIX tool (the rm command) to delete the following directories:

   - Data storage destination
   - Backup data storage destination
   - Transaction log storage destination (if a directory different from the data storage directory was specified)

Chapter 5 Uninstallation

This chapter describes the procedure for uninstalling FUJITSU Enterprise Postgres.

5.1 Run Uninstallation

Uninstall according to the following procedure:

Note that "*x*SP*z*" in sample windows indicates the version and level of products to uninstall and "<*x*>" in paths indicates the product version.

Note

- All files and directories in the installation directory are deleted during uninstallation. If user files have been placed in the installation directory, back them up before uninstallation if necessary.
- To reinstall FUJITSU Enterprise Postgres after it was uninstalled, and reuse an instance that was already created so that it can be managed from WebAdmin, back up the directory shown below in which the WebAdmin instance management information had been defined before uninstalling FUJITSU Enterprise Postgres, and then restore the backed up directory to its original location once FUJITSU Enterprise Postgres has been reinstalled.

  Follow the procedure below to perform the backup.

  1. Stop the WebAdmin server. Refer to "B.1.3 Stopping the Web Server Feature of WebAdmin" for details.
  2. Back up the following directory:

     webAdminInstallDir/data/fepwa

1. Delete the operation information

If the FUJITSU Enterprise Postgres operation information has been registered in the operating system or another middleware product, for example, then it must be deleted. Cases in which deletion is required are as follows:

- If you have set automatic start and stop of the instance, execute the following commands to disable the script and cancel registration.

  ```
  systemctl disable nameOfUnitFileThatPerformsAutomaticStartAndStop
  rm /usr/lib/systemd/system/nameOfUnitFileThatPerformsAutomaticStartAndStop
  ```

  Example

  ```
  # systemctl disable fsepsvoi_inst1.service
  # rm /usr/lib/systemd/system/fsepsvoi_inst1.service
  ```

2. Stop applications and programs

Before starting the uninstallation, stop the following:

- Applications that use the product
- Connection Manager
- Instance

  Using WebAdmin

  In the [Instances] tab, select the instance to stop and click  .

  Using server commands

  Execute the pg_ctl command in stop mode.

  ```
  $ /opt/fsepv<x>server64/bin/pg_ctl stop -D /database/inst1
  ```

- Web server feature of WebAdmin

  Execute the WebAdminStop command to stop the Web server feature of WebAdmin.

  Example

  If WebAdmin is installed in /opt/fsepv<*x*>webadmin:

```
# cd /opt/fsepv<x>webadmin/sbin
# ./WebAdminStop
```

- Mirroring Controller

  Execute the mc_ctl command with the stop mode option specified and stop the Mirroring Controller.

  Example

```
$ mc_ctl stop -M /mcdir/inst1
```

- pgBadger
- Pgpool-II

3. Remove WebAdmin setup

When uninstall WebAdmin feature, execute the WebAdminSetup command to remove WebAdmin setup.

Example

If WebAdmin is installed in /opt/fsepv<*x*>webadmin:

```
# cd /opt/fsepv<x>webadmin/sbin
# ./WebAdminSetup -d
```

4. Verifying Installation Features

Verify that the feature to be removed is installed by executing the following command.

Feature Name	Package Name
Server	FJSVfsep-SV-<*x*>
WebAdmin	FJSVfsep-WAD-<*x*>
Client	FJSVfsep-CL-<*x*>
Pgpool-II	FJSVfsep-POOL2-<*x*>

* Where *x* is a number indicating the version.

Example

```
# rpm -qi FJSVfsep-SV-14
```

5. Run the uninstallation

Run the following command.

Example

```
# rpm -e FJSVfsep-SV-14
```

The installation directory may remain after uninstallation. If it is not required, delete it.

Appendix A Recommended WebAdmin Environments

This appendix describes the recommended WebAdmin environment. The following explanation is based on the assumption that Microsoft Edge is used unless otherwise stated.

Note

The displayed screen varies depending on your environment, so check and set according to the screen.

A.1 Recommended Browser Settings

- Use a display resolution of 1280 x 768 or higher, and 256 colors or more.
- Select [Setting] >>[Appearance] >> [Font size] >> [Medium (Recommended)].
- Select [Setting] >>[Appearance] >> [Zoom] >> [100%].

A.2 How to Set Up the Pop-up Blocker

If the Pop-up Blocker is enabled, use the procedure below to configure settings to allow pop-ups from the server where FUJITSU Enterprise Postgres is installed.

1. Click [Setting] >> [Cookie and site permissions] >> [All Permissions] >> [Pop-ups and redirects].
   If the [Block (Recommended)] switch is not on (blue), the pop-up blocker is not working, and no further action is required.
2. Under [Pop-ups and Redirects], click the [Allow] >> [Add] button.
3. In [Add Site], in [Site], enter the address of the server where you installed FUJITSU Enterprise Postgres and click the [Add] button.
4. Close Microsoft Edge.

Appendix B Setting Up and Removing WebAdmin

This appendix describes how to set up and remove WebAdmin.

Note that "<*x*>" in paths indicates the product version.

B.1 Setting Up WebAdmin

This section explains how to set up WebAdmin.

B.1.1 Setting Up WebAdmin

Follow the procedure below to set up WebAdmin.

1. Change to the superuser

   Acquire superuser privileges on the system.

   Example

   ```
   $ su -
   Password:******
   ```

2. Set the JAVA_HOME environment variable

   Set the JAVA_HOME environment variable to the installation destination of Open JRE 8.

   Example

   ```
   # export JAVA_HOME="OpenJRE8InstallDir"
   ```

3. Set up WebAdmin

   Set up WebAdmin.

   Example

   If WebAdmin is installed in /opt/fsepv<*x*>webadmin:

   ```
   # cd /opt/fsepv<x>webadmin/sbin
   # ./WebAdminSetup
   ```

4. Specify the port number

   Specify the following port numbers to be used in WebAdmin.

   Refer to the "/etc/services" file and only change to a different port number if there is overlap with a port number from another service.

   Make a note of the port number for the Web server, because it will be required for starting the WebAdmin window.

Item	Value (recommended value)
Web server port number enter port number of Web Server (default: 27515):	27515
WebAdmin internal port number enter Internal port number for WebAdmin (default: 27516):	27516
WebAdmin automatic start Start WebAdmin automatically when system starting? [y,n] (default: y)	y

Web server port number

Specify a numeric value from 1024 to 32767 for the port number to be used for communication between the Web browser and the Web server.

The Web server port number will be registered as a port number with the following service name in the "/etc/services" file.

fsep_140_WA_64_WebAdmin_Port1

WebAdmin internal port number

Specify a numeric value from 1024 to 32767 for the port number to be used for communication between the Web server and the WebAdmin runtime environment.

The WebAdmin internal port number will be registered as a port number with the following service name in the /etc/services file.

fsep_140_WA_64_WebAdmin_Port2

WebAdmin automatic start

Select whether or not to start WebAdmin when the machine is started.

Note

- Unused port numbers
  Irrespective of the information specified in the "/etc/services" file, unused port numbers in the OS and other products can sometimes be automatically numbered and then used, or port numbers specified in environment files within products may also be used. Check the port numbers used by the OS and other products, and ensure that these are not duplicated.
- Access restrictions
  Prevent unauthorized access and maintain security by using a firewall product, or the packet filtering feature of a router device, to restrict access to the server IP address and the various specified port numbers.
- Port access permissions
  If a port is blocked (access permissions have not been granted) by a firewall, enable use of the port by granting access. Refer to the vendor document for information on how to grant port access permissions.
  Consider the security risks carefully when opening ports.
- Changing port numbers
  When using WebAdmin in multiserver mode, it is recommended not to change WebAdmin ports after creating instances. Otherwise, the created instances may not be accessible through WebAdmin after the port is changed.

B.1.2 Starting the Web Server Feature of WebAdmin

Follow the procedure below to start the Web server feature of WebAdmin.

1. Change to the superuser

   Acquire superuser privileges on the system.

   Example

   ```
   $ su -
   Password:******
   ```

2. Start the Web server feature of WebAdmin

   Execute the WebAdminStart command to start the Web server feature of WebAdmin.

   Example

   If WebAdmin is installed in /opt/fsepv<*x*>webadmin:

   ```
   # cd /opt/fsepv<x>webadmin/sbin
   # ./WebAdminStart
   ```

B.1.3 Stopping the Web Server Feature of WebAdmin

Follow the procedure below to stop the Web server feature of WebAdmin.

1. Change to the superuser

   Acquire superuser privileges on the system.

   Example

   ```
   $ su -
   Password:******
   ```

2. Stop the Web server feature of WebAdmin

   Execute the WebAdminStop command to stop the Web server feature of WebAdmin.

   Example

   If WebAdmin is installed in /opt/fsepv<*x*>webadmin:

   ```
   # cd /opt/fsepv<x>webadmin/sbin
   # ./WebAdminStop
   ```

Note

- For efficient operation of WebAdmin, it is recommended that the Web server feature be stopped only during a scheduled maintenance period.
- When WebAdmin is used to create and manage instances in a multiserver configuration, the Web server feature must be started and running on all servers at the same time.

B.2 Removing WebAdmin

This section explains how to remove WebAdmin.

This removal procedure stops WebAdmin and ensures that it no longer starts automatically when the machine is restarted.

1. Change to the superuser

   Acquire superuser privileges on the system.

   Example

   ```
   $ su -
   Password:******
   ```

2. Remove WebAdmin setup

   Execute the WebAdminSetup command to remove WebAdmin setup.

   Example

   If WebAdmin is installed in /opt/fsepv<*x*>webadmin:

   ```
   # cd /opt/fsepv<x>webadmin/sbin
   # ./WebAdminSetup -d
   ```

B.3 Using an External Repository for WebAdmin

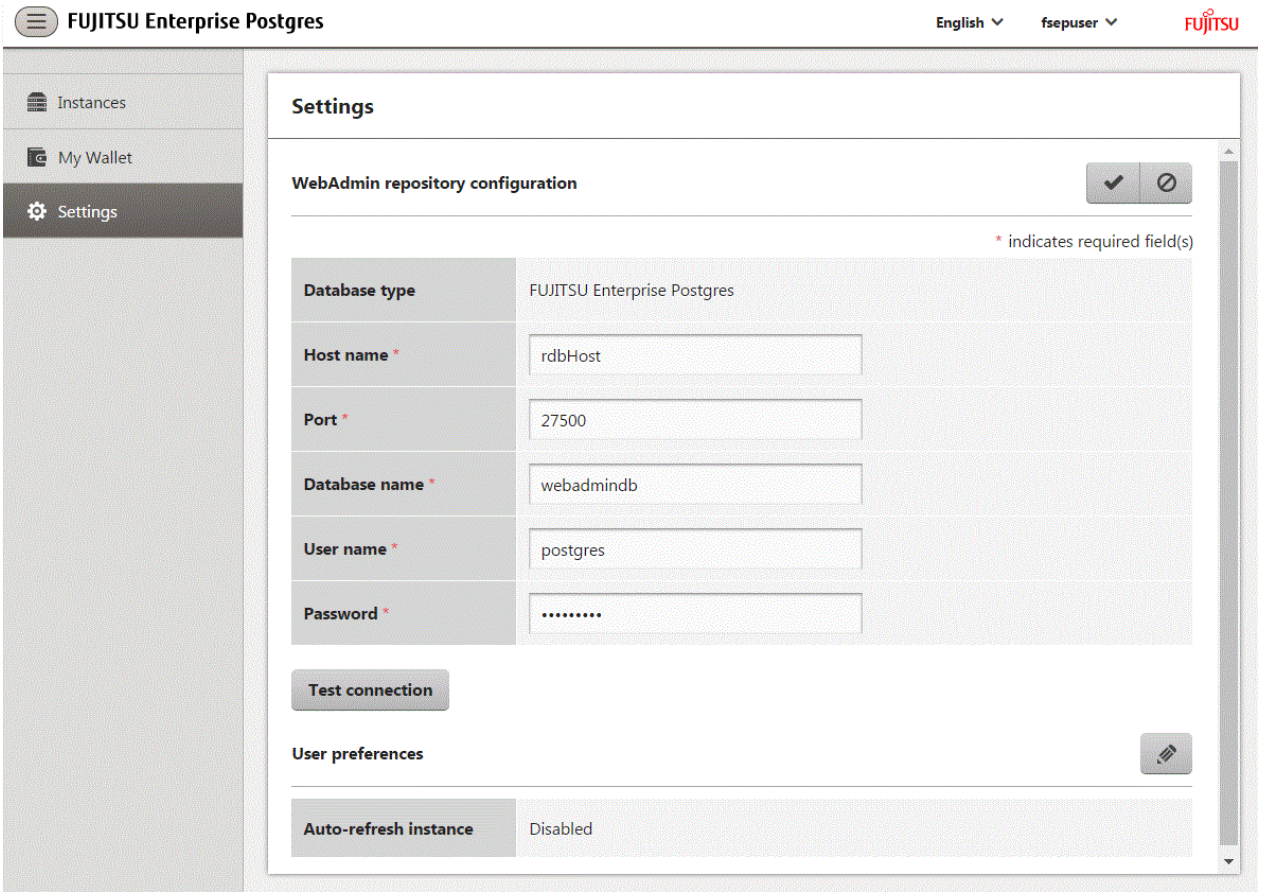
WebAdmin can be configured to use an external database, where it can store the various metadata information it uses. WebAdmin will use this database as a repository to store the information it uses to manage all the created instances. This can be a FUJITSU Enterprise Postgres database or an Open Source PostgreSQL V9.2 or later database.

Using an external database as a WebAdmin repository provides you with more flexibility in managing WebAdmin. This repository can be managed, backed up and restored as needed using command line tools, allowing users to have greater flexibility and control.

Follow the procedure below to set up the repository.

1. Start WebAdmin, and log in to the database server.

2. Click the [Settings] tab, and then click in the [WebAdmin repository configuration] section.



3. Enter the following items:

   - [Host name]: Host name of the database server
   - [Port]: Port number of the database server
   - [Database name]: Name of the database
   - [User name]: User name to access the database
   - [Password]: Password of the database user

Note

- Database type
  It is recommended to use a FUJITSU Enterprise Postgres database as a repository. A compatible PostgreSQL database can also be used as an alternative.
- It is recommended to click [Test connection] to ensure that the details entered are valid and WebAdmin is able to connect to the target database.
- Host name, Database name, User name, Password should not contain hazardous characters. Refer to "Appendix C WebAdmin Disallow User Inputs Containing Hazardous Characters".

4. Click to register the repository details.

Note

- Once the repository is set up, it can be changed any number of times by the user logged into WebAdmin. When a repository is changed:
  - It is recommended to preload the backup into this database.
  - If the data is not preloaded, WebAdmin will create a new repository.
- The database repository can be set up even after WebAdmin was already used to create instances. In that scenario, the instances already created are retained and can continue to be operated on.
- If the instance used as a repository is stopped, WebAdmin will be unusable. For this reason, it is recommended to be familiar with starting an instance from the command line. If the instance is stopped for any reason, start it from the command line and WebAdmin will be usable again.

B.4 Using the WebAdmin Auto-Refresh Feature

The WebAdmin auto-refresh feature automatically refreshes the operating status of all instances in the Instance list at the specified interval. It also refreshes the details of the selected instance.

Follow the procedure below to configure the auto-refresh options.

1. Click the [Settings] tab, and then click  in the [User preferences] section.
2. Enter the following items:
   - [Auto-refresh instance]: To use the auto-refresh feature, select "Enabled". The default is "Disabled".
   - [Refresh interval (seconds)]: Number of seconds between each refresh. This is a countdown timer, which is reset every time the instance status is refreshed by any operation. Specify a value from 30 to 3600 (seconds). The default is 30.
3. Click  to save the auto-refresh settings.

Note

- Auto-refresh will run only if the [Instances] page is displayed and no user-initiated operation is in progress.
- A text indicator, which is independent of auto-refresh, is displayed at the top of the Instance list. It is dynamically updated to display when the page was last refreshed.

Appendix C WebAdmin Disallow User Inputs Containing Hazardous Characters

WebAdmin considers the following as hazardous characters, which are not allowed in user inputs.

```
| (pipe sign)

& (ampersand sign)

; (semicolon sign)

$ (dollar sign)

% (percent sign)

@ (at sign)

' (single apostrophe)

" (quotation mark)

\' (backslash-escaped apostrophe)

\" (backslash-escaped quotation mark)

<> (triangular parenthesis)

() (parenthesis)

+ (plus sign)

CR (Carriage return, ASCII 0x0d)

LF (Line feed, ASCII 0x0a)

, (comma sign)

\ (backslash)
```

Appendix D Configuring Parameters

WebAdmin operates and manages databases according to the contents of the following configuration files:

- postgresql.conf

  Contains various items of information that define the operating environment of FUJITSU Enterprise Postgres.

- pg_hba.conf

  Contains various items of information related to client authentication.

These configuration files are deployed to a data storage destination. Data is written to them when the instance is created by WebAdmin and when settings are changed, and data is read from them when the instance is started and when information from the [Setting] menu is displayed.

Direct editing of each configuration file is possible with a text editor.

See

Refer to "Server Configuration" and "Client Authentication" in "Server Administration" in the PostgreSQL Documentation for information on the parameters.

Note

WebAdmin checks for port number and backup storage path anomalies when various operations are performed. An anomaly occurs when the value of [Port number] and/or [Backup storage path] in WebAdmin is different from the value of the corresponding parameter in postgresql.conf. Refer to "Anomaly Detection and Resolution" in the Operation Guide for details.

postgresql.conf

Parameters that can be changed in WebAdmin

The postgresql.conf parameters that can be changed in WebAdmin are shown below:

Section	WebAdmin item	postgresql.conf file parameter
Instance Configuration		
Character encoding	Character set	client_encoding
	Message locale	lc_messages
Communication	Max connections	max_connections
SQL options	Transform NULL format	transform_null_equals
	Date output format	DateStyle (*1)
	Interval output format	IntervalStyle
	Number of digits for floating values	extra_float_digits
	Transaction isolation levels	default_transaction_isolation
	Currency format	lc_monetary
	Date and time format	lc_time
	Numerical value format	lc_numeric
Memory	Sort memory (KB)	work_mem
	Shared buffers (KB)	shared_buffers
Streaming replication	WAL level	wal_level

Section	WebAdmin item	postgresql.conf file parameter
	Maximum WAL senders	max_wal_senders
	WAL save size (MB)	wal_keep_size
	Hot standby	hot_standby
	Synchronous standby names	synchronous_standby_names
	WAL receiver timeout (ms)	wal_receiver_timeout
Edit instance		
	Instance name	n/a
	Instance port	port
	Backup storage path	backup_destination

*1: If you specify "Postgres" as the output format, dates will be output in the "12-17-1997" format, not the "Wed Dec 17 1997" format used in the PostgreSQL Documentation.

Information

- Calculate the maximum number of connections using the formula below:

```
maximumNumberOfConnections = maximumNumberOfConnectionsFromApplications + 3 (*1)
```

*1: 3 is the default number of connections required by the system.
Calculate the maximum number of connections using the following formula when changing superuser_reserved_connections (connections reserved for use by the superuser) in postgresql.conf.

```
maximumNumberOfConnections = maximumNumberOfConnectionsFromApplications +
superuser_reserved_connections
```

- Also check if the memory used exceeds the memory installed (refer to "Parameters automatically set by WebAdmin according to the amount of memory").
- When modifying "Shared buffers" or "Max connections", edit the kernel parameter. Refer to "Appendix H Configuring Kernel Parameters", and "Managing Kernel Resources" in "Server Administration" in the PostgreSQL Documentation for details.

Parameters set by WebAdmin

The following postgresql.conf parameters are set by WebAdmin during instance startup (they will be ignored even if specified in postgresql.conf):

Parameter	Value
listen_addresses	*
log_destination	'stderr,syslog'
logging_collector	on
log_line_prefix	'%e: %t [%p]: [%l-1] user = %u,db = %d,remote = %r app = %a '
log_filename (*1) (*2)	'logfile-%a.log'
log_file_mode	0600
log_truncate_on_rotation	on
log_rotation_age	1d

*1: The server logs are split into files based on the day of the week, and are rotated after each week.

*2: If the date changes while the instance is stopped, old logs are not deleted and continue to exist.
Manually delete old logs that are no longer required to release disk space.

Parameters automatically set by WebAdmin according to the amount of memory

The postgresql.conf parameters automatically set according to the amount of installed memory, during the creation of instances by WebAdmin, are shown below:

Parameter	Value
shared_buffers	30% of the machine's installed memory
work_mem	30% of the machine's installed memory / max_connections / 2
effective_cache_size	75% of the machine's installed memory
maintenance_work_mem	10% of the machine's installed memory / (1 + autovacuum_max_workers) (*1)

*1: The value will be capped at 2097151 KB.

When determining the values to be configured in the above parameters, you must take into account any anticipated increases in access volume or effects on performance during business operations, such as the number of applications and commands that will access the instance, and the content of processes. Also, note that in addition to FUJITSU Enterprise Postgres, other software may be running on the actual database server. You will need to determine the degree of priority for the database and other software, as well as the memory allocation size.

WebAdmin automatically configures complex parameter settings such as those mentioned above, based on the size of the internal memory of the machine. This enables maximum leverage of the machine memory to facilitate resistance against fluctuations during business operations.

Accordingly, the effects of the above-mentioned factors must be estimated and taken into account when determining and configuring parameter values, so that memory resources can be effectively allocated among other software or instances, and so that adverse effects can be mutually avoided. Refer to "Memory" in "Resource Consumption", and "Planner Cost Constants" in "Query Planning", under "Server Administration" in the PostgreSQL Documentation for information on parameter values and required considerations.

Parameter values can be modified using the WebAdmin [Setting] menu, or edited directly using a text editor.

If adding an instance, determine the parameter values, including for existing instances, and make changes accordingly.

See

Kernel parameters need to be tuned according to the parameters being changed. Refer to "Appendix H Configuring Kernel Parameters", and "Managing Kernel Resources" in "Server Administration" in the PostgreSQL Documentation for information on tuning kernel parameters.

Note

- Do not directly edit the following postgresql.conf parameters with a text editor, otherwise WebAdmin may not work properly if you make a mistake):
  - archive_mode
  - archive_command (Only allow changing compression settings)
  - wal_level
  - log_line_prefix
  - log_destination
  - logging_collector
  - log_directory
  - log_file_mode
  - log_filename

    - log_truncate_on_rotation
    - log_rotation_age
- You must take care with the following parameter:
    - superuser_reserved_connections

      Set it to a number that includes the 3 connections required in WebAdmin (the default is 3).

pg_hba.conf

Refer to "Client Authentication" in "Server Administration" in the PostgreSQL Documentation for information on content that can be configured in pg_hba.conf.

- Configure the instance administrator permissions in the "local" connection format settings. WebAdmin may not work properly if permissions are not configured.
- If you specify an item or value that cannot be set by WebAdmin when editing the pg_hba.conf file with a text editor, it will not be possible to reference that line from WebAdmin.

Appendix E Estimating Database Disk Space Requirements

This appendix describes how to estimate database disk space requirements.

E.1 Estimating Table Size Requirements

The following tables provide the formulas for estimating table size requirements.

Table E.1 Estimation formula when the record length is 2032 bytes or less

Item	Estimation formula (bytes)
(1) Record length	27(*1) + NULL map + OID + column data NULL map: Number of columns / 8 (*2) OID: 4 Column data: Sum of column lengths *1: Record header section *2: Round the result up to the next integer. - Because the column data is placed in boundaries of 8 bytes, you need to make an adjustment so that the sum of the record header section, NULL map and OID is a multiple of 8. For example, if the calculated length is 27 + 1 / 8 (rounded up) + 0 = 28 bytes, add 4 to make the length 32 bytes. - Because the data of each column is placed in boundaries of the defined data type, take the boundary of each data type into account for the length of the column data. For example, the length of the column data in the table below will not be the sum of the data types, which is 37 bytes, but will instead be 64 bytes following boundary adjustment. Definition: create table tb1(c1 char(1), c2 bigint, c3 int, c4 box) Estimation: CHAR type 1 byte + boundary adjustment of 7 bytes for BIGINT type 8 bytes + BIGINT type 8 bytes + INT type 4 bytes + boundary adjustment of 12 bytes for BOX type 32 bytes + BOX type 32 bytes = 64 bytes - Because each record is placed in boundaries of 8 bytes, you need to make an adjustment so that the length of the column data is a multiple of 8. - If the calculated record length exceeds 2,032 bytes, the variable length data in the record might be compressed automatically. If so, use the estimation formulas in "Table E.2 Estimation formula when the record length exceeds 2032 bytes" to estimate the table size.
(2) Page size requirement	8192 (*1) × fillfactor (*2) - 24 (*3) *1: Page length (8192) *2: Value of the fillfactor specified in the table definitions (if omitted, 100%) *3: Page header (24) - The calculated (2) page size requirement will be rounded down to the nearest integer.
(3) Number of records per page	(2) Page size requirement / ((1) record length + 4 (*1)) *1: Pointer length (4) - The result will be rounded down to the nearest integer.

Item	Estimation formula (bytes)
(4) Number of pages required for storing records	Total number of records / (3) number of records per page - The result will be rounded up to the next integer.
(5) Amount of space	(4) Number of pages required for storing records x page length x safety factor (*1) *1: Specify 2.0 or higher. - This is the safety factor assumed if vacuuming is performed for garbage collection in tables and indexes.

Table E.2 Estimation formula when the record length exceeds 2032 bytes

Item	Estimation formula (bytes)
(5) Amount of space	Total number of records x (1) record length x safety factor (*1) *1: Specify 2.0 or higher. - This is the safety factor assumed if vacuuming is performed for garbage collection in tables and indexes.

E.2 Estimating Index Size Requirements

This section provides the formulas for estimating index size requirements.

FUJITSU Enterprise Postgres provides six index types: B-tree, Hash, GiST, GIN, SP-GiST, and VCI. If you do not specify the index type in the CREATE INDEX statement, a B-tree index is generated.

The following describes how to estimate a B-tree index. Refer to "E.7 Estimating VCI Disk Space Requirements" for information on how to estimate VCI.

A B-tree index is saved as a fixed-size page of 8 KB. The page types are meta, root, leaf, internal, deleted, and empty. Since leaf pages usually account for the highest proportion of space required, you need to calculate the requirements for these only.

Table E.3 Estimation formula when the key data length is 512 bytes or less

Item	Estimation formula (bytes)
(1) Entry length	8 (*1) + key data length (*2) *1: Entry header *2: The key data length depends on its data type (refer to "E.3 Sizes of Data Types" for details). Because each entry is placed in boundaries of 8 bytes, you need to make an adjustment so that the length of the key data is a multiple of 8. For example, if the calculated length is 28 bytes, add 4 to make the length 32 bytes. - If the key data length exceeds 512 bytes, key data may be automatically compressed. In this case, use the estimation formula given in "Table E.4 Estimation formula when the key data length exceeds 512 bytes" to estimate the key data length.
(2) Page size requirement	8192 (*1) × fillfactor (*2) - 24 (*3) - 16 (*4) *1: Page length (8192) *2: Value of the fillfactor specified in the index definitions (if omitted, 90%) In the case of indexes of primary key constraints and unique constraints, the value of the fillfactor specified for each constraint in the table definitions (if omitted, 90%) *3: Page header (24) *4: Special data (16)

Item	Estimation formula (bytes)
	- The calculated (2) page size requirement will be rounded down to the nearest integer.
(3) Number of entries per page	(2) Page size requirement / ((1) entry length + 4 (*1)) *1: Pointer length - Result of (3) number of entries per page will be rounded down to the nearest integer.
(4) Number of pages required for storing indexes	Total number of records / (3) number of entries per page - Result of (4) number of pages required for storing indexes will be rounded up to the nearest integer.
(5) Space requirement	(4) Number of pages required for storing indexes x 8192 (*1) / usage rate (*2) *1: Page length *2: Specify 0.7 or lower.

Table E.4 Estimation formula when the key data length exceeds 512 bytes

Item	Estimation formula (bytes)
(5) Space requirement	Total number of records x key data length x compression ratio (*1) / usage rate (*2) *1: The compression ratio depends on the data value, so specify 1. *2: Specify 0.7 or lower as the usage rate.

E.3 Sizes of Data Types

This section lists the sizes of the data types.

E.3.1 Sizes of Fixed-Length Data Types

The following table lists the sizes of fixed-length data types.

Data type	Size (bytes)
SMALLINT (INT2)	2
INTEGER (INT4)	4
BIGINT (INT8)	8
REAL	4
DOUBLE PRECISION	8
SERIAL (SERIAL4)	4
BIGSERIAL (SERIAL8)	8
MONEY	8
FLOAT	8
FLOAT (1-24)	4
FLOAT (25-53)	8
TIMESTAMP WITHOUT TIME ZONE	8
TIMESTAMP WITH TIME ZONE	8
DATE	4
TIME WITHOUT TIME ZONE	8
TIME WITH TIME ZONE	12

Data type	Size (bytes)
INTERVAL	12
BOOLEAN	1
CIDR	IPv4: 7 IPv6: 19
INET	IPv4: 7 IPv6: 19
MACADDR	6
MACADDR8	8
POINT	16
LINE	32
LSEG	32
BOX	32
CIRCLE	24

E.3.2 Sizes of Variable-Length Data Types

The following table lists the sizes of variable-length data types.

Data type	Size (bytes)	Remarks
path	Length of size portion + 12 + 16 x number of vertices	1) When carrying out division, round to the next integer. 2) If the real data length is less than 127, then the length of the size portion is 1 byte, otherwise it is 4 bytes. 3) The number of bytes per character depends on the character set (refer to "E.3.4 Number of Bytes per Character" for details).
polygon	Length of size portion + 36 + 16 x number of vertices	
decimal	Length of size portion + 2 + (integer precision / 4 + decimal precision / 4) x 2	
numeric		
bytea	Length of size portion + real data length	
character varying(*n*), varchar(*n*)	Length of size portion + number of characters x number of bytes per character	
character(*n*), char(*n*)	Length of size portion + *n* x number of bytes per character	
text	Length of size portion + number of characters x number of bytes per character	

E.3.3 Sizes of Array Data Types

The following table lists the sizes of array data types.

Data type	Size (bytes)	Remarks
Array	Length of size portion + 12 + 8 x number of dimensions + data size of each item	If the real data length is less than 127, then the length of the size portion is 1 byte, otherwise it is 4 bytes. - Example of estimation when array data is "ARRAY[[1,2,3],[1,2,3]]" Number of dimensions: 2 INTEGER data size: 4 Total size = 1+12+8x2+6x4 = 53

E.3.4 Number of Bytes per Character

The following table lists the number of bytes per character.

The given values relate to the common character sets EUC-JP and UTF8.

Character type	Character set	Number of bytes per character
ASCII	EUC_JP	1
Halfwidth katakana	EUC_JP	2
JIS X 0208 kanji characters	EUC_JP	2
JIS X 0212 kanji characters	EUC_JP	3
ASCII	UTF8	1
Halfwidth katakana	UTF8	3
JIS X 0208 kanji characters	UTF8	3
JIS X 0212 kanji characters	UTF8	3

E.4 Estimating Transaction Log Space Requirements

This section provides the formula for estimating transaction log space requirements.

```
Transaction log space requirements = max_wal_size
```

However, if the update volume is extremely high (for example, due to a large data load and batch processing), disk writing at a checkpoint may not be able to keep up with the load, and a higher number of transaction logs than indicated here may temporarily be accumulated.

E.5 Estimating Archive Log Space Requirements

This section explains how to estimate archive log space requirements.

The archive log is an archive of the transaction logs from the time of a previous backup to the present, so it fluctuates depending on the backup period and the content of update transactions.

The longer the backup period and the more update transactions, the greater the space required for the archive log.

Therefore, measure the actual archive log space by using a test environment to simulate backup scheduling and database update in a real operating environment.

E.6 Estimating Backup Disk Space Requirements

This section provides the formula for estimating backup disk space requirements.

```
Backup disk space requirements = size of the database cluster x 2 x compression ratio
                                 + transaction log space requirements + archive log space requirements
```

Note

If the pgx_dmpall command performs a backup using a user command, the backup disk size differs according to the database resources targeted for backup and the copy method.

When using compression, the compression ratio depends on the data. Therefore, measure the actual compression ratio by using a test environment to simulate backup scheduling and database update in a real operating environment. Specify 1 to not use compression.

E.7 Estimating VCI Disk Space Requirements

This section provides the formula for estimating VCI disk space requirements.

```
Disk space = (number of rows in tables) x (number of bytes per row) x (compression ratio) + (WOS size)
```

Number of bytes per row

```
Number of bytes per row = (19 + (number of columns specified in CREATE INDEX) / 8
                                  + (number of bytes per single column value)) x 1.1
```

Note: Round up the result to the nearest integer.

Compression ratio

Specify a value between 0 and 1. Since compression ratio depends on the data being compressed, use actual data or test data that simulates it, then compare the value with the estimation result. As a guide, the compression ratio measured with the Fujitsu sample data is shown below:

- Data with high degree of randomness (difficult to compress): Up to approximately 0.9 times.
- Data with high degree of similarity (easy to compress): Up to approximately 0.5 times.

WOS size

```
WOS size = (number of WOS rows) / 185 x 8096
```

One row is added to the number of WOS rows for each INSERT and DELETE, and two rows are added for UPDATE. On the other hand, the number decreases to 520,000 rows or less during conversion to ROS performed by the ROS control daemon.

Note

VCI does not support retrieval of disk space usage using the database object size function pg_indexes_size. To find out the actual total VCI disk space, check the disk space of the storage directory using an OS command or other method.

Appendix F Estimating Memory Requirements

This appendix explains how to estimate the memory.

F.1 FUJITSU Enterprise Postgres Memory Requirements

This section describes the formulas for estimating FUJITSU Enterprise Postgres memory requirements.

Use the following formula to obtain a rough estimate of memory required for FUJITSU Enterprise Postgres:

```
fujitsuEnterprisePostgresRequiredMemory = sharedMemoryAmount + localMemoryAmount
```

Shared memory amount

Refer to "Shared Memory and Semaphores" under "Server Administration" in the PostgreSQL Documentation for information on shared memory. If you enable the Global Meta Cache feature, you must also add the value of pgx_global_metacache. Refer to "Parameters" in the Operation Guide for the setting values.

However, note that if instances have been created using WebAdmin, the parameters below will be configured automatically when the instances are created. Take this into account when calculating the shared memory size.

Parameter name	Set value
shared_buffers	30 percent of the internal memory of the machine.
max_connections	100
max_prepared_transactions	100

Local memory amount

```
localMemoryAmount = processStackArea
                  + memoryUsedInDbSessionsThatUseTempTables
                  + memoryUsedInDbSessionsThatPerformSortAndHashTableOperations
                  + memoryUsedInMaintenanceOperations
                  + baseMemoryUsedInEachProcess
                  + memoryUsedPreparingForDataAccess
```

Process stack area

```
processStackArea
  = max_stack_depth x (max_connections + autovacuum_max_workers + 9)
```

This formula evaluates to the maximum value.
Actually it is used according to the growth of the stack.
In the formula above, 9 is the number of processes that perform roles specific to servers.

Memory used in database sessions that use temporary tables

```
memoryUsedInDbSessionsThatUseTempTables
  = temp_buffers x max_connections
```

This formula evaluates to the maximum value.
Memory is gradually used as temporary buffers are used, and is released when the session ends.

Memory used in database sessions that perform sort and hash table operations

```
memoryUsedInDbSessionsThatPerformSortAndHashTableOperations
  = work_mem (*1) x max_connections
```

*1) For hash table operations, multiply work_mem by hash_mem_multiplier.
This formula evaluates to the maximum value.
Memory is gradually used as operations such as sort are performed, and is released when the query ends.

Memory used in maintenance operations

```
memoryUsedInMaintenanceOperations
  = maintenance_work_mem x (numOfSessionsPerformingMaintenance + autovacuum_max_workers)
```

Note that 'maintenance operations' are operations such as VACUUM, CREATE INDEX, and ALTER TABLE ADD FOREIGN KEY.

Base memory used in each process

```
baseMemoryUsedInEachProcess
  = baseMemoryUsedInOneProcess x (max_connections + autovacuum_max_workers + 9)
```

Use the result of the following formula for memory consumed per process. This formula evaluates to the memory used when server processes are running.
In the formula above, 9 is the number of processes that perform roles specific to servers.

The amount of memory consumed per process is determined by the number of tables, indexes, and all columns of all tables that the process accesses. If your system has about 100 tables, you can estimate it to be 3 MB, but otherwise use the following estimate:

```
baseMemoryUsedInOneProcess
  = (1.9KB x All user tables + 2.9KB x All user indexes + 1.0KB x All user columns) x 1.5(*1)

If you enable the Global Meta Cache feature, use the following formula:
baseMemoryUsedInOneProcess
 = (All user tables + All user indexes + All user columns) x 1.0KB x 1.5 (*1)
    + (All user tables x 1.4KB + All user indexes x 2.4KB)
```

*1) Safety Factor (1.5)
There are variable length information. This value takes that into account.

Memory used preparing for data access

```
memoryUsedPreparingForDataAccess
 = variationAmount x (max_connections + autovacuum_max_workers + 4)

  where variationAmount = shared_buffers / 8KB x 4 bytes
      (note that 8KB is the page length, and 4 bytes is the size of page management data)
```

This formula evaluates to the memory required to access the database cache in the shared memory.
In the formula above, among the processes that perform roles specific to servers, 4 is the number of processes that access the database.

F.2 Database Multiplexing Memory Requirements

This section describes the formula for estimating database multiplexing memory requirements for the database server.

Use the following formula to obtain a rough estimate of memory required for database multiplexing:

```
Memory usage of the database multiplexing feature for the database server
           = Peak memory usage of the Mirroring Controller processes
           + Peak memory usage of the Mirroring Controller commands

Peak memory usage of the Mirroring Controller processes=150 MB

Peak memory usage of the Mirroring Controller commands=50 MB x Number of commands executed
simultaneously
```

F.3 VCI Memory Requirements

This section describes the formula for estimating VCI memory requirements.

Use the following formula to obtain a rough estimate of memory requirements:

```
memUsedByVci = memForData + memForEachProcess
```

Memory required to store data in memory

Secure the space estimated using the formula below on the stable buffer (part of shared_buffers).

```
memForData = (numOfRowsInTables) x (numOfBytesPerRow) + (wosSize)
```

Number of bytes per row

```
numOfBytesPerRow
 = (19 + (numOfColsInCreateIndexStatement) / 8 + (numOfBytesPerSingleColValue)) x 1.1
```

Note: Round up the result to the nearest integer.

WOS size

```
wosSize = (numOfWosRows) / 185 x 8096
```

One row is added to the number of WOS rows for each INSERT and DELETE, and two rows are added for UPDATE. On the other hand, the number decreases to 520,000 rows or less during conversion to ROS performed by the ROS control daemon.

Memory required for each process

```
memForEachProcess
 = memUsedPerScanning
 + memUsedForVciMaintenace
 + memUsedByCreateIndexStatement
```

Memory used per scanning

- Parallel scan

```
memUsedPerScanning
 = vci.shared_work_mem + (numOfParallelWorkers + 1) x vci.maintenance_work_mem
```

Note: The number of parallel workers used by VCI simultaneously in the entire instance is equal to or less than vci.max_parallel_degree.

- Non-parallel scan

```
memUsedPerScanning = vci.max_local_ros + vci.maintenance_work_mem
```

Note

- vci.shared_work_mem, and vci.max_local_ros are used to create local ROS. If local ROS exceeds these sizes, execute a query without using VCI according to the conventional plan.
- vci.maintenance_work_mem specifies the memory size to be secured dynamically. If it exceeds the specified value, a disk temporary file is used for operation.

Memory used for VCI maintenance

```
memUsedForVciMaintenace = vci.maintenance_work_mem x vci.control_max_workers
```

Memory used by CREATE INDEX

```
memUsedByCreateIndexStatement = vci.maintenance_work_mem
```

Note

vci.maintenance_work_mem specifies the memory to be secured dynamically. If it exceeds the specified value, a disk temporary file is used for operation.

F.4 High-Speed Data Load Memory Requirements

This section describes the formula for estimating memory requirements for the high-speed data load feature.

Use the following formula to obtain a rough estimate of memory requirements:

```
Memory usage of high speed data load
 = (Peak memory usage of pgx_loader processes + Peak memory usage of the pgx_loader commands)
 x Number of commands executed simultaneously

Peak memory usage of pgx_loader processes
 = Peak memory usage of the backend process   (6 MB)
 + Peak memory usage of parallel workers       (6 MB x number of parallel workers)
 + Peak memory usage of dynamic shared memory (80 MB x number of parallel workers)

Peak memory usage of the pgx_loader commands=9 MB
```

Point

In addition to the size calculated using the formula above, the database cache on the shared memory estimated using the shared_buffers parameter is consumed according to the size of the data (table and index keys) loaded using this feature. Refer to "E.1 Estimating Table Size Requirements" and "E.2 Estimating Index Size Requirements" for information on estimating an appropriate shared buffers value.

F.5 Global Meta Cache Memory Requirements

This section describes the formula for estimating Global Meta Cache memory requirements.

The memory calculated by "Size of the GMC area" is allocated to the shared memory. The memory calculated by the per-process meta cache management information is allocated to the local memory. Refer to the graphic in "Architecture of Global Meta Cache Feature" in the "Memory usage reduction by Global Meta Cache" in the General Description for more information.

Use the following formula to obtain a rough estimate of memory requirements:

```
Amount of memory used by the Global Meta Cache feature
  = Size of GMC area + Per-process meta cache management information

Size of GMC area = (All user tables x 0.4 KB
     + All user indexes x 0.3 KB
     + All user columns x 0.8 KB) x 1.5 (*1)

Per-process meta cache management information
  = (All user tables + All user indexes + All user columns) x 0.1KB x max_connections x 1.5 (*1)
```

*1) Safety Factor (1.5)
This value takes into account the case where both GMC before and after the change temporarily exist at the same time in shared memory when the table definition is changed or the row of the system catalog is changed.

Appendix G Quantitative Limits

This appendix lists the quantitative limits of FUJITSU Enterprise Postgres.

Table G.1 Length of identifier

Item	Limit
Database name	Up to 63 bytes (*1) (*2)
Schema name	Up to 63 bytes (*1) (*2)
Table name	Up to 63 bytes (*1) (*2)
View name	Up to 63 bytes (*1) (*2)
Index name	Up to 63 bytes (*1) (*2)
Tablespace name	Up to 63 bytes (*1) (*2)
Cursor name	Up to 63 bytes (*1) (*2)
Function name	Up to 63 bytes (*1) (*2)
Aggregate function name	Up to 63 bytes (*1) (*2)
Trigger name	Up to 63 bytes (*1) (*2)
Constraint name	Up to 63 bytes (*1) (*2)
Conversion name	Up to 63 bytes (*1) (*2)
Role name	Up to 63 bytes (*1) (*2)
Cast name	Up to 63 bytes (*1) (*2)
Collation sequence name	Up to 63 bytes (*1) (*2)
Encoding method conversion name	Up to 63 bytes (*1) (*2)
Domain name	Up to 63 bytes (*1) (*2)
Extension name	Up to 63 bytes (*1) (*2)
Operator name	Up to 63 bytes (*1) (*2)
Operator class name	Up to 63 bytes (*1) (*2)
Operator family name	Up to 63 bytes (*1) (*2)
Rewrite rule name	Up to 63 bytes (*1) (*2)
Sequence name	Up to 63 bytes (*1) (*2)
Text search settings name	Up to 63 bytes (*1) (*2)
Text search dictionary name	Up to 63 bytes (*1) (*2)
Text search parser name	Up to 63 bytes (*1) (*2)
Text search template name	Up to 63 bytes (*1) (*2)
Data type name	Up to 63 bytes (*1) (*2)
Enumerator type label	Up to 63 bytes (*1) (*2)

*1: This is the character string byte length when converted by the server character set character code.

*2: If an identifier that exceeds 63 bytes in length is specified, the excess characters are truncated and it is processed.

Table G.2 Database object

Item	Limit
Number of databases	Less than 4,294,967,296 (*1)

Item	Limit
Number of schemas	Less than 4,294,967,296 (*1)
Number of tables	Less than 4,294,967,296 (*1)
Number of views	Less than 4,294,967,296 (*1)
Number of indexes	Less than 4,294,967,296 (*1)
Number of tablespaces	Less than 4,294,967,296 (*1)
Number of functions	Less than 4,294,967,296 (*1)
Number of aggregate functions	Less than 4,294,967,296 (*1)
Number of triggers	Less than 4,294,967,296 (*1)
Number of constraints	Less than 4,294,967,296 (*1)
Number of conversion	Less than 4,294,967,296 (*1)
Number of roles	Less than 4,294,967,296 (*1)
Number of casts	Less than 4,294,967,296 (*1)
Number of collation sequences	Less than 4,294,967,296 (*1)
Number of encoding method conversions	Less than 4,294,967,296 (*1)
Number of domains	Less than 4,294,967,296 (*1)
Number of extensions	Less than 4,294,967,296 (*1)
Number of operators	Less than 4,294,967,296 (*1)
Number of operator classes	Less than 4,294,967,296 (*1)
Number of operator families	Less than 4,294,967,296 (*1)
Number of rewrite rules	Less than 4,294,967,296 (*1)
Number of sequences	Less than 4,294,967,296 (*1)
Number of text search settings	Less than 4,294,967,296 (*1)
Number of text search dictionaries	Less than 4,294,967,296 (*1)
Number of text search parsers	Less than 4,294,967,296 (*1)
Number of text search templates	Less than 4,294,967,296 (*1)
Number of data types	Less than 4,294,967,296 (*1)
Number of enumerator type labels	Less than 4,294,967,296 (*1)
Number of default access privileges defined in the ALTER DEFAULT PRIVILEGES statement	Less than 4,294,967,296 (*1)
Number of large objects	Less than 4,294,967,296 (*1)
Number of index access methods	Less than 4,294,967,296 (*1)

*1: The total number of all database objects must be less than 4,294,967,296.

Table G.3 Schema element

Item	Limit
Number of columns that can be defined in one table	From 250 to 1600 (according to the data type)
Table row length	Up to 400 gigabytes
Number of columns comprising a unique constraint	Up to 32 columns
Data length comprising a unique constraint	Less than 2,000 bytes (*1) (*2)

Item	Limit
Table size	Up to 32 terabyte
Search condition character string length in a trigger definition statement	Up to 800 megabytes (*1) (*2)
Item size	Up to 1 gigabyte

*1: Operation might proceed correctly even if operations are performed with a quantity outside the limits.

*2: This is the character string byte length when converted by the server character set character code.

Table G.4 Index

Item	Limit
Number of columns comprising a key (including VCI)	Up to 32 columns
Key length (other than VCI)	Less than 2,000 bytes (*1)

*1: This is the character string byte length when converted by the server character set character code.

Table G.5 Data types and attributes that can be handled

Item			Limit
Character	Data length		Data types and attributes that can be handled (*1)
	Specification length (n)		Up to 10,485,760 characters (*1)
Numeric	External decimal expression		Up to 131,072 digits before the decimal point, and up to 16,383 digits after the decimal point
	Internal binary expression	2 bytes	From -32,768 to 32,767
		4 bytes	From -2,147,483,648 to 2,147,483,647
		8 bytes	From -9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
	Internal decimal expression		Up to 13,1072 digits before the decimal point, and up to 16,383 digits after the decimal point
	Floating point expression	4 bytes	From -3.4E+38 to -7.1E-46, 0, or from 7.1E-46 to 3.4E+38
		8 bytes	From -1.7E+308 to -2.5E-324, 0, or from 2.5E-324 to 1.7E+308
bytea			Up to one gigabyte minus 53 bytes
Large object			Up to 4 terabyte

*1: This is the character string byte length when converted by the server character set character code.

Table G.6 Function definition

Item	Limit
Number of arguments that can be specified	Up to 100
Number of variable names that can be specified in the declarations section	No limit
Number of SQL statements or control statements that can be specified in a function processing implementation	No limit

Table G.7 Data operation statement

Item	Limit
Maximum number of connections for one process in an application (remote access)	4,000 connections
Number of expressions that can be specified in a selection list	Up to 1,664
Number of tables that can be specified in a FROM clause	No limit
Number of unique expressions that can be specified in a selection list/ DISTINCT clause/ORDER BY clause/GROUP BY clause within one SELECT statement	Up to 1,664
Number of expressions that can be specified in a GROUP BY clause	No limit
Number of expressions that can be specified in an ORDER BY clause	No limit
Number of SELECT statements that can be specified in a UNION clause/INTERSECT clause/EXCEPT clause	Up to 4,000 (*1)
Number of nestings in joined tables that can be specified in one view	Up to 4,000 (*1)
Number of functions or operator expressions that can be specified in one expression	Up to 4,000 (*1)
Number of expressions that can be specified in one row constructor	Up to 1,664
Number of expressions that can be specified in an UPDATE statement SET clause	Up to 1,664
Number of expressions that can be specified in one row of a VALUES list	Up to 1,664
Number of expressions that can be specified in a RETURNING clause	Up to 1,664
Total expression length that can be specified in the argument list of one function specification	Up to 800 megabytes (*2)
Number of cursors that can be processed simultaneously by one session	No limit
Character string length of one SQL statement	Up to 800 megabytes (*1) (*3)
Number of input parameter specifications that can be specified in one dynamic SQL statement	No limit
Number of tokens that can be specified in one SQL statement	Up to 10,000
Number of values that can be specified as a list in a WHERE clause IN syntax	No limit
Number of expressions that can be specified in a USING clause	No limit
Number of JOINs that can be specified in a joined table	Up to 4,000 (*1)
Number of expressions that can be specified in COALESCE	No limit
Number of WHEN clauses that can be specified for CASE in a simple format or a searched format	No limit
Data size per record that can be updated or inserted by one SQL statement	Up to one gigabyte minus 53 bytes
Number of objects that can share a lock simultaneously	Up to 256,000 (*1)

*1: Operation might proceed correctly even if operations are performed with a quantity outside the limits.

*2: The total number of all database objects must be less than 4,294,967,296.

*3: This is the character string byte length when converted by the server character set character code.

Table G.8 Data size

Item	Limit
Data size per record for input data files (COPY statement, psql command \copy meta command)	Up to 800 megabytes (*1)
Data size per record for output data files (COPY statement, psql command \copy meta command)	Up to 800 megabytes (*1)

*1: Operation might proceed correctly even if operations are performed with a quantity outside the limits.

Appendix H Configuring Kernel Parameters

Use the "System V IPC Parameters" table in "Managing Kernel Resources" in the PostgreSQL Documentation for the relationship between configuration parameters and kernel parameters, as well as calculation formulas.
Refer to the "Managing Kernel Resources" in the PostgreSQL Documentation to calculate shared memory usage.

For multiple instances, the kernel parameters should be evaluated for all instances. For example, in the case of the maximum number of shared memory segments for the entire system (SHMMNI), the total number of segments obtained by all instances should be added to the kernel parameters. In the case of the maximum number of semaphores for each process (SEMMSL), the largest of all sizes obtained by all instances should be compared to the current value prior to configuring the settings.

Note

If there is insufficient shared memory due to miscalculation of SHMMAX, a message will be output indicating that the shmget system call failed at "errno=22 (EINVAL)". Review the calculation, and reconfigure.

The relationship between System V IPC parameters and kernel parameters in various operating systems is shown below.

System	V IPC parameter	Kernel parameter action
SHMMAX	kernel.shmmax	If *currentValue* < *calculatedValue*, configure the calculated value
SHMMIN	No compatible parameter	
SHMALL	kernel.shmall	Specify *currentValue* + *calculatedValue*
SHMSEG	No compatible parameter	
SHMMNI	kernel.shmmni	Specify *currentValue* + *calculatedValue*
SEMMNI	Fourth parameter of kernel.sem	Specify *currentValue* + *calculatedValue*
SEMMNS	Second parameter of kernel.sem	Specify *currentValue* + *calculatedValue*
SEMMSL	First parameter of kernel.sem	If *currentValue* < *calculatedValue*, configure the calculated value
SEMMAP	No compatible parameter	
SEMVMX	No compatible parameter	

Remark 1: kernel.shmall specifies the number of pages.
Remark 2: Specify all four parameters for kernel.sem. At this time, the value specified in the third parameter should be the same value as before configuration.

Appendix I Determining the Preferred WebAdmin Configuration

This appendix describes the two different configurations in which WebAdmin can be used and how to select the most suitable configuration.

I.1 WebAdmin Configurations

WebAdmin can be installed in two configurations:

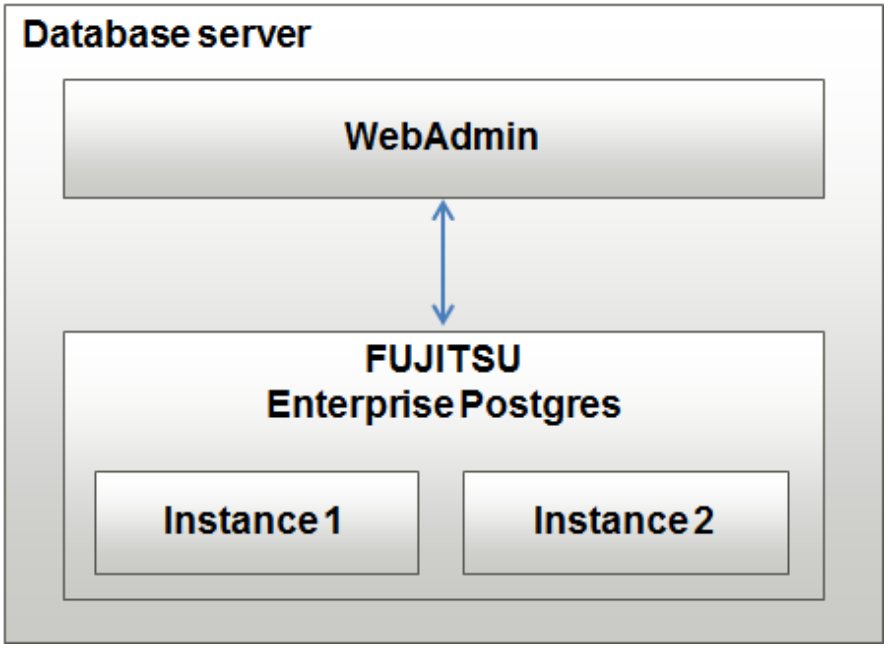
- Single-server
- Multiserver

WebAdmin does not support encrypted communication between browser and server or between servers. Therefore, when using WebAdmin in either configuration, build the communication path with the browser or each server on a network that cannot be accessed externally.

I.1.1 Single-Server Configuration

A single-server configuration enables you to create and operate instances on a single server. In this configuration, WebAdmin must be installed on the same database server as the FUJITSU Enterprise Postgres Server component.

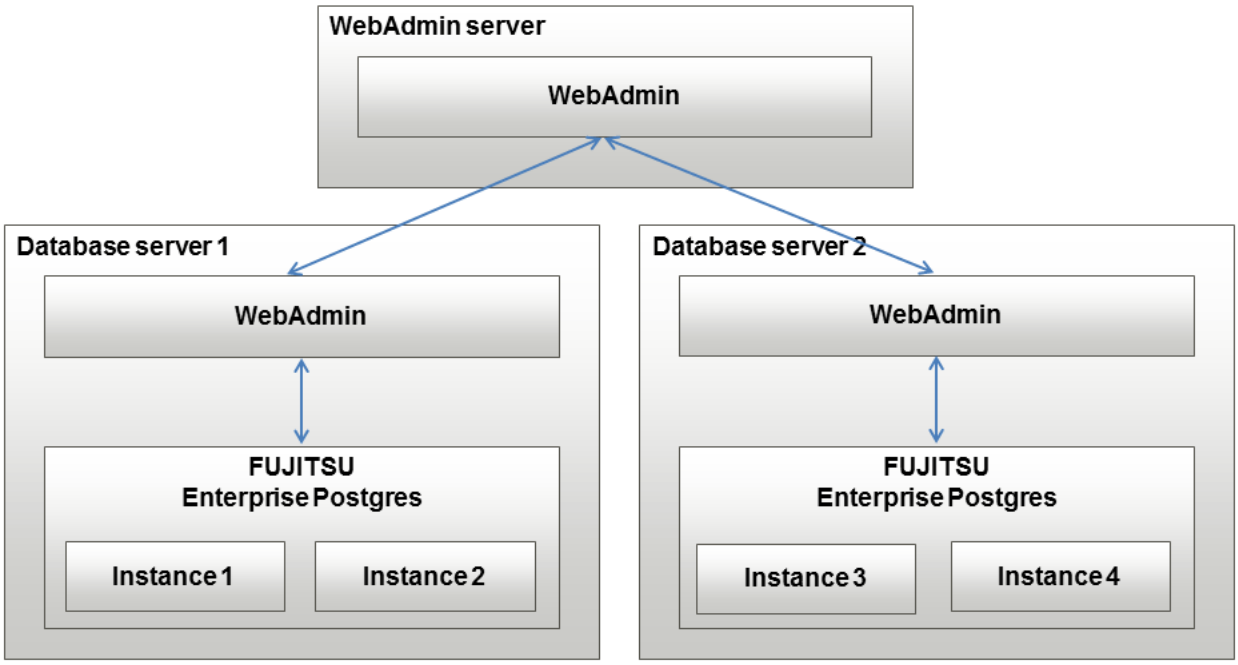
Single-server configuration



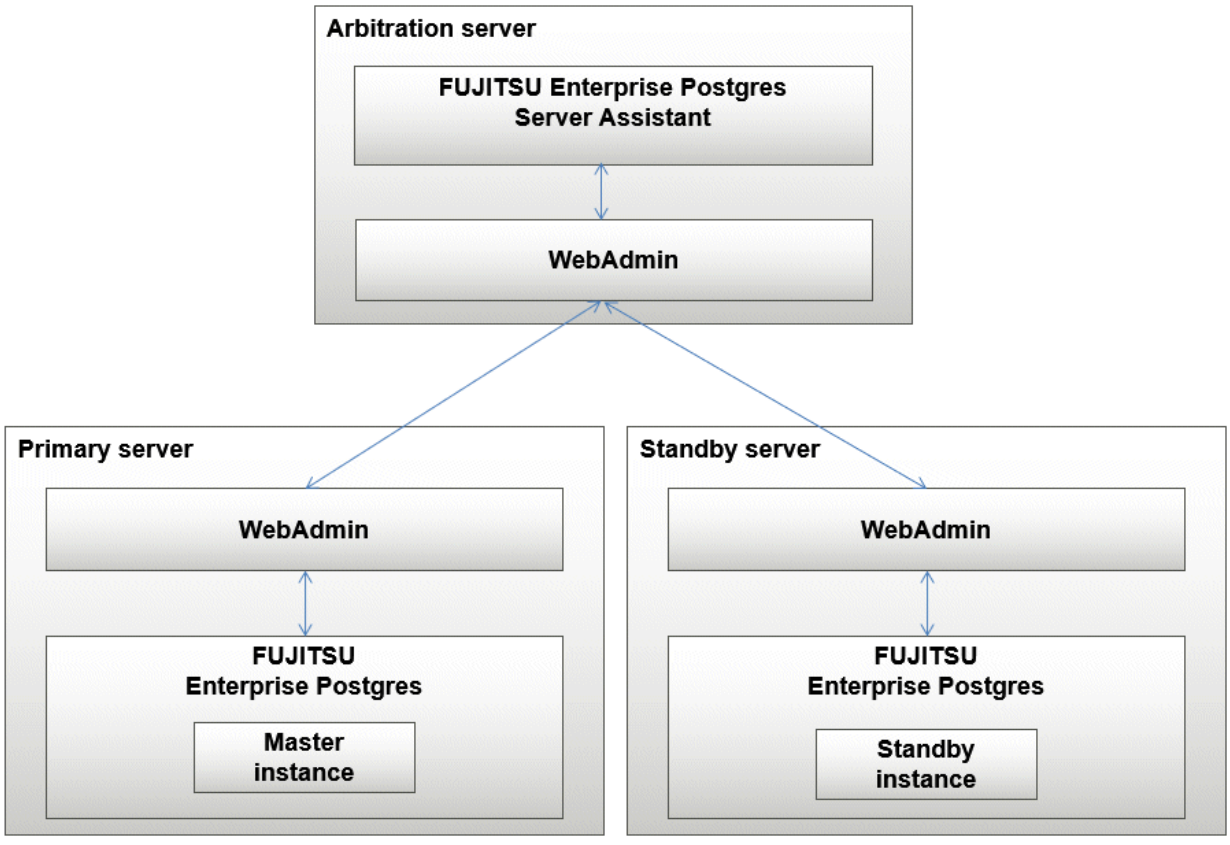
I.1.2 Multiserver Configuration

A multiserver configuration enables you to create and operate instances stored on multiple database servers. As shown in the figure below, WebAdmin can be installed on a dedicated WebAdmin server and used to collectively manage the instances stored on the database servers.

Multiserver configuration



Also, when setting up the arbitration server by WebAdmin during database multiplexing mode, install WebAdmin on the arbitration server.



I.2 Installing WebAdmin in a Single-Server Configuration

To install WebAdmin in a single-server configuration, the FUJITSU Enterprise Postgres Server component and WebAdmin must be installed on the same machine.

Select the following items when installing FUJITSU Enterprise Postgres in a single-server configuration:

- FUJITSU Enterprise Postgres Advanced Edition
- WebAdmin

I.3 Installing WebAdmin in a Multiserver Configuration

In a multiserver configuration, install WebAdmin on one server, and both WebAdmin and the FUJITSU Enterprise Postgres Server component on any number of database servers.

Select the following items when installing FUJITSU Enterprise Postgres in a multiserver configuration:

- WebAdmin server:
  - WebAdmin
- Database server:
  - FUJITSU Enterprise Postgres Advanced Edition
  - WebAdmin

Also, when setting up the arbitration server by WebAdmin during database multiplexing mode, select the following when installing FUJITSU Enterprise Postgres.

- Arbitration server
  - FUJITSU Enterprise Postgres Server Assistant
  - WebAdmin

 See

Refer to the Installation and Setup Guide for Server Assistant for details on how to install the Server Assistant.

Appendix J System Configuration when using Pgpool-II

Describes the system configuration when using Pgpool-II.

The system configuration when using Pgpool-II is as follows:

Place on database server

System configuration to coexist the database server with Pgpool-II.

Place on application server

System configuration to coexist the application server with Pgpool-II.

Place on dedicated server

System configuration in which Pgpool-II resides on a dedicated server (Pgpool-II Server) that is separate from the database and application servers.

Select the system configuration that best meets your operational requirements.

J.1 Pgpool-II Configuration

In this example, Pgpool-II is deployed on a different Pgpool-II server than the database and application servers.

There are three configurations of Pgpool-II:

- Single-machine configuration
- Two-machine configuration
- Three-machine configuration

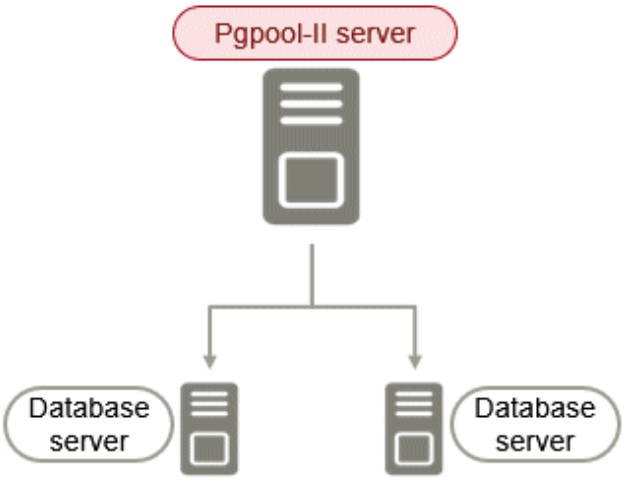
Although the Pgpool-II server can be operated on a single machine, to ensure business continuity, it is recommended to operate the Pgpool-II server using a three-machine configuration in FUJITSU Enterprise Postgres.

If employing a configuration of three or more machines, use an odd number of machines in the configuration.

J.1.1 Single-Machine Configuration

This is the basic configuration when running Pgpool-II.

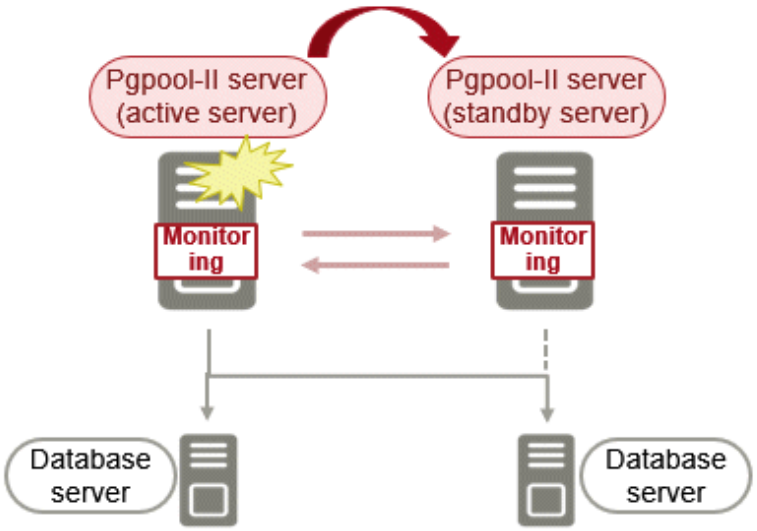
Although the database server has redundancy, if an error occurs on the Pgpool-II server that accesses the database server, the job will stop.



J.1.2 Two-Machine Configuration

When an error occurs on the active server, the Pgpool-II monitoring feature that mutually monitors the status of the Pgpool-II servers enables jobs to continue uninterrupted by switching to the standby server.

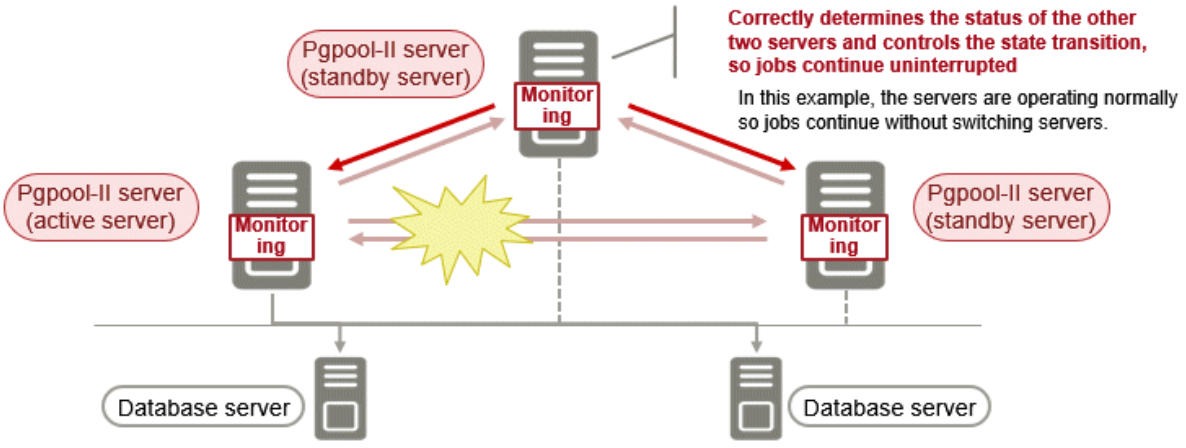
If the network between Pgpool-II servers is disconnected, even if the Pgpool-II servers are running correctly, which may lead to stoppage of jobs.



J.1.3 Three-Machine Configuration

The Pgpool-II monitoring feature enables a Pgpool-II server to monitor the other two Pgpool-II servers.

Even if any of the networks monitoring the Pgpool-II servers are disconnected, the status of servers on a network that is operating normally can be checked correctly, enabling accurate continuation of jobs.



J.2 Installing Pgpool-II

Pgpool-II is bundled with the server program and the client program. To use Pgpool-II, use the server program or the client program to install and set up Pgpool-II.

Depending on where Pgpool-II is installed, select the appropriate DVD for deployment:

Installing on Database Server (coexist)

Install the Pgpool-II program along with the server program from the server program DVD.

Installing on Application Server (coexist)

Install the Pgpool-II program along with the client program from the client program DVD.

Installing on Dedicated server different from the above (Pgpool-II server)

Install the Pgpool-II program along with the client program from the client program DVD.

J.3 Pgpool-II Setup

Describes how to set up Pgpool-II.

J.3.1 Setting Environment Variables

If you use the Pgpool-II command, set the following environment variables:

PATH environment variable

Add "Install Directory/bin".

LD_LIBRARY_PATH environment variable

Add "Install Directory/bin".

The following is an example of setting environment variables:

Example

The following is an example of setting environment variables when the installation directory is "/ opt/fsepv < x > pgpool-II".

"< x >"” indicates the product version.

```
$ PATH=/opt/fsepv<x>pgpool-II/bin:$PATH ; export PATH
$ LD_LIBRARY_PATH=/opt/fsepv<x>pgpool-II/lib:$LD_LIBRARY_PATH ; export LD_LIBRARY_PATH
```

J.3.2 Configuration file

Describes Pgpool-II configuration files.

J.3.2.1 Configuring pgpool.conf

To configure pgpool.conf, see the Pgpool-II documentation.

A sample configuration file is located under the installation directory/etc.

J.3.2.2 Using Configuration Files

The pgpool command makes use of configuration files such as pgpool.conf, pcp.conf, and pool_hba.conf.

To take advantage of these configuration files, specify the path to the files in the pgpool command options.

The following example shows how to configure options for the pgpool command:

Example

```
$ pgpool -f /usr/local/etc/pgpool.conf -F /usr/local/etc/pcp.conf -a / usr/local/etc/pool_hba.conf
```

Appendix K Supported contrib Modules and Extensions Provided by External Projects

FUJITSU Enterprise Postgres supports PostgreSQL contrib modules, and extensions provided by external projects.

Refer to the following for details on the supported contrib modules:

- "Additional Supplied Modules" in the PostgreSQL Documentation
- "Additional Supplied Programs" in the PostgreSQL Documentation

Information

You can also check the list of available extensions using the pg_available_extensions view.

Refer to "OSS Supported by FUJITSU Enterprise Postgres" in the General Description for information on supported extensions provided by external projects.

Appendix L Procedure when Modifying the JRE Installation

This appendix describes the procedures to follow when modifying the JRE installation.

The JRE is used by features such as WebAdmin and database multiplexing.

Therefore, when updating or reinstalling JRE after installing FUJITSU Enterprise Postgres, the procedures below must be performed.

L.1 When Using WebAdmin

WebAdmin must be set up again.

Follow the procedure below to modify the JRE installation:

1. Stop the Web server feature of WebAdmin

   Refer to "B.1.3 Stopping the Web Server Feature of WebAdmin" for details.

2. Remove WebAdmin

   Refer to "B.2 Removing WebAdmin" for details.

3. Modify the JRE installation

4. Set the JAVA_HOME environment variable

   Set the JAVA_HOME environment variable to the installation destination of Open JRE 8.

   Example

   ```
   # export JAVA_HOME="OpenJRE8InstallDir "
   ```

5. Set up WebAdmin

   Refer to "B.1.1 Setting Up WebAdmin" for details.

6. Start the Web server feature of WebAdmin

   Refer to "B.1.2 Starting the Web Server Feature of WebAdmin" for details.

L.2 When Performing Database Multiplexing

Mirroring Controller must be restarted.

Follow the procedure below to modify the JRE installation:

1. Stop Mirroring Controller

   Refer to the Cluster Operation Guide (Database Multiplexing) for details.

2. Modify the JRE installation

3. Change the installation environment to be used by Mirroring Controller

   Note

   If database multiplexing is performed using WebAdmin, perform the procedure described in this procedure after performing step 4 "Set the JAVA_HOME environment variable" in "L.1 When Using WebAdmin".

   Set the JAVA_HOME environment variable to the installation destination of Open JRE 8, and use the mc_update_jre_env command to change the installation environment to be used by Mirroring Controller.
   This procedure must be executed by the superuser.

   Example

/opt/fsepv<*x*>server64/bin is the installation directory where the server product is installed.

```
$ su -
Password:******
# export JAVA_HOME="OpenJRE8InstallDir "
# /opt/fsepv<x>server64/bin/mc_update_jre_env
```

4. Start Mirroring Controller

   Refer to the Cluster Operation Guide (Database Multiplexing) for details.

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Fujitsu Enterprise Postgres 14 SP1 on IBM LinuxONE

Installation and Setup Guide for Client

SP1

Linux

FUJITSU

J2UL-2746-02ZLZ0(00)
September-2022

Preface

Purpose of this document

This document describes how to install, uninstall and set up the "FUJITSU Enterprise Postgres client feature".

Intended readers

This document is intended for those who install and operate FUJITSU Enterprise Postgres.

Readers of this document are assumed to have general knowledge of:

- PostgreSQL
- SQL
- Linux

Structure of this document

This document is structured as follows:

Chapter 1 Overview of Installation

Describes the features that can be installed, and provides an overview of installation methods

Chapter 2 Installation and Uninstallation of the Linux Client

Describes how to install the FUJITSU Enterprise Postgres client feature (Linux client)

Chapter 3 Setup

Describes the setup procedures to be performed after installation completes

Export restrictions

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Issue date and version

```
Edition 2.0: September 2022
Edition 1.0: February 2022
```

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Contents

Chapter 1 Overview of Installation

This chapter provides an overview of FUJITSU Enterprise Postgres installation.

1.1 Features that can be Installed

FUJITSU Enterprise Postgres provides features to enable access to the database from a variety of platforms and languages, as the connection environment for the client and the database server.

The FUJITSU Enterprise Postgres client package must be installed on the client system to use these features.

The following list shows the features provided by client packages.

- JDBC
- ODBC
- C language (libpq)
- Embedded SQL (ECPG) in C language
- Connection Manager
- High speed data load
- Pgpool-II

1.2 Installation Types

The following installation types are available for FUJITSU Enterprise Postgres:

- New installation
- Reinstallation
- Multi-version installation

1.2.1 New Installation

In initial installation, the FUJITSU Enterprise Postgres client feature is installed for the first time.

1.2.2 Reinstallation

Perform reinstallation to repair installed program files that have become unusable for any reason.

1.2.3 Multi-Version Installation

Perform multi-version installation to install different versions to the installed program files separately.

1.3 Uninstallation

Uninstallation removes the system files of the installed FUJITSU Enterprise Postgres client feature.

Chapter 2 Installation and Uninstallation of the Linux Client

This chapter explains how to install and uninstall the Linux client.

2.1 Operating Environment

This section describes the operating environment required to use the Linux client.

2.1.1 Required Operating System

The following operating systems is required to use the Linux client. Check and use minor version, which is certified and currently supported by Red Hat or SUSE for the target IBM z / Linux One hardware.

- RHEL8.2 or later minor version
- SLES 15 SP3

Information

- The following packages are required for operations on RHEL8.

Package name	Remarks
glibc	-
libgcc	-
libmemcached	Required when using Pgpool-II.
libstdc++	-
libtool-ltdl	-
ncurses-libs	-
nss-softokn-freebl	-
unixODBC	Required when using ODBC drivers.
xz-libs	-
zlib	-

- The following packages are required for operations on SLES 15.

Package name	Remarks
glibc	-
libgcc	-
libmemcached	Required when using Pgpool-II.
libstdc++	-
libtool-ltdl	-
ncurses-libs	-
nss-softokn-freebl	-
unixODBC	Required when using ODBC drivers.
xz-libs	-
zlib	-

2.1.2 Related Software

The following table lists the software required to use the Linux client.

Table 2.1 Related software

No.	Software name	Version
1	C compiler (*1)	-
2	JDK or JRE (*2)	Java SE 8 or later

*1: Only operations using the C compiler provided with the operating system are guaranteed.

*2: OpenJDK and IBM Java are supported.

The following table lists servers that can be connected to the Linux client.

Table 2.2 Connectable servers

OS	Software name
Linux	FUJITSU Software Enterprise Postgres Advanced Edition 11 or later , up to 14 SP1

Note

Connecting this client to a server product of a different version depends on compatibility with PostgreSQL on which the server product is based, so some features may not be available.

2.1.3 Excluded Software

There are no exclusive products.

2.1.4 Required Patches

There are no required patches.

2.1.5 Hardware Environment

The following hardware is required to use the Linux client.

Memory

At least 160 MB of memory is required.

Mandatory hardware

None.

2.1.6 Disk Space Required for Installation

The following table lists the disk space requirements of the corresponding directories for new installation of the Linux client. If necessary, increase the size of the file system.

Table 2.3 Disk space required for installation

Directory	Required disk space Unit: MB
/etc	1
Installation destination of the client	114

2.1.7 Supported System Environment

This section describes the supported system environment.

TCP/IP protocol

FUJITSU Enterprise Postgres supports version 4 and 6 (IPv4 and IPv6) of TCP/IP protocols.

Note

Do not use link-local addresses if TCP/IP protocol version 6 addresses are used.

2.1.8 Versions of Open-Source Software Used as the Base for FUJITSU Enterprise Postgres Drivers

The following table lists the versions of open-source software used as the base for the various FUJITSU Enterprise Postgres drivers.

Driver	Open-source software version
JDBC	pgjdbc 42.2.23
ODBC	psqlodbc 13.02.0000
libpq	PostgreSQL 14.0

2.2 Installation

This section explains how to install the Linux client.

2.2.1 Pre-installation Tasks

Check the system environment for the following before the Linux client is installed.

Check the disk capacity

Check if sufficient free disk space is available for installing the Linux client.

Refer to "Table 2.3 Disk space required for installation" for information on disk space requirements.

If sufficient free disk space is unavailable, reconfigure disk partitions.

Executable Users

Installation and uninstallation is performed by superuser.

On the system, run the following command to become superuser.

```
$ su -
Password:******
```

2.2.2 Run Installation

The installation procedure is described below.

Note

The following characters can be used as input values:

Alphanumeric characters, hyphens, commas and forward slashes

1. Stop applications and programs

If the installation method is the following, all applications and programs that use the product must be stopped:

- Reinstallation

Before starting the installation, stop the following:

- Applications that use the product
- Connection Manager
- pgBadger
- Pgpool-II

2. Mount the DVD drive

Insert the client program DVD into the DVD drive, and then execute the following command:

Example

```
# mount -t iso9660 -r -o loop /dev/dvd /media/dvd
```

Here /dev/dvd is the device name for the DVD drive (which may vary depending on your environment), and /media/dvd is the mount point (which may need to be created before calling the command).

Note

If the DVD was mounted automatically using the automatic mount daemon (autofs), "noexec" is set as the mount option, so the installer may fail to start. In this case, use the mount command to remount the DVD correctly, and then run the installation. Note that the mount options of a mounted DVD can be checked by executing the mount command without any arguments.

3. Run the installation

Install the following packages (rpm) with the rpm command.

Feature Name	Operating System	Package (Path)
Client	RHEL8	CLIENT64/Linux/packages/r80s390x/FJSVfsep-CL-*.rpm
	SLES 15	CLIENT64/Linux/packages/SUSE15s390x/FJSVfsep-CL-*.rpm
Pgpool-II	RHEL8	PGPOOL2/Linux/packages/r80s390x/FJSVfsep-POOL2-*.rpm
	SLES 15	PGPOOL2/Linux/packages/SUSE15s390x/FJSVfsep-POOL2-*.rpm

*is the version, OS, etc.

Example

In the following example, /media/dvd is the name of the mount point where the DVD is mounted.

Below is an example of new installation on RHEL8.

```
# cd /media/dvd/CLIENT64/Linux/packages/r80s390x
# rpm -ivh FJSVfsep-CL-14-1401-0.el8.s390x.rpm
```

Below is an example of new installation on SLES 15.

```
# cd /media/dvd/CLIENT64/Linux/packages/SUSE15s390x
# rpm -ivh FJSVfsep-CL-14-1401-0.s15.s390x.rpm
```

Below is an example of reinstallation on RHEL8.

```
# cd /media/dvd/CLIENT64/Linux/packages/r80s390x
# rpm -ivh --replacepkgs FJSVfsep-CL-14-1401-0.el8.s390x.rpm
```

Below is an example of reinstallation on SLES 15.

```
# cd /media/dvd/CLIENT64/Linux/packages/SUSE15s390x
# rpm -ivh --replacepkgs FJSVfsep-CL-14-1401-0.s15.s390x.rpm
```

Note

If you perform reinstallation, and an installation prefix (in the --prefix option of the rpm command) was used for the new installation, you must use the same prefix.

2.3 Uninstallation

This section describes the procedure for uninstalling the Linux client.

Note

- Before uninstalling the product, close the product program and all applications that are using it.

2.3.1 Run Uninstallation

The uninstallation procedure is described below.

1. Stop applications and programs

Before starting the uninstallation, stop the following:

- Applications that use the product
- Connection Manager
- pgBadger
- Pgpool-II

2. Verifying Installation Features

Verify that the feature to be removed is installed by executing the following command.

Feature Name	Package Name
Client	FJSVfsep-CL-<*x*>

* Where *x* is a number indicating the version.

Example

```
# rpm -qi FJSVfsep-CL-14
```

3. Run the uninstallation

Run the following command.

Example

```
# rpm -e FJSVfsep-CL-14
```

The installation directory may remain after uninstallation. If it is not required, delete it.

Chapter 3 Setup

This chapter describes the setup procedures to be performed after installation completes.

3.1 Configuring Environment Variables

Configure the following environment variables when using client commands.

PATH environment variable

Add "*installationDirectory*/bin".

MANPATH environment variable

Add "*installationDirectory*/share/man".

PGLOCALEDIR environment variable

Add "*installationDirectory*/share/locale".

LD_LIBRARY_PATH environment variable

Add "*installationDirectory*/lib".

Examples of environment variable configurations are shown below.

Example

Note that "<*x*>" indicates the product version.

```
$ PATH=/opt/fsepv<x>client64/bin:$PATH ; export PATH
$ MANPATH=/opt/fsepv<x>client64/share/man:$MANPATH ; export MANPATH
$ PGLOCALEDIR=/opt/fsepv<x>client64/share/locale ; export PGLOCALEDIR
$ LD_LIBRARY_PATH=/opt/fsepv<x>client64/lib:$LD_LIBRARY_PATH ; export LD_LIBRARY_PATH
```

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Fujitsu Enterprise Postgres 14 SP1 on IBM LinuxONE

Installation and Setup Guide for Server Assistant

SP1

Linux

FUJITSU

J2UL-2747-02ZLZ0(00)
September-2022

Preface

Purpose of this document

This document describes how to install and uninstall the FUJITSU Enterprise Postgres Server Assistant.

Intended readers

This document is intended for those who install and operate FUJITSU Enterprise Postgres.

Readers of this document are assumed to have general knowledge of:

- PostgreSQL
- SQL
- Linux

Structure of this document

This document is structured as follows:

Chapter 1 Overview of Installation

Describes the features that can be installed, and provides an overview of installation methods

Chapter 2 Installation and Uninstallation of the Linux Server Assistant

Describes how to install and uninstall the Linux Server Assistant

Chapter 3 Setup of the Server Assistant

Describes the setup to be performed after installation

Appendix A Estimating Memory Requirements

Describes the formulas for estimating memory requirements

Appendix B Procedure when Modifying the JRE Installation

Describes the procedure to follow when modifying the JRE installation.

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Issue date and version

```
Edition 2.0: September 2022
Edition 1.0: February 2022
```

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Contents

Chapter 1 Overview of Installation

This chapter provides an overview of FUJITSU Enterprise Postgres Server Assistant installation and uninstallation.

1.1 Features that can be Installed

The Server Assistant can be installed.

The Server Assistant is provided as a Server Assistant package, which is installed on a different server (referred to as the arbitration server) to that of the database server.

1.2 Installation Types

The following installation types are available for FUJITSU Enterprise Postgres:

- New installation
- Reinstallation
- Multi-version installation

1.2.1 New Installation

In initial installation, the FUJITSU Enterprise Postgres Server Assistant is installed for the first time.

1.2.2 Reinstallation

Perform reinstallation to repair installed program files that have become unusable for any reason.

1.2.3 Multi-Version Installation

FUJITSU Enterprise Postgres products can be installed on the same server if the product version (indicated by "*x*" in "*x* SP*z*") is different from that of any version of the product that is already installed.

1.3 Uninstallation

Uninstallation removes the system files of the installed FUJITSU Enterprise Postgres Server Assistant.

Chapter 2 Installation and Uninstallation of the Linux Server Assistant

This chapter explains how to install and uninstall the Linux Server Assistant.

2.1 Operating Environment

This section describes the operating environment required in order to use the Linux Server Assistant.

2.1.1 Required Operating System

One of the following operating systems is required in order to use the Linux Server Assistant. Check and use minor version, which is certified and currently supported by Red Hat or SUSE for the target IBM z / Linux One hardware.

- RHEL8.2 or later minor version
- SLES 15 SP3

Information

- The following packages are required for operations on RHEL8.

Package name	Remarks
glibc	-
libgcc	-
libstdc++	-
ncurses-libs	-
nss-softokn-freebl	-
xz-libs	-
zlib	-
java-1.8.0-openjdk	Use build 1.8.0.242.b08 or later for s390x architecture.

- The following packages are required for operations on SLES 15.

Package name	Remarks
glibc	-
libgcc	-
libstdc++	-
ncurses-libs	-
nss-softokn-freebl	-
xz-libs	-
zlib	-
java-1_8_0-openjdk	Use build 1.8.0.302 or later for s390x architecture.

2.1.2 Related Software

No other software is required in order to use FUJITSU Enterprise Postgres.

The following table lists servers that can be connected to the Linux Server Assistant.

Table 2.1 Connectable servers

OS	Software name
Linux	FUJITSU Software Enterprise Postgres Advanced Edition 14 or 14 SP1

2.1.3 Excluded Software

There is no excluded software.

2.1.4 Required Patches

There are no required patches.

2.1.5 Hardware Environment

The following hardware is required in order to use the Linux Server Assistant:

Memory

At least 150 MB of memory is required.

Mandatory hardware

None.

2.1.6 Disk Space Required for Installation

The following table lists the disk space requirements of the corresponding directories for new installation of the Linux Server Assistant. If necessary, increase the size of the file system.

Table 2.2 Disk space required for installation

Directory	Required disk space Unit: MB
/etc	1
serverAssistantInstallDir	2

2.1.7 Supported System Environment

This section describes the supported system environment.

TCP/IP Protocol

FUJITSU Enterprise Postgres supports version 4 and 6 (IPv4 and IPv6) of TCP/IP protocols.

Note

Do not use link-local addresses if TCP/IP protocol version 6 addresses are used.

2.2 Installation

This section describes how to install the Linux Server Assistant.

2.2.1 Pre-installation Tasks

Check the following system environment before installing the Linux Server Assistant.

Check the disk space

Ensure that there is sufficient disk space to install the Linux Server Assistant.

Refer to "2.1.6 Disk Space Required for Installation" for information on disk space requirements.

If sufficient free disk space is unavailable, reconfigure disk partitions.

Set JAVA_HOME

Ensure that Open JRE 8 is installed, and export the JAVA_HOME environment variable.

```
#export JAVA_HOME="OpenJre8InstallDir"
```

Refer to "Appendix B Procedure when Modifying the JRE Installation" for information on modifying JRE after installation.

Executable Users

Installation and uninstallation is performed by superuser.

On the system, run the following command to become superuser.

```
$ su -
Password:******
```

2.2.2 Run Installation

The installation procedure is described below.

Note

The following characters can be used as input values:

Alphanumeric characters, hyphens and forward slashes

1. Stop the program

If the installation method is the following, the program must be stopped:

- Reinstallation

Before starting the installation, stop the following:

- Mirroring Controller arbitration process

  Execute the mc_arb command in stop mode to stop the Mirroring Controller arbitration process.

  Example

  ```
  $ mc_arb stop -M /mcarb_dir/arbiter1
  ```

2. Mount the DVD drive

Insert the Server Assistant program DVD into the DVD drive, and then execute the following command:

Example

```
# mount -t iso9660 -r -o loop /dev/dvd /media/dvd
```

Here /dev/dvd is the device name for the DVD drive (which may vary depending on your environment), and /media/dvd is the mount point (which may need to be created before calling the command).

Note

If the DVD was mounted automatically using the automatic mount daemon (autofs), "noexec" is set as the mount option, so the installer may fail to start. In this case, use the mount command to remount the DVD correctly, and then run the installation. Note that the mount options of a mounted DVD can be checked by executing the mount command without any arguments.

3. Run the installation

Install the following packages (rpm) with the rpm command.

Feature Name	Operating System	Package (Path)
Server Assistant	RHEL8	ARBITER/Linux/packages/r80s390x/FJSVfsep-ARB-*rpm
	SLES 15	ARBITER/Linux/packages/SUSE15s390x/FJSVfsep-ARB-*rpm

*is the version, OS, etc.

Example

In the following example, /media/dvd is the name of the mount point where the DVD is mounted.

Below is an example of new installation on RHEL8.

```
# cd /media/dvd/ARBITER/Linux/packages/r80s390x
# rpm -ivh FJSVfsep-ARB-14-1401-0.el8.s390x.rpm
```

Below is an example of new installation on SLES 15.

```
# cd /media/dvd/ARBITER/Linux/packages/SUSE15s390x
# rpm -ivh FJSVfsep-ARB-14-1401-0.s15.s390x.rpm
```

Below is an example of reinstallation on RHEL8.

```
# cd /media/dvd/ARBITER/Linux/packages/r80s390x
# rpm -ivh --replacepkgs FJSVfsep-ARB-14-1401-0.el8.s390x.rpm
```

Below is an example of reinstallation on SLES15.

```
# cd /media/dvd/ARBITER/Linux/packages/SUSE15s390x
# rpm -ivh --replacepkgs FJSVfsep-ARB-14-1401-0.s15.s390x.rpm
```

Note

If you perform reinstallation, and an installation prefix (in the --prefix option of the rpm command) was used for the new installation, you must use the same prefix.

4. Set the installation environment

Use the mc_update_jre_env command to set the installation environment to be used by the Server Assistant.

Example

```
# /opt/fsepv<x>assistant/bin/mc_update_jre_env
```

2.3 Uninstallation

This section describes how to uninstall the Linux Server Assistant.

Note

Before uninstalling the product, close the product program.

2.3.1 Run Uninstallation

The uninstallation procedure is described below.

1. Stop the program

Before starting the uninstallation, stop the following:

- Mirroring Controller arbitration process

  Execute the mc_arb command in stop mode to stop the Mirroring Controller arbitration process.

  Example

```
$ mc_arb stop -M /mcarb_dir/arbiter1
```

2. Verifying Installation Features

Verify that the feature to be removed is installed by executing the following command.

Feature Name	Package Name
Server Assistant	FJSVfsep-ARB-<*x*>

* Where *x* is a number indicating the version.

Example

```
# rpm -qi FJSVfsep-ARB-14
```

3. Run the uninstallation

Run the following command.

```
# rpm -e FJSVfsep-ARB-14
```

The installation directory may remain after uninstallation. If it is not required, delete it.

Chapter 3 Setup of the Server Assistant

The Server Assistant is a feature that is installed and used on the arbitration server, so its setup is performed as the arbitration server setup.

See

Refer to "Setting Up Database Multiplexing Mode" in the Cluster Operation Guide (Database Multiplexing) for information on setting up and operating the Mirroring Controller arbitration server.

Appendix A Estimating Memory Requirements

This appendix explains how to estimate the memory.

A.1 Server Assistant Memory Requirements

This section describes the formula for estimating memory requirements for the Server Assistant.

Use the following formula to obtain a rough estimate of memory requirements:

```
Memory usage of the Server Assistant
                                = Peak memory usage of the Mirroring Controller arbitration processes
                                 + Peak memory usage of the Mirroring Controller commands

Peak memory usage of the Mirroring Controller arbitration processes=100 MB

Peak memory usage of the Mirroring Controller commands=50 MB * Number of commands executed
simultaneously
```

Appendix B Procedure when Modifying the JRE Installation

This appendix describes the procedure to follow when modifying the JRE installation.

Therefore, when updating or reinstalling JRE, it is necessary to restart the Mirroring Controller arbitration process, therefore follow the procedure below to modify the JRE installation:

1. Stop the Mirroring Controller arbitration process.

   Refer to the Cluster Operation Guide (Database Multiplexing) for details.

2. Modify the JRE installation.

3. Change the installation environment to be used by Mirroring Controller.

   Set the JAVA_HOME environment variable to the installation destination of new JRE 8, and use the mc_update_jre_env command to change the installation environment to be used by the Server Assistant.
   This procedure must be executed by the superuser.

   Example

   /opt/fsepv<*x*>assistant/bin is the installation directory where the Server Assistant is installed.

```
$ su -
Password:******
# export JAVA_HOME="OpenJre8InstallDir"
# /opt/fsepv<x>assistant/bin/mc_update_jre_env
```

4. Start the Mirroring Controller arbitration process.

   Refer to the Cluster Operation Guide (Database Multiplexing) for details.

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Fujitsu Enterprise Postgres 14 SP1 on IBM LinuxONE

Application Development Guide

SP1

Linux

FUJITSU

J2UL-2752-02ZLZ0(01)
April-2024

Preface

Purpose of this document

This is a guide for the developers of FUJITSU Enterprise Postgres applications.

Intended readers

This document is intended for developers of applications that use FUJITSU Enterprise Postgres. Of the interfaces provided by FUJITSU Enterprise Postgres, this guide describes the PostgreSQL extended interface.

Readers of this document are also assumed to have general knowledge of:

- PostgreSQL
- SQL
- Linux

Structure of this document

This document is structured as follows:

Chapter 1 Overview of the Application Development Function

Provides an overview of FUJITSU Enterprise Postgres application development.

Chapter 2 JDBC Driver

Explains how to use JDBC drivers.

Chapter 3 ODBC Driver

Explains how to use ODBC drivers.

Chapter 4 C Library (libpq)

Explains how to use C applications.

Chapter 5 Embedded SQL in C

Explains how to use embedded SQL in C.

Chapter 6 SQL References

Explains the SQL statements which were extended in FUJITSU Enterprise Postgres development.

Chapter 7 Compatibility with Oracle Databases

Explains features that are compatible with Oracle databases.

Chapter 8 Application Connection Switch Feature

Explains the application connection switch feature.

Chapter 9 Performance Tuning

Explains how to tune application performance.

Chapter 10 Scan Using a Vertical Clustered Index (VCI)

Explains how to perform scan using a Vertical Clustered Index (VCI).

Appendix A Precautions when Developing Applications

Provides some points to note about application development.

Appendix B Conversion Procedures Required due to Differences from Oracle Database

Explains how to convert from an Oracle database to FUJITSU Enterprise Postgres, within the scope noted in "Compatibility with Oracle Databases" from the following perspectives.

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Issue date and version

```
Edition 2.1: April 2024
Edition 2.0: September 2022
Edition 1.0: February 2022
```

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Revision History

Changes	Place of Change	Edition
When fixing statistics in pg_dbms_stats, change behavior so that the height of the Btree index is fixed as well.	9.1.2 Locked Statistics	Edition 2.1

Contents

Chapter 1 Overview of the Application Development Function

The interface for application development provided by FUJITSU Enterprise Postgres is perfectly compatible with PostgreSQL.

Along with the PostgreSQL interface, FUJITSU Enterprise Postgres also provides the following extended interfaces:

- Support for National Characters

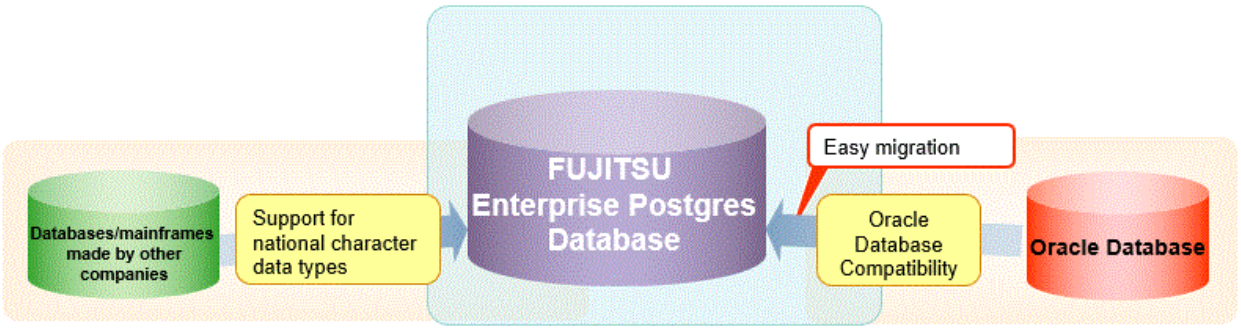
  In order to secure portability from mainframes and databases of other companies, FUJITSU Enterprise Postgres provides data types that support national characters. The national characters are usable from the client application languages.

  Refer to "1.1 Support for National Characters" for details.

- Compatibility with Oracle Databases

  Compatibility with Oracle databases is offered. Use of the compatible features means that the revisions to existing applications can be isolated, and migration to open interfaces is made simpler.

  Refer to "1.2 Compatibility with Oracle Database" for details.



- Application connection switch feature

  The application connection switch feature is provided to enable automatic connection to the target server when there are multiple servers with redundant configurations.

  Refer to "1.3 Application Connection Switch Feature" for details.

- Performance tuning

  The following features are provided to control SQL statement query plans:

  - Optimizer hints
  - Locked statistics

  Refer to "9.1 Enhanced Query Plan Stability" for details.

- Scanning using a Vertical Clustered Index (VCI)

  Scans becomes faster during aggregation of many rows by providing the features below:

  - Vertical clustered index (VCI)
  - In-memory data

  Refer to "Chapter 10 Scan Using a Vertical Clustered Index (VCI)" for details.

1.1 Support for National Characters

NCHAR type is provided as the data type to deal with national characters.

Point

- NCHAR can only be used when the character set of the database is UTF-8.
- NCHAR can be used in the places where CHAR can be used (function arguments, etc.).
- For applications handling NCHAR type data in the database, the data format is the same as CHAR type. Therefore, applications handling data in NCHAR type columns can also be used to handle data stored in CHAR type columns.

Note

Note the following in order to cast NCHAR type data as CHAR type.

- When comparing NCHAR type data where the length differs, ASCII spaces are used to fill in the length of the shorter NCHAR type data so that it can be processed as CHAR type data.
- Depending on the character set, the data size may increase by between 1.5 and 2 times.
- Use the AS clause to specify "varchar" as the column alias.

1.1.1 Literal

Syntax

```
{ N | n }'[national character [ ...]]'
```

General rules

National character string literals consist of an 'N' or 'n', and the national character is enclosed in single quotation marks ('). Example: N'ABCDEF'

The data type is national character string type.

1.1.2 Data Type

Syntax

```
{ NATIONAL CHARACTER | NATIONAL CHAR | NCHAR } [ VARYING ][(length) ]
```

The data type of the NCHAR type column is as follows:

Data type specification format	Explanation
NATIONAL CHARACTER(*n*) NATIONAL CHAR(*n*) NCHAR(*n*)	National character string with a fixed length of *n* characters This will be the same as (1) if (*n*) is omitted. *n* is a whole number larger than 0.
NATIONAL CHARACTER VARYING(*n*) NATIONAL CHAR VARYING(*n*) NCHAR VARYING(*n*)	National character string with a variable length with a maximum of *n* characters Any length of national character string can be accepted when this is omitted.

Data type specification format	Explanation
	n is a whole number larger than 0.

General rules

NCHAR is the national character string type data type. The length is the number of characters.

The length of the national character string type is as follows:

- When VARYING is not specified, the length of national character strings is fixed and will be the specified length.
- When VARYING is specified, the length of national character strings will be variable.
  In this case, the lower limit will be 0 and the upper limit will be the value specified for length.
- NATIONAL CHARACTER, NATIONAL CHAR, and NCHAR each have the same meaning.

When the national character string to be stored is shorter than the declared upper limit, the NCHAR value is filled with spaces, whereas NCHAR VARYING is stored as is.

The upper limit for character storage is approximately 1GB.

1.1.3 Functions and Operator

Comparison operator

When a NCHAR type or NCHAR VARYING type is specified in a comparison operator, comparison is only possible between NCHAR types or NCHAR VARYING types.

String functions and operators

All of the string functions and operators that can be specified by a CHAR type can also be specified by a NCHAR type. The behavior of these string functions and operators is also the same as with CHAR type.

Pattern matching (LIKE, SIMILAR TO regular expression, POSIX regular expression)

The patterns specified when pattern matching with NCHAR types and NCHAR VARYING types specify the percent sign (%) and the underline (_).

The underline (_) means a match with one national character. The percent sign (%) means a match with any number of national characters 0 or over.

1.2 Compatibility with Oracle Database

The following features have been extended in order to enhance compatibility with Oracle databases:

- Query (external join operator (+), DUAL table)
- Function (DECODE, SUBSTR, NVL)
- Built-in package (DBMS_OUTPUT, UTL_FILE, DBMS_SQL)

Refer to "Chapter 7 Compatibility with Oracle Databases" for information on the features compatible with Oracle databases.

1.3 Application Connection Switch Feature

The application connection switch feature enables automatic connection to the target server when there are multiple servers with redundant configurations.

Refer to " Chapter 8 Application Connection Switch Feature " for information on the application connection switch feature.

1.3.1 Integration with Database Multiplexing

The application connection switch feature is provided to enable automatic connection to the appropriate server when there are multiple servers with redundant configurations.

See

Refer to the Cluster Operation Guide (Database Multiplexing) for information on database multiplexing.

1.4 Notes on Application Compatibility

FUJITSU Enterprise Postgres upgrades contain feature improvements and enhancements that may affect the applications.

Accordingly, note the points below when developing applications, to ensure compatibility after upgrade.

- Checking execution results
- Referencing system catalogs
- Using functions

1.4.1 Checking Execution Results

Refer to SQLSTATE output in messages to check the SQL statements used in applications and the execution results of commands used during development.

See

Refer to Messages for information on the message content and number.

Refer to "PostgreSQL Error Codes" under "Appendixes" in the PostgreSQL Documentation for information on SQLSTATE.

1.4.2 Referencing System Catalogs

System catalogs can be used to obtain information about the FUJITSU Enterprise Postgres system and database objects.

However, system catalogs may change when the FUJITSU Enterprise Postgres version is upgraded. Also, there are many system catalogs that return information that is inherent to FUJITSU Enterprise Postgres.

Accordingly, reference the information schema defined in standard SQL (information_schema) wherever possible. Note also that queries specifying "*" in the selection list must be avoided to prevent columns being added.

See

Refer to "The Information Schema" under "Client Interfaces" in the PostgreSQL Documentation for details.

The system catalog must be referenced to obtain information not found in the information schema. Instead of directly referencing the system catalog in the application, define a view for that purpose. Note, however, that when defining the view, the column name must be clearly specified after the view name.

An example of defining and using a view is shown below.

Example

```
CREATE VIEW my_tablespace_view(spcname) AS SELECT spcname FROM pg_tablespace;
SELECT * FROM my_tablespace_view V1, pg_tables T1 WHERE V1.spcname = T1.tablespace;
```

If changes are made to a system catalog, the user will be able to take action by simply making changes to the view, without the need to make changes to the application.

The following shows an example of taking action by redefining a view as if no changes were made.

The pg_tablespace system catalog is redefined in response to the column name being changed from spcname to spacename.

Example

```
DROP VIEW my_tablespace_view;
CREATE VIEW my_tablespace_view(spcname) AS SELECT spacename FROM pg_tablespace;
```

1.4.3 Using Functions

The default functions provided with FUJITSU Enterprise Postgres enable a variety of operations and manipulations to be performed, and information to be obtained, using SQL statements.

However, it is possible that internal FUJITSU Enterprise Postgres functions, such as those relating to statistical information or for obtaining system-related information, may change as FUJITSU Enterprise Postgres versions are upgraded.

Accordingly, when using these functions, define them as new functions and then use the newly-defined functions in the applications.

An example of defining and using a function is shown below.

Example

```
CREATE FUNCTION my_func(relid regclass) RETURNS bigint LANGUAGE SQL AS 'SELECT
pg_relation_size(relid)';
SELECT my_func(2619);
```

If changes are made to a function, the user will be able to take action by simply redefining the function, without the need to make changes to the application.

The following shows an example of taking action by redefining a function as if no changes were made.

The pg_relation_size function is redefined after arguments are added.

Example

```
DROP FUNCTION my_func(regclass);
CREATE FUNCTION my_func(relid regclass) RETURNS bigint LANGUAGE SQL AS 'SELECT pg_relation_size(relid,
$$main$$)';
```

Chapter 2 JDBC Driver

This section describes how to use JDBC drivers.

2.1 Development Environment

This section describes application development using JDBC drivers and the runtime environment.

2.1.1 Combining with JDK or JRE

Refer to Installation and Setup Guide for Client for information on combining with JDK or JRE where JDBC drivers can operate.

2.2 Setup

This section describes the environment settings required to use JDBC drivers and how to encrypt communication data.

2.2.1 Environment Settings

Configuration of the CLASSPATH environment variable is required as part of the runtime environment for JDBC drivers.

The name of the JDBC driver file is as follows:

```
postgresql-jdbc42.jar
```

The examples below show how to set the CLASSPATH environment variable.

Note that "<*x*>" indicates the product version.

- Setting example (TC shell)

```
setenv CLASSPATH /opt/fsepv<x>client64/jdbc/lib/postgresql-jdbc42.jar:${CLASSPATH}
```

- Setting example (bash)

```
CLASSPATH=/opt/fsepv<x>client64/jdbc/lib/postgresql-jdbc42.jar:$CLASSPATH;export CLASSPATH
```

2.2.2 Message Language and Encoding System Used by Applications Settings

If the JDBC driver is used, it will automatically set the encoding system on the client to UTF-8, so there is no need to configure this.

See

Refer to "Automatic Character Set Conversion Between Server and Client" in "Server Administration" in the PostgreSQL Documentation for information on encoding systems.

Language settings

You must match the language settings for the application runtime environment with the message locale settings of the database server.

Set language in the "user.language" system property.

Example

Example of running a Java command with system property specified

```
java -Duser.language=en TestClass1
```

2.2.3 Settings for Encrypting Communication Data

When using the communication data encryption feature to connect to the database server, set as follows:

Settings for encrypting communication data for connection to the server

This section describes how to create applications for encrypting communication data.

Set the property of the SSL parameter to "true" to encrypt. The default for the SSL parameter is "false".

If ssl is set to "true", sslmode is internally treated as "verify-full".

Example

- Setting example 1

```
String url = "jdbc:postgresql://sv1/test";
Properties props = new Properties();
props.setProperty("user","fsepuser");
props.setProperty("password","secret");
props.setProperty("ssl","true");
props.setProperty("sslfactory","org.postgresql.ssl.DefaultJavaSSLFactory");
Connection conn = DriverManager.getConnection(url, props);
```

- Setting example 2

```
String url = "jdbc:postgresql://sv1/test?
user=fsepuser&password=secret&ssl=true&sslfactory=org.postgresql.ssl.DefaultJavaSSLFactory";
Connection conn = DriverManager.getConnection(url);
```

To prevent spoofing of the database server, you need to use the keytool command included with Java to import the CA certificate to the Java keystore. In addition, specify "org.postgresql.ssl.DefaultJavaSSLFactory" for the sslfactory parameter.

Refer to JDK documentation for details.

Note

There is no need to set the ssl parameter if the connection string of the DriverManager class is specified, or if the sslmode parameter is specified in the data source, such as when the application connection switch feature is used. If the ssl parameter is set, the value in the sslmode parameter will be enabled.

See

Refer to "Secure TCP/IP Connections with SSL" in "Server Administration" in the PostgreSQL Documentation for information on encrypting communication data.

2.3 Connecting to the Database

This section explains how to connect to a database.

- Using the DriverManager Class
- Using the PGConnectionPoolDataSource Class
- Using the PGXADataSource Class

Note

Do not specify "V2" for the "*protocolVersion*" of the connection string.

2.3.1 Using the DriverManager Class

To connect to the database using the DriverManager class, first load the JDBC driver, then specify the connection string as a URI in the API of the DriverManager class.

Load the JDBC driver

Specify org.postgresql.Driver.

Connection string

URI connection is performed as follows:

```
jdbc:postgresql://host:port/database?
user=user&password=password1&loginTimeout=loginTimeout&socketTimeout=socketTimeout
```

Argument	Description
host	Specify the host name for the connection destination.
port	Specify the port number for the database server. The default is "27500".
database	Specify the database name.
user	Specify the username that will connect with the database. If this is omitted, the username logged into the operating system that is executing the application will be used.
password	Specify a password when authentication is required.
loginTimeout	Specify the timeout for connections (in units of seconds). Specify a value between 0 and 2147483647. There is no limit set if you set 0 or an invalid value. An error occurs when a connection cannot be established within the specified time.
socketTimeout	Specify the timeout for communication with the server (in units of seconds). Specify a value between 0 and 2147483647. There is no limit set if you set 0 or an invalid value. An error occurs when data is not received from the server within the specified time.

Example

Code examples for applications

```
import java.sql.*;
...
Class.forName("org.postgresql.Driver");
String url = "jdbc:postgresql://sv1:27500/mydb?
user=myuser&password=myuser01&loginTimeout=20&socketTimeout=20";
Connection con = DriverManager.getConnection(url);
```

2.3.2 Using the PGConnectionPoolDataSource Class

To connect to databases using data sources, specify the connection information in the properties of the data source.

Method description

Argument	Description
setServerName	Specify the host name for the connection destination.
setPortNumber	Specify the port number for the database server. The default is "27500".
setDatabaseName	Specify the database name.
setUser	Specify the username of the database. By default, the name used will be that of the user on the operating system that is executing the application.
setPassword	Specify a password for server authentication.
setLoginTimeout	Specify the timeout for connections (in units of seconds). Specify a value between 0 and 2147483647. There is no limit set if you set 0 or an invalid value. An error occurs when a connection cannot be established within the specified time.
setSocketTimeout	Specify the timeout for communication with the server (in units of seconds). Specify a value between 0 and 2147483647. There is no limit set if you set 0 or an invalid value. An error occurs when data is not received from the server within the specified time.

Example

Code examples for applications

```
import java.sql.*;
import org.postgresql.ds.PGConnectionPoolDataSource;
...
PGConnectionPoolDataSource source = new PGConnectionPoolDataSource();
source.setServerName("sv1");
source.setPortNumber(27500);
source.setDatabaseName("mydb");
source.setUser("myuser");
source.setPassword("myuser01");
source.setLoginTimeout(20);
source.setSocketTimeout(20);
...
Connection con = source.getConnection();
```

2.3.3 Using the PGXADataSource Class

To connect to databases using data sources, specify the connection information in the properties of the data source.

Method description

Argument	Description
setServerName	Specify the host name for the connection destination.
setPortNumber	Specify the port number for the database server. The default is "27500".
setDatabaseName	Specify the database name.
setUser	Specify the username that will connect with the database. If this is omitted, the name used will be that of the user on the operating system that is executing the application.
setPassword	Specify a password when authentication by a password is required.

Argument	Description
setLoginTimeout	Specify the timeout for connections. The units are seconds. Specify a value between 0 and 2147483647. There is no limit set if you set 0 or an invalid value. An error occurs when a connection cannot be established within the specified time.
setSocketTimeout	Specify the timeout for communication with the server. The units are seconds. Specify a value between 0 and 2147483647. There is no limit set if you set 0 or an invalid value. An error occurs when data is not received from the server within the specified time.

Example

Code examples for applications

```
import java.sql.*;
import org.postgresql.xa.PGXADataSource;
...
PGXADataSource source = new PGXADataSource();
source.setServerName("sv1");
source.setPortNumber(27500);
source.setDatabaseName("mydb");
source.setUser("myuser");
source.setPassword("myuser01");
source.setLoginTimeout(20);
source.setSocketTimeout(20);...
Connection con = source.getConnection();
```

2.4 Application Development

This section describes the data types required when developing applications that will be connected with FUJITSU Enterprise Postgres.

2.4.1 Relationship between the Application Data Types and Database Data Types

The following table shows the correspondence between data types in applications and data types in databases.

Data type on the server	Java data type	Data types prescribed by java.sql.Types
character	String	java.sql.Types.CHAR
national character	String	java.sql.Types.NCHAR
character varying	String	java.sql.Types.VARCHAR
national character varying	String	java.sql.Types.NVARCHAR
text	String	java.sql.Types.VARCHAR
bytea	byte[]	java.sql.Types.BINARY
smallint	short	java.sql.Types.SMALLINT
integer	int	java.sql.Types.INTEGER
bigint	long	java.sql.Types.BIGINT
smallserial	short	java.sql.Types.SMALLINT

Data type on the server	Java data type	Data types prescribed by java.sql.Types
serial	int	java.sql.Types.INTEGER
bigserial	long	java.sql.Types.BIGINT
real	float	java.sql.Types.REAL
double precision	double	java.sql.Types.DOUBLE
numeric	java.math.BigDecimal	java.sql.Types.NUMERIC
decimal	java.math.BigDecimal	java.sql.Types.DECIMAL
money	String	java.sql.Types.OTHER
date	java.sql.Date	java.sql.Types.DATE
time with time zone	java.sql.Time	java.sql.Types.TIME
time without time zone	java.sql.Time	java.sql.Types.TIME
timestamp without time zone	java.sql.Timestamp	java.sql.Types.TIMESTAMP
timestamp with time zone	java.sql.Timestamp	java.sql.Types.TIMESTAMP
interval	org.postgresql.util.PGInterval	java.sql.Types.OTHER
boolean	boolean	java.sql.Types.BIT
bit	boolean	java.sql.Types.BIT
bit varying	org.postgresql.util.Pgobject	java.sql.Types.OTHER
oid	long	java.sql.Types.BIGINT
xml	java.sql.SQLXML	java.sql.Types.SQLXML
array	java.sql.Array	java.sql.Types.ARRAY
uuid	java.util.UUID	java.sql.Types.OTHER
point	org.postgresql.geometric.Pgpoint	java.sql.Types.OTHER
box	org.postgresql.geometric.Pgbox	java.sql.Types.OTHER
lseg	org.postgresql.geometric.Pglseg	java.sql.Types.OTHER
path	org.postgresql.geometric.Pgpath	java.sql.Types.OTHER
polygon	org.postgresql.geometric.PGpolygon	java.sql.Types.OTHER
circle	org.postgresql.geometric.PGcircle	java.sql.Types.OTHER
json	org.postgresql.util.PGobject	java.sql.Types.OTHER
Network address type (inet,cidr,macaddr, macaddr8)	org.postgresql.util.PGobject	java.sql.Types.OTHER
Types related to text searches (svector, tsquery)	org.postgresql.util.PGobject	java.sql.Types.OTHER
Enumerated type	org.postgresql.util.PGobject	java.sql.Types.OTHER
Composite type	org.postgresql.util.PGobject	java.sql.Types.OTHER
Range type	org.postgresql.util.PGobject	java.sql.Types.OTHER

Although the getString() method of the ResultSet object can be used for all server data types, it is not guaranteed that it will always return a string in the same format for the same data type.

Strings in a format compatible with the JDBC specifications can be obtained using the Java toString() method of the appropriate data type (for example, getInt(), getTimestamp()) to conform to the data type on the server.

2.4.2 Statement Caching Feature

The statement caching feature caches SQL statements for each individual connection. This means that when an SQL statement with an identical string is next executed, the analysis and creation of the statement can be skipped. This improves performance in cases such as when an SQL statement with an identical string is executed within a loop or method that is executed repeatedly. Furthermore, the statement caching feature can be combined with the connection pooling feature to further enhance performance.

Cache registration controls

You can configure whether to cache SQL statements using the setPoolable(boolean) method of the PreparedStatement class when the statement caching feature is enabled.

Values that can be configured are shown below:

false

SQL statements will not be cached, even when the statement caching feature is enabled.

true

SQL statements will be cached if the statement caching feature is enabled.

2.4.3 Creating Applications while in Database Multiplexing Mode

This section explains points to consider when creating applications while in database multiplexing mode.

See

- Refer to the Cluster Operation Guide (Database Multiplexing) for information on database multiplexing mode.

2.4.3.1 Errors when an Application Connection Switch Occurs and Corresponding Actions

If an application connection switch occurs while in database multiplexing mode, explicitly close the connection and then reestablish the connection or reexecute the application.

The table below shows errors that may occur during a switch, and the corresponding action to take.

State		Error information (*1)	Action
Server failure or FUJITSU Enterprise Postgres system failure	Failure occurs during access	57P01 08006 08007	After the switch is complete, reestablish the connection, or reexecute the application.
	Accessed during system failure	08001	
Switch to the standby server	Switched during access	57P01 08006 08007	
	Accessed during switch	08001	

*1: Return value of the getSQLState() method of SQLException.

Chapter 3 ODBC Driver

This section describes application development using ODBC drivers.

3.1 Development Environment

Applications using ODBC drivers can be developed using ODBC interface compatible applications.

Refer to the manuals for the programming languages corresponding to the ODBC interface for information about the environment for development.

FUJITSU Enterprise Postgres supports ODBC 3.5.

3.2 Setup

You need to set up PsqlODBC, which is an ODBC driver, in order to use applications that use ODBC drivers with FUJITSU Enterprise Postgres. PsqlODBC is included in the FUJITSU Enterprise Postgres client package.

The following describes how to register the ODBC drivers and the ODBC data source.

3.2.1 Registering ODBC Drivers

When using the ODBC driver on Linux platforms, register the ODBC driver using the following procedure:

1. Install the ODBC driver manager (unixODBC)

   Information

   - FUJITSU Enterprise Postgres supports unixODBC Version 2.3 or later.

     You can download unixODBC from the following site:

     http://www.unixodbc.org/

   - To execute unixODBC, you must first install libtool 2.2.6 or later.

     You can download libtool from the following website:

     http://www.gnu.org/software/libtool/

   [Note]

   - ODBC driver operation is supported.
   - unixODBC operation is not supported.

2. Register the ODBC drivers

   Edit the ODBC driver manager (unixODBC) odbcinst.ini file.

   Information

   [location of the odbcinst.ini file]

   ```
   unixOdbcInstallDir/etc/odbcinst.ini
   ```

   Set the following content:

Definition name	Description	Setting value
[Driver name]	ODBC driver name	Set the name of the ODBC driver. Select the two strings below that correspond to the application type. Concatenate the strings with no spaces, enclose in "[ ]", and then specify this as the driver name. **Note** The placeholders shown below are enclosed in angle brackets '<>' to avoid confusion with literal text. Do not include the angle brackets in the string. - Application architecture "FUJITSUEnterprisePostgres<*fujitsuEnterprisePostgresClientVers*>s390x" - Encoding system used by the application - In Unicode (only UTF-8 can be used) "unicode" - Other than Unicode "ansi" Example: The encoding system used by the application is Unicode: "[FUJITSUEnterprisePostgres<*fujitsuEnterprisePostgresClientVers*>s390xunicode]"
Description	Description of the ODBC driver	Specify a supplementary description for the current data source. Any description may be set.

Driver64	Path of the ODBC driver (64-bit)	Set the path of the ODBC driver (64-bit).
		- If the encoding system is Unicode:
		`fujitsuEnterprisePostgresClientInstallDir/odbc/lib/psqlodbcw.so`
		- If the encoding system is other than Unicode:
		`fujitsuEnterprisePostgresClientInstallDir/odbc/lib/psqlodbca.so`

FileUsage	Use of the data source file	Specify 1.
Threading	Level of atomicity secured for connection pooling	Specify 2.

Example

Note that "<x>" indicates the product version.

```
[FUJITSU Enterprise Postgres14s390xunicode]
Description = FUJITSU Enterprise Postgres 14 s390x unicode driver
Driver64    = /opt/fsepv<x>client64/odbc/lib/psqlodbcw.so
FileUsage   = 1
Threading   = 2
```

3.2.2 Registering ODBC Data Sources

This section describes how to register ODBC data sources on Linux.

1. Register the data sources

   Edit the odbc.ini definition file for the data source.

   Information

   Edit the file in the installation directory for the ODBC driver manager (unixODBC)

   ```
   unixOdbcInstallDir/etc/odbc.ini
   ```

   Or

   Create a new file in the HOME directory

   ```
   ~/.odbc.ini
   ```

   Point

   If *unixOdbcInstallDir* is edited, these will be used as the shared settings for all users that log into the system. If created in the HOME directory (~/), the settings are used only by the single user.

   Set the following content:

Definition name	Setting value
[Data source name]	Set the name for the ODBC data source.
Description	Set a description for the ODBC data source. Any description may be set.
Driver	Set the following as the name of the ODBC driver. Do not change this value. Select the two strings below that correspond to the application type. Concatenate the strings with no spaces and then specify this as the driver name. **Note** The placeholders shown below are enclosed in angle brackets '<>' to avoid confusion with literal text. Do not include the angle brackets in the string. - Application architecture "FUJITSU Enterprise Postgres<fujitsuEnterprisePostgresClientVers>s390x" - Encoding system used by the application - In Unicode (only UTF-8 can be used) "unicode" - Other than Unicode

Definition name	Setting value
	"ansi" Example: The encoding system used by the application is Unicode: "FUJITSU Enterprise Postgres<*fujitsuEnterprisePostgresClientVers*>s390xunicode"
Database	Specify the database name to be connected.
Servername	Specify the host name for the database server.
Username	Specify the user ID that will connect with the database.
Password	Specify the password for the user that will connect to the database.
Port	Specify the port number for the database server. The default is "27500".
SSLMode	Specify the communication encryption method. The setting values for SSLMode are as follows: - disable: Connect without SSL - allow: Connect without SSL, and if it fails, connect using SSL - prefer: Connect using SSL, and if it fails, connect without SSL - require: Connect always using SSL - verify-ca: Connect using SSL, and use a certificate issued by a trusted CA (*1) - verify-full: Connect using SSL, and use a certificate issued by a trusted CA to verify if the server host name matches the certificate (*1)
ReadOnly	Specify whether to set the database as read-only. - 1: Set read-only - 0: Do not set read-only

*1: If specifying either "verify-ca" or "verify-full", use the environment variable PGSSLROOTCERT to specify the CA certificate file as shown below.

Example

```
export PGSSLROOTCERT=cACertificateFileStorageDir/root.crt
```

Example

```
[MyDataSource]
Description     = FUJITSU Enterprise Postgres
Driver          = FUJITSU Enterprise Postgres14s390xansi
Database        = db01
Servername      = sv1
Port            = 27500
ReadOnly        = 0
```

Note

In consideration of security, specify the UserName and the Password by the application.

2. Configure the environment variable settings

   To execute applications that use ODBC drivers, all of the following settings must be configured in the LD_LIBRARY_PATH environment variable:

- *fujitsuEnterprisePostgresClientInstallDir*\lib
- *unixOdbcInstallDir(*1)*\lib
- *libtoolInstallDir(*1)*\lib

*1: If the installation directory is not specified when unixODBC and libtool are installed, they will be installed in /usr/local.

3.2.3 Message Language and Encoding System Used by Applications Settings

This section explains the language settings for the application runtime environment and the encoding settings for the application.

Language settings

You must match the language settings for the application runtime environment with the message locale settings of the database server.

Messages output by an application may include text from messages sent from the database server. In the resulting text, the text of the application message will use the message locale of the application, and the text of the message sent by the database server will use the message locale of the database server. If the message locales do not match, more than one language or encoding system will be used. Moreover, if the encoding systems do not match, characters in the resulting text can be garbled.

Set the locale for messages (LC_MESSAGES category) to match the message locale of the database server. This can be done in a few different ways, such as using environment variables. Refer to the relevant manual of the operating system for information on the setlocale function.

 Example

Example of specifying "en_US.UTF-8" with the setlocale function

```
setlocale(LC_ALL,"en_US.UTF-8");
```

Specifying the locale of the LC_ALL category propagates the setting to LC_MESSAGE.

Encoding System Settings

Ensure that the encoding system that is embedded in the application and passed to the database, and the encoding system setting of the runtime environment, are the same. The encoding system cannot be converted correctly on the database server.

Use one of the following methods to set the encoding system for the application:

- Set the PGCLIENTENCODING environment variable in the runtime environment.
- Set the client_encoding keyword in the connection string.
- Use the PQsetClientEncoding function.

 See

Refer to "Supported Character Sets" in "Server Administration" in the PostgreSQL Documentation for information on the strings that represent the encoding system that can be set.

For example, when using "Unicode" and "8 bit", set the string "UTF8".

 Example

Setting the "PGCLIENTENCODING" environment variable

An example of setting when the encoding of the client is "UTF8" (Bash)

```
> PGCLIENTENCODING=UTF8; export PGCLIENTENCODING
```

Note

Text may be garbled when outputting results to the command prompt. Review the font settings for the command prompt if this occurs.

3.3 Connecting to the Database

Refer to the manual for the programming language corresponding to the ODBC interface.

3.4 Application Development

This section describes how to develop applications using ODBC drivers.

3.4.1 Compiling Applications

Specify the following options when compiling applications.

Table 3.1 Include file and library path

Option	How to specify the option
Path of the include file	-I *unixOdbc64bitIncludeFileDir*
Path of the library	-L *unixOdbc64bitLibraryDir*

Table 3.2 ODBC library

Type of library	Library name
Dynamic library	libodbc.so

Note

Specify -m64 when creating a 64-bit application.

Example

The following are examples of compiling ODBC applications:

```
gcc -m64 -I/usr/local/include(*1) -L/usr/local/lib(*1) -lodbc testproc.c -o testproc
```

*1: This is an example of building and installing from the source without specifying an installation directory for unixODBC. If you wish to specify a location, set the installation directory.

3.4.2 Creating Applications While in Database Multiplexing Mode

This section explains points to consider when creating applications while in database multiplexing mode.

See

- Refer to the Cluster Operation Guide (Database Multiplexing) for information on database multiplexing mode.

3.4.2.1 Errors when an Application Connection Switch Occurs and Corresponding Actions

If an application connection switch occurs while in database multiplexing mode, explicitly close the connection and then reestablish the connection or reexecute the application.

The table below shows errors that may occur during a switch, and the corresponding action to take.

State		Error information (*1)	Action
Server failure or FUJITSU Enterprise Postgres system failure	Failure occurs during access	57P01 08S01	After the switch is complete, reestablish the connection, or reexecute the application.
	Accessed during system failure	08001	
Switch to the standby server	Switched during access	57P01 08S01	
	Accessed during switch	08001	

*1: Return value of SQLSTATE.

Chapter 4 C Library (libpq)

This chapter describes how to use C libraries.

4.1 Development Environment

Install FUJITSU Enterprise Postgres Client Package for the architecture to be developed and executed.

See

Refer to Installation and Setup Guide for Client for information on the C compiler required for C application development.

4.2 Setup

This section describes the environment settings required to use C libraries and how to encrypt data for communication.

4.2.1 Environment Settings

To execute an application that uses libpq, set the environment variable as shown below.

- Required for compile/link
  - LD_LIBRARY_PATH
    fujitsuEnterprisePostgresClientInstallDir/lib
- Required for execution of the application
  - PGLOCALEDIR
    fujitsuEnterprisePostgresClientInstallDir/share/locale

Example

Note that "<*x*>" indicates the product version.

```
> LD_LIBRARY_PATH=/opt/fsepv<x>client64/lib:$LD_LIBRARY_PATH;export LD_LIBRARY_PATH
> PGLOCALEDIR=/opt/fsepv<x>client64/share/locale;export PGLOCALEDIR
```

4.2.2 Message Language and Encoding System Used by Applications Settings

This section explains the language settings for the application runtime environment and the encoding settings for the application.

Language settings

You must match the language settings for the application runtime environment with the message locale settings of the database server.

Messages output by an application may include text from messages sent from the database server. In the resulting text, the text of the application message will use the message locale of the application, and the text of the message sent by the database server will use the message locale of the database server. If the message locales do not match, more than one language or encoding system will be used. Moreover, if the encoding systems do not match, characters in the resulting text can be garbled.

Set the locale for messages (LC_MESSAGES category) to match the message locale of the database server. This can be done in a few different ways, such as using environment variables. Refer to the relevant manual of the operating system for information on the setlocale function.

Example

Example of specifying "en_US.UTF-8" with the setlocale function

```
setlocale(LC_ALL,"en_US.UTF-8");
```

Specifying the locale of the LC_ALL category propagates the setting to LC_MESSAGE.

Encoding System Settings

Ensure that the encoding system that is embedded in the application and passed to the database, and the encoding system setting of the runtime environment, are the same. The encoding system cannot be converted correctly on the database server.

Use one of the following methods to set the encoding system for the application:

- Set the PGCLIENTENCODING environment variable in the runtime environment.
- Set the client_encoding keyword in the connection string.
- Use the PQsetClientEncoding function.

See

Refer to "Supported Character Sets" in "Server Administration" in the PostgreSQL Documentation for information on the strings that represent the encoding system that can be set.

For example, when using "Unicode" and "8 bit", set the string "UTF8".

Note

Text may be garbled when outputting results to the command prompt. Review the font settings for the command prompt if this occurs.

4.2.3 Settings for Encrypting Communication Data

Set in one of the following ways when performing remote access using communication data encryption:

When setting from outside with environment variables

Specify "require", "verify-ca", or "verify-full" in the PGSSLMODE environment variable.

In addition, the parameters for the PGSSLROOTCERT and PGSSLCRL environment variables need to be set to prevent spoofing of the database server.

See

Refer to "Environment Variables" in "Client Interfaces" in the PostgreSQL Documentation for information on environment variables.

When specifying in the connection URI

Specify "require", "verify-ca", or "verify-full" in the "sslmode" parameter of the connection URI.

In addition, the parameters for the sslcert, sslkey, sslrootcert, and sslcrl need to be set to prevent spoofing of the database server.

See

Refer to "Secure TCP/IP Connections with SSL" in "Server Administration" in the PostgreSQL Documentation for information on encrypting communication data.

4.3 Connecting with the Database

Point

Use the connection service file to specify the connection destination. In the connection service file, a name (service name) is defined as a set, comprising information such as connection destination information and various types of tuning information set for connections. By using the service name defined in the connection service file when connecting to databases, it is no longer necessary to modify applications when the connection information changes.

Refer to "Client Interfaces", "The Connection Service File" in the PostgreSQL Documentation for details.

See

Refer to "Database Connection Control Functions" in "Client Interfaces" in the PostgreSQL Documentation.

In addition, refer to "5.3 Connecting with the Database" in "Embedded SQL in C " for information on connection string.

4.4 Application Development

See

Refer to "libpq - C Library" in "Client Interfaces" in the PostgreSQL Documentation for information on developing applications.

However, if you are using the C library, there are the following differences to the PostgreSQL C library (libpq).

4.4.1 Compiling Applications

Specify the following paths when compiling applications.

Refer to your compiler documentation for information on how to specify the path.

Table 4.1 Include file and library path

Type of path	Path name
Path of the include file	*fujitsuEnterprisePostgresClientInstallDir*/include
Path of the library	*fujitsuEnterprisePostgresClientInstallDir*/lib

Table 4.2 C Library (libpq library)

Type of library	Library name
Dynamic library	libpq.so
Static library	libpq.a

4.4.2 Creating Applications while in Database Multiplexing Mode

This section explains points to consider when creating applications while in database multiplexing mode.

See

- Refer to the Cluster Operation Guide (Database Multiplexing) for information on database multiplexing mode.

4.4.2.1 Errors when an Application Connection Switch Occurs and Corresponding Actions

If an application connection switch occurs while in database multiplexing mode, explicitly close the connection and then reestablish the connection or reexecute the application.

The table below shows errors that may occur during a switch, and the corresponding action to take.

State		Error information	Action
Server failure or FUJITSU Enterprise Postgres system failure	Failure occurs during access	PGRES_FATAL_ERROR(*1) 57P01(*2) NULL(*2)	After the switch is complete, reestablish the connection, or reexecute the application.
	Accessed during system failure	CONNECTION_BAD(*3)	
Switch to the standby server	Switched during access	PGRES_FATAL_ERROR(*1) 57P01(*2) NULL(*2)	
	Accessed during switch	CONNECTION_BAD(*3)	

*1: Return value of PQresultStatus().

*2: Return value of PQresultErrorField() PG_DIAG_SQLSTATE.

*3: Return value of PQstatus().

Chapter 5 Embedded SQL in C

This chapter describes application development using embedded SQL in C.

5.1 Development Environment

Install FUJITSU Enterprise Postgres Client Package for the architecture to be developed and executed.

See

Refer to Installation and Setup Guide for Client for information on the C compiler required for C application development.

Note

C++ is not supported. Create a library by implementing embedded SQL in C, and call it from C++.

5.2 Setup

5.2.1 Environment Settings

When using embedded SQL in C, the same environment settings as when using the C library (libpq) are required.

Refer to "4.2.1 Environment Settings" in "C Library (libpq)" for information on the environment settings for the library for C.

Additionally, set the following path for the precompiler ecpg in the PATH environment variable:

```
fujitsuEnterprisePostgresClientInstallDir/bin
```

5.2.2 Message Language and Encoding System Used by Applications Settings

The message language and the encoding System Settings Used by Applications settings are the same as when using the library for C.

However, in embedded SQL, the PQsetClientEncoding function cannot be used in the encoding system settings. In embedded SQL, use the SET command to specify the encoding system in client_encoding.

Refer to "4.2.2 Message Language and Encoding System Used by Applications Settings" in "C Library (libpq)" for information on the settings for the library for C.

5.2.3 Settings for Encrypting Communication Data

When encrypting the communication data, the same environment settings as when using the C library (libpq) are required.

Refer to "4.2.3 Settings for Encrypting Communication Data" in "C Library (libpq)" for information on the environment settings for the C library.

5.3 Connecting with the Database

Point

- It is recommended to use a connection service file to specify connection destinations. In the connection service file, a name (service name) is defined as a set, comprising information such as connection destination information and various types of tuning information set for connections. By using the service name defined in the connection service file when connecting to databases, it is no longer

necessary to modify applications when the connection information changes.
Refer to "The Connection Service File" in "Client Interfaces" in the PostgreSQL Documentation for information.

- If using a connection service file, perform either of the procedures below:
  - Set the service name as a string literal or host variable, as follows:

    tcp:postgresql://?service=my_service
  - Set the service name in the environment variable PGSERVICE, and use CONNECT TO DEFAULT

Use the CONNECT statement shown below to create a connection to the database server.

Format

```
EXEC SQL CONNECT TO target [AS connection-name] [USER user-name];
```

target

Write in one of the following formats:

- dbname@host:port
- tcp:postgresql://host:port/dbname[?options]
- unix:postgresql://host[:port][/dbname][?options]
  (Definition method when using the UNIX domain socket)
- SQL string literal containing one of the above formats
- Reference to a character variable containing one of the above formats
- DEFAULT

user-name

Write in one of the following formats:

- username
- username/password
- username IDENTIFIED BY password
- username USING password

Description of the arguments

Argument	Description
dbname	Specify the database name.
host	Specify the host name for the connection destination.
port	Specify the port number for the database server. The default is "27500".
connection-name	Specify connection names to identify connections when multiple connections are to be processed within a single program.
username	Specify the user that will connect with the database. If this is omitted, the name used will be that of the user on the operating system that is executing the application.
password	Specify a password when authentication is required.
options	Specify the following parameter when specifying a time for timeout. Connect parameters with & when specifying more than one. The following shows the values specified for each parameter. - connect_timeout

Argument	Description
	Specify the timeout for connections. Specify a value between 0 and 2147483647 (in seconds). There is no limit set if you set 0 or an invalid value. If "1" is specified, the behavior will be the same as when "2" was specified. An error occurs when a connection cannot be established within the specified time. - keepalives This enables keepalive. Keepalive is disabled if 0 is specified. Keepalive is enabling when any other value is specified. The default is keepalive enabled. Keepalive causes an error to occur when it is determined that the connection with the database is disabled. - keepalives_idle Specify the time until the system starts sending keepalive messages when communication with the database is not being performed. Specify a value between 1 and 32767 (in seconds). The default value of the system is used if this is not specified. - keepalives_interval Specify the interval between resends when there is no response to keepalive messages. Specify a value between 1 and 32767 (in seconds). The default value of the system is used if this is not specified. - keepalives_count Specify the number of resends for keepalive messages. Specify a value between 1 and 127. The default value of the system is used if this is not specified. - tcp_user_timeout After establishing the connection, when sending from the client to the server, if the TCP resend process operates, specify the time until it is considered to be disconnected. Specify a value between 0 and 2147483647 (in millseconds). The default value of the system is used if 0. 0 will be set as default if nothing is specified.

If a value other than 0 is specified for the tcp_user_timeout parameter, the waiting time set by the tcp_keepalives_idle parameter and tcp_keepalives_interval parameter will be invalid and the waiting time specified by the tcp_user_timeout parameter will be used.

Code examples for applications

```
EXEC SQL CONNECT TO tcp:postgresql://sv1:27500/mydb?
connect_timeout=20&keepalives_idle=20&keepalives_interval=5&keepalives_count=2&keepalives=1 USER
myuser/myuser01;
```

5.4 Application Development

Refer to "ECPG - Embedded SQL in C" in "Client Interfaces" in the PostgreSQL Documentation for information on developing applications.

However, when using embedded SQL in C, there are the following differences to the embedded SQL (ECPG) in PostgreSQL C.

5.4.1 Support for National Character Data Types

This section describes how to use the national character data types using the SQL embedded C preprocessor.

The following explains the C language variable types corresponding to the NCHAR type:

Specify the number of characters specified for the NCHAR type multiple by 4, plus 1 for the length of the host variable.

Data Type	Host variable type
NATIONAL CHARACTER(*n*)	NCHAR variable name [nx4+1]
NATIONAL CHARACTER VARYING(*n*)	NVARCHAR variable name [nx4+1]

See

Refer to "Handling Character Strings" in "Client Interfaces" in the PostgreSQL documentation for information on using character string types.

5.4.2 Compiling Applications

Append the extension "pgc" to the name of the source file for the embedded SQL in C.

When the pgc file is precompiled using the ecpg command, C source files will be created, so use the C compiler for the compile.

Precompiling example

```
ecpg testproc.pgc
```

If an optimizer hint block comment is specified for the SQL statement, specify the following option in the ecpg command:

--enable-hint

Enables the optimizer hint block comment (hereafter, referred to as the "hint clause"). If this option is not specified, the hint clause will be removed as a result of the ecpg precompile and be disabled.

The SQL statements that can be specified in the hint clause are SELECT, INSERT, UPDATE, and DELETE.

The locations in which the hint clause can be specified are immediately after one of the SELECT, INSERT, UPDATE, DELETE, or WITH keywords. A syntax error will occur if any other location is specified.

Example of specifying the hint clause

```
EXEC SQL SELECT /*+ IndexScan(prod ix01) */ name_id INTO :name_id FROM prod WHERE id = 1;
```

Refer to "9.1.1 Optimizer Hints" for information on optimizer hints.

Note

Take the following points into account when using embedded SQL source files:

- Multibyte codes expressed in SJIS or UTF-16 cannot be included in statements or host variable declarations specified in EXEC SQL.
- Do not use UTF-8 with a byte order mark (BOM), because an error may occur during compilation if the BOM character is incorrectly recognized as the source code.
- Multibyte characters cannot be used in host variable names.
- It is not possible to use a TYPE name that contains multibyte characters, even though it can be defined.

Specify the following paths when compiling a C application output with precompiling.

Refer to your compiler documentation for information on how to specify the path.

Table 5.1 Include file and library path

Type of path	Path name
Path of the include file	*fujitsuEnterprisePostgresClientInstallDir*/include
Path of the library	*fujitsuEnterprisePostgresClientInstallDir*/lib

Table 5.2 C Library

Type of library	Library name	Note
Dynamic library	libecpg.so	
	libpgtypes.so	When using the pgtypes library
Static library	libecpg.a	
	libpgtypes.a	When using the pgtypes library

5.4.3 Bulk INSERT

This section describes the bulk INSERT.

Synopsis

```
EXEC SQL [ AT conn ] [ FOR { numOfRows | ARRAY_SIZE } ]
    INSERT INTO tableName [ ( colName [, ...] ) ]
    { VALUES ( { expr | DEFAULT } [, ...] ) [, ...] | query }
    [ RETURNING * | outputExpr [ [ AS ] outputName ] [, ...]
    INTO outputHostVar [ [ INDICATOR ] indicatorVar  ]  [, ...] ];
```

Description

Bulk INSERT is a feature that inserts multiple rows of data in bulk.

By specifying the array host variable that stored the data in the VALUES clause of the INSERT statement, the data for each element in the array can be inserted in bulk. This feature is used by specifying the insertion count in the FOR clause immediately before the INSERT statement.

FOR Clause

Specify the insertion count using numOfRows or ARRAY_SIZE in the FOR clause. The FOR clause can be specified only in the INSERT statement, not in other update statements.

numOfRows and ARRAY_SIZE

Insertion processing will be executed only for the specified count. However, if the count is 1, it will be assumed that the FOR clause was omitted when the application is executed. In this case, proceed according to the INSERT specification in the PostgreSQL Documentation.

Specify the FOR clause as an integer host variable or as a literal.

Specify ARRAY_SIZE to insert all elements of the array in the table. When specifying ARRAY_SIZE, specify at least one array in *expr*.

If two or more arrays were specified in expr, it will be assumed that ARRAY_SIZE is the minimum number of elements in the array.

numOfRows or ARRAY_SIZE must exceed the minimum number of elements in all arrays specified in *expr*, *outputHostVar*, and *indicatorVal*.

The following example shows how to specify the FOR clause.

```
int  number_of_rows = 10;
int id[25];
char name[25][10];

EXEC SQL FOR :number_of_rows    /* will process 10 rows */
INSERT INTO prod (name, id) VALUES (:name, :id);

EXEC SQL FOR ARRAY_SIZE           /* will process 25 rows */
INSERT INTO prod (name, id) VALUES (:name, :id);
```

expr

Specify the value to be inserted in the table. Array host variables, host variable literals, strings, and pointer variables can be specified. Structure type arrays and pointer variable arrays cannot be specified.

Do not use pointer variables and ARRAY_SIZE at the same time. The reason for this is that the number of elements in the area represented by the pointer variable cannot be determined.

query

A query (SELECT statement) that supplies the rows to be inserted. The number of rows returned by *query* must be 1. If two or more rows are returned, an error will occur. This cannot be used at the same time as ARRAY_SIZE.

outputHostVar, indicatorVal

These must be array host variables or pointer variables.

Error Messages

Given below are the error messages that are output when bulk INSERT functionality is not used correctly.

Message

invalid statement name "FOR value should be positive integer"

Cause

The value given for *numOfRows* is less than or equal to 0.

Solution

Specify a value that is more than or equal to 1 for *numOfRows*.

Message

invalid statement name "Host array variable is needed when using FOR ARRAY_SIZE"

Cause

A host array is not specified in the values clause when using the ARRAY_SIZE keyword.

Solution

At least one host array variable should be included in the values clause

Message

SELECT...INTO returns too many rows

Cause

The number of rows returned by the 'SELECT ... INTO' query in the INSERT statement is more than one.

Solution

When the value of *numOfRows* is more than one, the maximum number of rows that can be returned by the 'SELECT ... INTO' query in the INSERT statement is one.

Limitations

The limitations when using bulk INSERT are given below.

- Array of structures should not be used as an input in the 'VALUES' clause. Attempted use will result in junk data being inserted into the table.
- Array of pointers should not be used as an input in the 'VALUES' clause. Attempted use will result in junk data being inserted into the table.
- ECPG supports the use of 'WITH' clause in single INSERT statements. 'WITH' clause cannot be used in bulk INSERT statements.
- ECPG does not calculate the size of the pointer variable. So when a pointer variable is used that includes multiple elements, *numOfRows* should be less than or equal to the number of elements in the pointer. Otherwise, junk data will be inserted into the table.
- If an error occurs, all bulk INSERT actions will be rolled back, therefore, no rows are inserted. However, if the RETURNING clause was used, and the error occurred while obtaining the rows after the insertion was successful, the insertion processing will not be rolled back.

Samples

Given below are some sample usages of the bulk INSERT functionality.

Basic Bulk INSERT

```
int in_f1[4] = {1,2,3,4};
...
EXEC SQL FOR 3 INSERT INTO target (f1) VALUES (:in_f1);
```

The number of rows to insert indicated by the FOR clause is 3, so the data in the first 3 elements of the host array variable are inserted into the table. The contents of the target table will be:

```
 f1
----
  1
  2
  3
(3 rows)
```

Also a host integer variable can be used to indicate the number of rows that will be inserted in FOR clause, which will produce the same result as above:

```
int num = 3;
int in_f1[4] = {1,2,3,4};
...
EXEC SQL FOR :num INSERT INTO target (f1) VALUES (:in_f1);
```

Inserting constant values

Constant values can also be bulk INSERTed into the table as follows:

```
EXEC SQL FOR 3 INSERT INTO target (f1,f2) VALUES (DEFAULT,'hello');
```

Assuming the 'DEFAULT' value for the 'f1' column is '0', the contents of the target table will be:

```
f1 |  f2
---+-------
 0 | hello
 0 | hello
 0 | hello
(3 rows)
```

Using ARRAY_SIZE

'FOR ARRAY_SIZE' can be used to insert the entire contents of a host array variable, without explicitly specifying the size, into the table.

```
    int in_f1[4] = {1,2,3,4};
...
EXEC SQL FOR ARRAY_SIZE INSERT INTO target (f1) VALUES (:in_f1);
```

In the above example, four rows are inserted into the table.

If there are multiple host array variables specified as input values, then the number of rows inserted is same as the smallest array size. The example given below demonstrates this usage.

```
int in_f1[4] = {1,2,3,4};
char in_f3[3][10] = {"one", "two", "three"};
...
EXEC SQL FOR ARRAY_SIZE INSERT INTO target (f1,f3) VALUES (:in_f1,:in_f3);
```

In the above example, the array sizes are 3 and 4. Given that the smallest array size is 3, only three rows are inserted into the table. The table contents are given below.

```
 f1 |  f3
----+-------
  1 | one
  2 | two
  3 | three
(3 rows)
```

Using Pointers as Input

Pointers that contain multiple elements can be used in bulk INSERT.

```
int *in_pf1 = NULL;
in_pf1 = (int*)malloc(4*sizeof(int));
in_pf1[0]=1;
in_pf1[1]=2;
in_pf1[2]=3;
in_pf1[3]=4;
...
EXEC SQL FOR 4 INSERT INTO target (f1) values (:in_pf1);
```

The above example will insert four rows into the target table.

Using SELECT query

When using bulk INSERT, the input values can be got from the results of a SELECT statement. For example,

```
EXEC SQL FOR 4 INSERT INTO target(f1) SELECT age FROM source WHERE name LIKE 'foo';
```

Assuming that the 'SELECT' query returns one row, the same row will be inserted into the target table four times.

If the 'SELECT' query returns more than one row, the INSERT statement will throw an error.

```
EXEC SQL FOR 1 INSERT INTO target(f1) SELECT age FROM source;
```

In the above example, all the rows returned by the 'SELECT' statement will be inserted into the table. In this context '1' has the meaning of 'returned row equivalent'.

Using RETURNING clause

Bulk INSERT supports the same RETURNING clause syntax as normal INSERT. An example is given below.

```
int out_f1[4];
int in_f1[4] = {1,2,3,4};
...
EXEC SQL FOR 3 INSERT INTO target (f1) VALUES (:in_f1) RETURNING f1 INTO :out_f1;
```

After the execution of the above INSERT statement, the 'out_f1' array will have 3 elements with the values of '1','2' and '3'.

5.4.4 Creating Applications while in Database Multiplexing Mode

This section explains points to consider when creating applications while in database multiplexing mode.

- Refer to the Cluster Operation Guide (Database Multiplexing) for information on database multiplexing mode.

5.4.4.1 Errors when an Application Connection Switch Occurs and Corresponding Actions

If an application connection switch occurs while in database multiplexing mode, explicitly close the connection and then reestablish the connection or reexecute the application.

The table below shows errors that may occur during a switch, and the corresponding action to take.

State		Error information (*1)	Action
Server failure or FUJITSU Enterprise Postgres system failure	Failure occurs during access	57P01 57P02 YE000 26000 40001	After the switch is complete, reestablish the connection, or reexecute the application.
	Accessed during node/system failure	08001	
Switch to the standby server	Switched during access	57P01 57P02 YE000 26000 40001	
	Accessed during switch	08001	

*1: Return value of SQLSTATE.

5.4.5 Notes

Notes on creating multithreaded applications

In embedded SQL in C, DISCONNECT ALL disconnects all connections within a process, and therefore it is not thread-safe in all operations that use connections. Do not use it in multithreaded applications.

Chapter 6 SQL References

This chapter explains the SQL statement features expanded by FUJITSU Enterprise Postgres.

6.1 Expanded Trigger Definition Feature

This section explains the expanded trigger definition feature.

6.1.1 CREATE TRIGGER

In addition to features of PostgreSQL, triggers can be created with DO option.

Synopsis

```
CREATE [ OR REPLACE ] [ CONSTRAINT ] TRIGGER name { BEFORE | AFTER | INSTEAD OF } { event [ OR ... ] }
    ON table_name
    [ FROM referenced_table_name ]
    [ NOT DEFERRABLE | [ DEFERRABLE ] [ INITIALLY IMMEDIATE | INITIALLY DEFERRED ] ]
    [ REFERENCING { { OLD | NEW } TABLE [ AS ] transition_relation_name } [ ... ] ]
    [ FOR [ EACH ] { ROW | STATEMENT } ]
    [ WHEN ( condition ) ]
    { EXECUTE { FUNCTION | PROCEDURE } function_name ( arguments )
        | DO [ LANGUAGE lang_name ] code }
```

Description

Refer to the PostgreSQL Documentation for information about CREATE TRIGGER. This section describes DO option.

A trigger which is created with DO option will be associated with the specified table or view and will execute the specified code by the specified procedural language of DO (unnamed code block) when certain events occur.

Parameters

lang_name

The name of the language that the function is implemented in.

plpgsql is supported in CREATE TRIGGER.

code

When the certain events occur, it executes the code in a specified procedural language. The unnamed code block does not require a prior definition like a function. Syntax is same as procedural language.

Note

- A trigger defined with DO option cannot be replaced by a trigger defined with EXECUTE PROCEDURE option.
- A trigger defined with EXECUTE PROCEDURE option cannot be replaced by a trigger defined with DO option.

Examples

It executes the code block that is specified by DO before the table is updated.
(Example that LANGUAGE is plpgsql)

```
CREATE TRIGGER check_update
    BEFORE UPDATE ON accounts
    FOR EACH ROW
    DO $$BEGIN RETURN NEW; END;$$ ;
```

Information

When a trigger created with DO option, a new function is created internally. The name of function is "schema name"."on table name"_"trigger name"_TRIGPROC(serial number).

Chapter 7 Compatibility with Oracle Databases

This chapter describes the environment settings and functionality offered for features that are compatible with Oracle databases.

7.1 Overview

Features compatible with Oracle databases are provided. These features enable you to easily migrate to FUJITSU Enterprise Postgres and reduce the costs of reconfiguring applications.

The table below lists features compatible with Oracle databases.

Table 7.1 Features compatible with Oracle databases

Category		Feature	
		Item	Overview
SQL	Queries	Outer join operator (+)	Operator for outer joins
		DUAL table	Table provided by the system
	Functions	DECODE	Compares values, and if they match, returns a corresponding value
		SUBSTR	Extracts part of a string using characters to specify position and length
		NVL	Returns a substitute value when a value is NULL
Package		DBMS_ALERT	Sends alerts
		DBMS_ASSERT	Perform assertions on input values
		DBMS_OUTPUT	Sends messages to clients
		DBMS_PIPE	Execution of inter-session communication
		DBMS_RANDOM	Random number generation
		DBMS_UTILITY	Addition of various functions
		UTL_FILE	Enables text file operations
		DBMS_SQL	Enables dynamic SQL execution

See

In addition to the above, refer to the file below for information on the features compatible with Oracle databases.

fujitsuEnterprisePostgresInstallDir/share/doc/extension/README.asciidoc

7.2 Precautions when Using the Features Compatible with Oracle Databases

This section provides notes on using the features compatible with oracle databases.

7.2.1 Notes on SUBSTR

SUBSTR is implemented in FUJITSU Enterprise Postgres and Oracle databases using different external specifications.

For this reason, when using SUBSTR, define which specification is to take precedence. In the default configuration of FUJITSU Enterprise Postgres, the specifications of FUJITSU Enterprise Postgres take precedence.

When using the SUBSTR function compatible with Oracle databases, set "oracle" and "pg_catalog" in the "search_path" parameter of postgresql.conf. You must specify "oracle" before "pg_catalog" when doing this.

```
search_path = '"$user", public, oracle, pg_catalog'
```

Information

- The search_path parameter specifies the order in which schemas are searched. The SUBSTR function in Oracle databases is defined in the oracle schema.
- Refer to "Statement Behavior" in "Client Connection Defaults" in "Server Administration" in the PostgreSQL Documentation for information on search_path.

7.2.2 Notes when Integrating with the Interface for Application Development

The SQL noted in "Table 7.1 Features compatible with Oracle databases" can be used in the interface for application development.

Note that both "public" and the schema name in the SQL statement must be specified as the SearchPath parameter before "oracle" and "pg_catalog" when using the Oracle database-compatible feature SUBSTR.

7.3 Queries

The following queries are supported:

- Outer Join Operator (+)
- DUAL Table

7.3.1 Outer Join Operator (+)

In the WHERE clause conditional expression, by adding the plus sign (+), which is the outer join operator, to the column of the table you want to add as a table join, it is possible to achieve an outer join that is the same as a joined table (OUTER JOIN).

Syntax

SELECT statement

```
SELECT … [WHERE [NOT] joinCond ...] …
SELECT … [WHERE srchCond ]... ] …
```

Join condition

```
{ colSpec(+) = colSpec | colSpec = colSpec(+) }
```

Note

Here we are dealing only with the WHERE clause of the SELECT statement. Refer to "SQL Commands" in "Reference" in the PostgreSQL Documentation for information on the overall syntax of the SELECT statement.

General rules

WHERE clause

- The WHERE clause specifies search condition or join conditions for the tables that are derived.
- Search conditions are any expressions that return BOOLEAN types as the results of evaluation. Any rows that do not meet these conditions are excluded from the output. When the values of the actual rows are assigned to variables and if the expression returns TRUE, those rows are considered to have met the conditions.
- Join conditions are comparison conditions that specify outer join operators. Join conditions in a WHERE clause return a table that includes all the rows that meet the join conditions, including rows that do not meet all the join conditions.
- Join conditions take precedence over search conditions. For this reason, all rows returned by the join conditions are subject to the search conditions.

- The following rules and restrictions apply to queries that use outer join operators. It is therefore recommended to use FROM clause joined tables (OUTER JOIN) rather than outer join operators:

  - Outer join operators can only be specified in the WHERE clause.
  - Outer join operators can only be specified for base tables or views.
  - To perform outer joins using multiple join conditions, it is necessary to specify outer join operators for all join conditions.
  - When combining join conditions with constants, specify outer join operators in the corresponding column specification. When not specified, they will be treated as search conditions.
  - The results column of the outer join of table t1 is not returned if table t1 is joined with table t2 by specifying an outer join operator in the column of t1, then table t1 is joined with table t3 by using search conditions.
  - It is not possible to specify columns in the same table as the left/right column specification of a join condition.
  - It is not possible to specify an expression other than a column specification for outer join operators, but they may be specified for the columns that compose the expression.

    There are the following limitations on the functionality of outer join operators when compared with joined tables (OUTER JOIN). To use functionality that is not available with outer join operators, use joined tables (OUTER JOIN).

    Table 7.2 Range of functionality with outer join operators

Functionality available with joined tables (OUTER JOIN)	Outer join operator
Outer joins of two tables	Y
Outer joins of three or more tables	Y (*1)
Used together with joined tables within the same query	N
Use of the OR logical operator to a join condition	N
Use of an IN predicate to a join condition	N
Use of subqueries to a join condition	N

    Y: Available
    N: Not available

    *1: The outer joins by outer join operators can return outer join results only for one other table. For this reason, to combine outer joins of table t1 and table t2 or table t2 and table t3, it is not possible to specify outer join operators simultaneously for table t2.

Example

Table configuration

t1

col1	col2	col3
1001	AAAAA	1000
1002	BBBBB	2000
1003	CCCCC	3000

t2

col1	col2
1001	aaaaa
1002	bbbbb
1004	ddddd

Example 1: Return all rows in table t2, including those that do not exist in table t1.

```
SELECT *
  FROM t1, t2
  WHERE t1.col1(+) = t2.col1;
 col1 |    col2    | col3 | col1 |    col2
------+------------+------+------+------------
 1001 | AAAAA      | 1000 | 1001 | aaaaa
 1002 | BBBBB      | 2000 | 1002 | bbbbb
      |            |      | 1004 | ddddd
(3 rows)
```

This is the same syntax as the joined table (OUTER JOIN) of the FROM clause shown next.

```
SELECT *
  FROM t1 RIGHT OUTER JOIN t2
       ON t1.col1 = t2.col1;
```

Example 2: In the following example, the results are filtered to records above 2000 in t1.col3 by search conditions, and the records are those in table t2 that include ones that do not exist in table t1. After filtering with the join conditions, there is further filtering with the search conditions, so there will only be one record returned.

```
SELECT *
  FROM t1, t2
  WHERE t1.col1(+) = t2.col1
    AND t1.col3 >= 2000;
 col1 |    col2    | col3 | col1 |    col2
------+------------+------+------+------------
 1002 | BBBBB      | 2000 | 1002 | bbbbb
(1 row)
```

This is the same syntax as the joined table (OUTER JOIN) of the FROM clause shown next.

```
SELECT *
  FROM t1 RIGHT OUTER JOIN t2
       ON t1.col1 = t2.col1
  WHERE t1.col3 >= 2000;
```

7.3.2 DUAL Table

DUAL table is a virtual table provided by the system. Use when executing SQL where access to a base table is not required, such as when performing tests to get result expressions such as functions and operators.

Example

In the following example, the current system date is returned.

```
SELECT  CURRENT_DATE  "date" FROM DUAL;
    date
------------
 2013-05-14
(1 row)
```

7.4 SQL Function Reference

The following SQL functions are supported:

- DECODE
- SUBSTR
- NVL

7.4.1 DECODE

Description

Compares values and if they match, returns a corresponding value.

Syntax

```
DECODE(expr, srch, result [, srch, result ]... [, default ])
```

General rules

- DECODE compares values of the value expression to be converted and the search values one by one. If the values match, a corresponding result value is returned. If no values match, the default value is returned if it has been specified. A NULL value is returned if a default value has not been specified.
- If the same search value is specified more than once, then the result value returned is the one listed for the first occurrence of the search value.
- The following data types can be used in result values and in the default value:
  - CHAR
  - VARCHAR
  - NCHAR
  - NCHAR VARYING
  - TEXT
  - INTEGER
  - BIGINT
  - NUMERIC
  - DATE
  - TIME WITHOUT TIME ZONE
  - TIMESTAMP WITHOUT TIME ZONE
  - TIMESTAMP WITH TIME ZONE
- The same data type must be specified for the values to be converted and the search values. However, note that different data types may also be specified if a literal is specified in the search value, and the value expression to be converted contains data types that can be converted. When specifying literals, refer to "Table A.1 Data type combinations that contain literals and can be converted implicitly" in "A.3 Implicit Data Type Conversions" for information on the data types that can be specified.
- If the result values and default value are all literals, the data types for these values will be as shown below:
  - If all values are string literals, all will become character types.
  - If there is one or more numeric literal, all will become numeric types.
  - If there is one or more literal cast to the datetime/time types, all will become datetime/time types.
- If the result values and default value contain a mixture of literals and non-literals, the literals will be converted to the data types of the non-literals. When specifying literals, refer to "Table A.1 Data type combinations that contain literals and can be converted implicitly" in "A.3 Implicit Data Type Conversions" for information on the data types that can be converted.
- The same data type must be specified for all result values and for the default value. However, different data types can be specified if the data type of any of the result values or default value can be converted - these data types are listed below:

Table 7.3 Data type combinations that can be converted by DECODE (summary)

		Other result values or default value		
		Numeric type	Character type	Date/time type
Result value (any)	Numeric type	Y	N	N
	Character type	N	Y	N
	Date/time type	N	N	S (*1)

Y: Can be converted
S: Some data types can be converted
N: Cannot be converted

*1: The data types that can be converted for date/time types are listed below:

Table 7.4 Result value and default value date/time data types that can be converted by DECODE

		Other result values or default value			
		DATE	TIME WITHOUT TIME ZONE	TIMESTAMP WITHOUT TIME ZONE	TIMESTAMP WITH TIME ZONE
Result value (any)	DATE	Y	N	Y	Y
	TIME WITHOUT TIME ZONE	N	Y	N	N
	TIMESTAMP WITHOUT TIME ZONE	Y	N	Y	Y
	TIMESTAMP WITH TIME ZONE	Y	N	Y	Y

Y: Can be converted
N: Cannot be converted

- The data type of the return value will be the data type within the result or default value that is longest and has the highest precision.

Example

In the following example, the value of col3 in table t1 is compared and converted to a different value. If the col3 value matches search value 1, the result value returned is "one". If the col3 value does not match any of search values 1, 2, or 3, the default value "other number" is returned.

```
SELECT col1, DECODE(col3, 1000, 'one',
                          2000, 'two',
                          3000, 'three',
                          'other number') "num-word"
       FROM t1;
col1  | num-word
------+----------
 1001 | one
 1002 | two
 1003 | three
(3 rows)
```

7.4.2 SUBSTR

Description

Extracts part of a string using characters to specify position and length.

Syntax

```
SUBSTR(str, startPos [, len ])
```

General rules

- SUBSTR extracts and returns a substring of string *str*, beginning at position *startPos*, for number of characters *len*.
- When *startPos* is positive, it will be the number of characters from the beginning of the string.
- When *startPos* is 0, it will be treated as 1.
- When *startPos* is negative, it will be the number of characters from the end of the string.
- When *len* is not specified, all characters to the end of the string are returned. NULL is returned when *len* is less than 1.
- For *startPos* and *len*, specify a SMALLINT or INTEGER type. When specifying literals, refer to "Table A.1 Data type combinations that contain literals and can be converted implicitly" in "A.3 Implicit Data Type Conversions" for information on the data types that can be specified.
- The data type of the return value is TEXT.

Note

- There are two types of SUBSTR. One that behaves as described above, and one that behaves the same as SUBSTRING. The search_path parameter must be modified for it to behave the same as the specification described above.
- It is recommended to set search_path in postgresql.conf. In this case, it will be effective for each instance. Refer to "7.2.1 Notes on SUBSTR" for information on how to configure postgresql.conf.
- The configuration of search_path can be done at the user level or at the database level. Setting examples are shown below.
  - Example of setting at the user level

    This can be set by executing an SQL command. In this example, user1 is used as the username.

    ```
    ALTER USER user1 SET search_path = "$user",public,oracle,pg_catalog;
    ```

  - Example of setting at the database level

    This can be set by executing an SQL command. In this example, db1 will be used as the database name.

    ```
    ALTER DATABASE db1 SET search_path = "$user",public,oracle,pg_catalog;
    ```

    You must specify "oracle" before "pg_catalog".
- If the change has not been implemented, SUBSTR is the same as SUBSTRING.

See

Refer to "SQL Commands" in "Reference" in the PostgreSQL Documentation for information on ALTER USER and ALTER DATABASE.

Information

The general rules for SUBSTRING are as follows:

- The start position will be from the beginning of the string, whether positive, 0, or negative.
- When *len* is not specified, all characters to the end of the string are returned.
- An empty string is returned if no string is extracted or *len* is less than 1.

See

Refer to "String Functions and Operators" under "The SQL Language" in the PostgreSQL Documentation for information on SUBSTRING.

Example

In the following example, part of the string "ABCDEFG" is extracted:

```
SELECT SUBSTR('ABCDEFG',3,4) "Substring" FROM DUAL;

 Substring
-----------
 CDEF
(1 row)

SELECT SUBSTR('ABCDEFG',-5,4) "Substring" FROM DUAL;

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

7.4.3 NVL

Description

Returns a substitute value when a value is NULL.

Syntax

```
NVL(expr1, expr2)
```

General rules

- NVL returns a substitute value when the specified value is NULL. When *expr1* is NULL, *expr2* is returned. When *expr1* is not NULL, *expr1* is returned.
- Specify the same data types for *expr1* and *expr2*. However, if a constant is specified in *expr2*, and the data type can also be converted by *expr1*, different data types can be specified. When this happens, the conversion by *expr2* is done to suit the data type in *expr1*, so the value of *expr2* returned when *expr1* is a NULL value will be the value converted in the data type of *expr1*.
- When specifying literals, refer to "Table A.1 Data type combinations that contain literals and can be converted implicitly" in "A.3 Implicit Data Type Conversions" for information on the data types that can be converted.

Example

In the following example, "IS NULL" is returned if the value of col1 in table t1 is a NULL value.

```
SELECT col2, NVL(col1,'IS NULL') "nvl" FROM t1;
 col2 |   nvl
------+---------
 aaa  | IS NULL
(1 row)
```

7.5 Package Reference

A "package" is a group of features, brought together by schemas, that have a single functionality, and are used by calling from PL/pgSQL.

The following packages are supported:

- DBMS_ALERT
- DBMS_ASSERTION
- DBMS_OUTPUT
- DBMS_PIPE
- DBMS_RANDOM
- DBMS_UTILITUY
- UTL_FILE
- DBMS_SQL

To call each feature from PL/pgSQL, use the PERFORM or SELECT statement and qualify the feature name with the package name. For more information on the calling format, refer to the feature-specific description for each package.

In the following, explain DBMS_SQL among the supported packages. For other packages, refer to the README stored in the installation location.

See

For packages other than DBMS_SQL, refer to the following file.

fujitsuEnterprisePostgresInstallDir/share/doc/extension/README.asciidoc

7.5.1 DBMS_SQL

Overview

Dynamic SQL can be executed from PL/pgSQL.

Features

Feature	Description
BIND_VARIABLE	Sets values in the host variable within the SQL statement.
CLOSE_CURSOR	Closes the cursor.
COLUMN_VALUE	Retrieves the value of the column in the select list extracted with FETCH_ROWS.
DEFINE_COLUMN	Defines the column from which values are extracted and the storage destination.
EXECUTE	Executes SQL statements.
FETCH_ROWS	Positions the specified cursor at the next row and extracts values from the row.
OPEN_CURSOR	Opens a new cursor.
PARSE	Parses SQL statements.

Note

- In DBMS_SQL, the data types supported in dynamic SQL are limited, and therefore the user must consider this. The supported data types are:
  - INTEGER
  - DECIMAL
  - NUMERIC
  - REAL

- DOUBLE PRECISION
- CHAR(*1)
- VARCHAR(*1)
- NCHAR(*1)
- NCHAR VARYING(*1)
- TEXT
- DATE
- TIMESTAMP WITHOUT TIME ZONE
- TIMESTAMP WITH TIME ZONE
- INTERVAL(*2)
- SMALLINT
- BIGINT

*1:
The host variables with CHAR, VARCHAR, NCHAR, and NCHAR VARYING data types are treated as TEXT, to match the string function arguments and return values. Refer to "String Functions and Operators" in "Functions and Operators" in "The SQL Language" in the PostgreSQL Documentation for information on string functions.
When specifying the arguments of the features compatible with Oracle databases NVL and/or DECODE, use CAST to convert the data types of the host variables to ensure that data types between arguments are the same.

*2:
When using COLUMN_VALUE to obtain an INTERVAL type value specified in the select list, use an INTERVAL type variable with a wide range such as when no interval qualifier is specified, or with a range that matches that of the variable in the select list. If an interval qualifier variable with a narrow range is specified, then the value within the interval qualifier range will be obtained, but an error that the values outside the range have been truncated will not occur.

Example

This example illustrates where a value expression that returns an INTERVAL value is set in the select list and the result is received with COLUMN_VALUE. Note that the SQL statement operation result returns a value within the INTERVAL DAY TO SECOND range.

[Bad example]

Values of MINUTE, and those after MINUTE, are truncated, because the variable(v_interval) is INTERVAL DAY TO HOUR.

```
    v_interval     INTERVAL DAY TO HOUR;
...
    PERFORM DBMS_SQL.PARSE(cursor, 'SELECT CURRENT_TIMESTAMP - ''2010-01-01'' FROM DUAL', 1);
...
    SELECT value INTO v_interval FROM DBMS_SQL.COLUMN_VALUE(cursor, 1, v_interval);
    result:1324 days 09:00:00
```

[Good example]

By ensuring that the variable(v_interval) is INTERVAL, the values are received correctly.

```
    v_interval     INTERVAL;
...
    PERFORM DBMS_SQL.PARSE(cursor, 'SELECT CURRENT_TIMESTAMP - ''2010-01-01'' FROM DUAL', 1);
...
    SELECT value INTO v_interval FROM DBMS_SQL.COLUMN_VALUE(cursor, 1, v_interval);
    result:1324 days 09:04:37.530623
```

Syntax

```
{ BIND_VARIABLE(cursor, varName, val [, len ])
| CLOSE_CURSOR(cursor)
| COLUMN_VALUE(cursor, colPos, varName)
| DEFINE_COLUMN(cursor, colPos, varName [, len ])
| EXECUTE(cursor)
| FETCH_ROWS(cursor)
| OPEN_CURSOR([parm1 ])
| PARSE(cursor, sqlStmt, parm1 [, parm2, parm3, parm4 ])
}
```

7.5.1.1 Description

This section explains each feature of DBMS_SQL.

BIND_VARIABLE

- BIND_VARIABLE sets values in the host variable within the SQL statement.
- Specify the cursor number to be processed.
- Specify the name of the host variable within the SQL statement using a string for the host variable name.
- Specify the value set in the host variable. The data type of the host variable is the same as that of the value expression - it is implicitly converted in accordance with its position within the SQL statement. Refer to "A.3 Implicit Data Type Conversions" for information on implicit conversions.
- If the value is a character type, the string length is the number of characters. If the string length is not specified, the size is the total length of the string.
- It is necessary to place a colon at the beginning of the host variable in SQL statements to identify the host variable. The colon does not have to be added to the host variable names specified at BIND_VARIABLE. The following shows examples of host variable names specified with SQL statements and host variable names specified with BIND_VARIABLE:

```
PERFORM DBMS_SQL.PARSE(cursor, 'SELECT emp_name FROM emp WHERE sal > :x', 1);
```

In this example, BIND_VARIABLE will be as follows:

```
PERFORM DBMS_SQL.BIND_VARIABLE(cursor, ':x', 3500);
```

Or,

```
PERFORM DBMS_SQL.BIND_VARIABLE(cursor, 'x', 3500);
```

- The length of the host variable name can be up to 30 bytes (excluding colons).
- If the data type of the set value is string, specify the effective size of the column value as the fourth argument.

Example

If the data type of the value to be set is not a string:

```
PERFORM DBMS_SQL.BIND_VARIABLE(cursor, ':NO', 1);
```

If the data type of the value to be set is a string:

```
PERFORM DBMS_SQL.BIND_VARIABLE(cursor, ':NAME', h_memid, 5);
```

CLOSE_CURSOR

- CLOSE_CURSOR closes the cursor.

- Specify the cursor number to be processed.
- The value returned is a NULL value.

Example

```
cursor := DBMS_SQL.CLOSE_CURSOR(cursor);
```

COLUMN_VALUE

- COLUMN_VALUE retrieves the value of the column in the select list extracted with FETCH_ROWS.
- Specify the cursor number to be processed.
- Specify the position of the column of the select list in the SELECT statement. The position of the first column is 1.
- Specify the destination variable name.
- Use a SELECT statement to obtain the values of the value, column_error, and actual_length columns.
- The value column returns the value of the column specified at the column position. The data type of the variable name must match that of the column. If the data type of the column in the SELECT statement specified in PARSE is not compatible with DBMS_SQL, use CAST to convert to a compatible data type.
- The data type of the column_error column is NUMERIC. If the column value could not be set correctly in the value column, a value other than 0 will be returned:
  22001: The extracted string has been truncated
  22002: The extracted value contains a NULL value
- The data type of the actual_length column is INTEGER. If the extracted value is a character type, the number of characters will be returned (if the value was truncated, the number of characters prior to the truncation will be returned), otherwise, the number of bytes will be returned.

Example

When retrieving the value of the column, the error code, and the actual length of the column value:

```
SELECT value, column_error, actual_length INTO v_memid, v_col_err, v_act_len FROM
DBMS_SQL.COLUMN_VALUE(cursor, 1, v_memid);
```

When retrieving just the value of the column:

```
SELECT value INTO v_memid FROM DBMS_SQL.COLUMN_VALUE(cursor, 1, v_memid);
```

DEFINE_COLUMN

- DEFINE_COLUMN defines the column from which values are extracted and the storage destination.
- Specify the cursor number to be processed.
- Specify the position of the column in the select list in the SELECT statement. The position of the first column is 1.
- Specify the destination variable name. The data type should be match with the data type of the column from which the value is to be extracted. If the data type of the column in the SELECT statement specified in PARSE is not compatible with DBMS_SQL, use CAST to convert to a compatible data type.
- Specify the maximum number of characters of character type column values.
- If the data type of the column value is string, specify the effective size of the column value as the fourth argument.

Example

When the data type of the column value is not a string:

```
PERFORM DBMS_SQL.DEFINE_COLUMN(cursor, 1, v_memid);
```

When the data type of the column value is a string:

```
PERFORM DBMS_SQL.DEFINE_COLUMN(cursor, 1, v_memid, 10);
```

EXECUTE

- EXECUTE executes SQL statements.
- Specify the cursor number to be processed.
- The return value is an INTEGER type, is valid only with INSERT statement, UPDATE statement, and DELETE statement, and is the number of rows processed. Anything else is invalid.

Example

```
ret := DBMS_SQL.EXECUTE(cursor);
```

FETCH_ROWS

- FETCH_ROWS positions at the next row and extracts values from the row.
- Specify the cursor number to be processed.
- The return value is an INTEGER type and is the number of rows extracted. 0 is returned if all are extracted.
- The extracted information is retrieved with COLUMN_VALUE.

Example

```
LOOP
    IF DBMS_SQL.FETCH_ROWS(cursor) = 0 THEN
        EXIT;
    END IF;

...

END LOOP;
```

OPEN_CURSOR

- OPEN_CURSOR opens a new cursor.
- The parameter is used for compatibility with Oracle databases only, and is ignored by FUJITSU Enterprise Postgres. An INTEGER type can be specified, but it will be ignored. If migrating from an Oracle database, specify 1.
- Close unnecessary cursors by executing CLOSE_CURSOR.
- The return value is an INTEGER type and is the cursor number.

Example

```
cursor := DBMS_SQL.OPEN_CURSOR();
```

PARSE

- PARSE analyzes dynamic SQL statements.
- Specify the cursor number to be processed.
- Specify the SQL statement to be parsed.
- Parameters 1, 2, 3, and 4 are used for compatibility with Oracle databases only, and are ignored by FUJITSU Enterprise Postgres. If you are specifying values anyway, specify the following:
  - Parameter 1 is an INTEGER type. Specify 1.
  - Parameters 2 and 3 are TEXT types. Specify NULL.
  - Parameter 4 is a BOOLEAN type. Specify TRUE.

  If migrating from an Oracle database, the specified values for parameters 2, 3, and 4 do not need to be changed.
- Add a colon to the beginning of host variables in SQL statements.
- The DDL statement is executed when PARSE is issued. EXECUTE is not required for the DDL statement.
- If PARSE is called again for opened cursors, the content in the data regions within the cursors is reset, and the SQL statement is parsed anew.

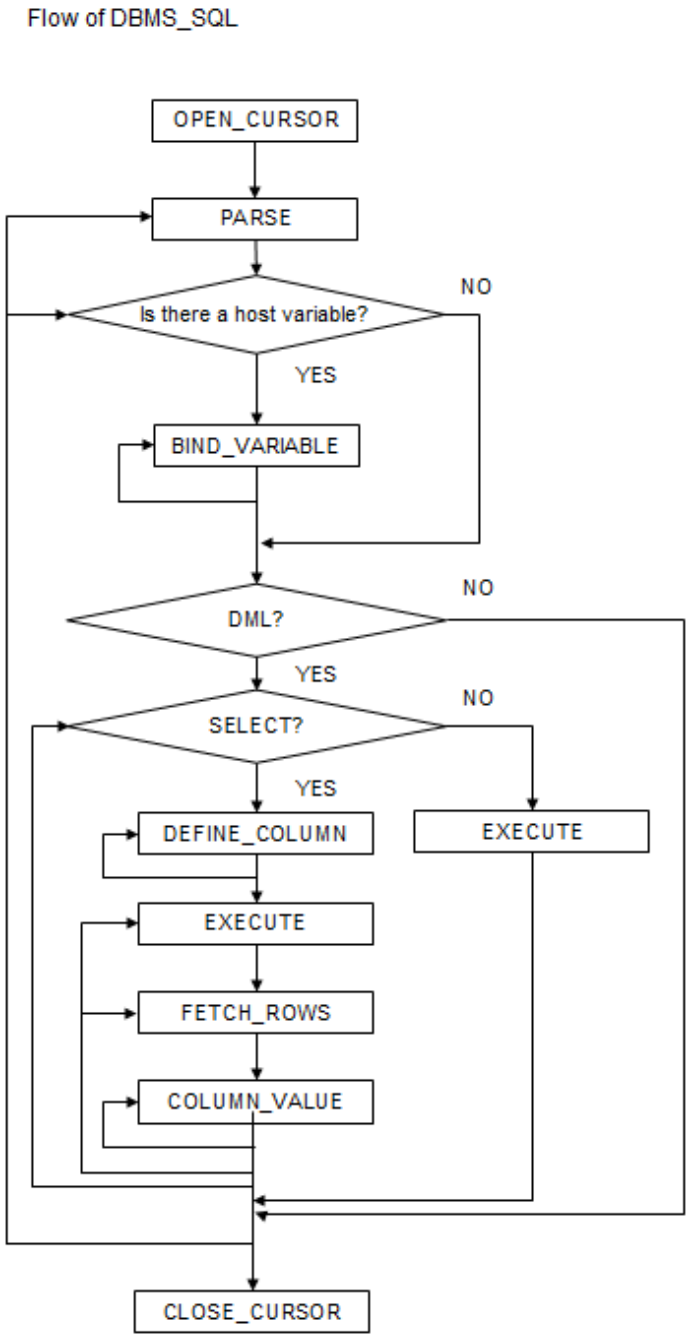
Example

```
PERFORM DBMS_SQL.PARSE(cursor, 'SELECT memid, memnm FROM member WHERE memid = :NO', 1);
```

7.5.1.2 Example

This section explains the flow of DBMS_SQL and provides an example.

Flow of DBMS_SQL



Example

```
CREATE FUNCTION smp_00()
RETURNS INTEGER
AS $$
DECLARE
    str_sql     VARCHAR(255);
    cursor      INTEGER;
    h_smpid     INTEGER;
    v_smpid     INTEGER;
    v_smpnm     VARCHAR(20);
    v_smpage    INTEGER;
    errcd       INTEGER;
```

```
    length      INTEGER;
    ret         INTEGER;
BEGIN
    str_sql     := 'SELECT smpid, smpnm, smpage FROM smp_tbl WHERE smpid < :H_SMPID ORDER BY smpid';
    h_smpid     := 3;
    v_smpid     := 0;
    v_smpnm     := '';
    v_smpage    := 0;

    cursor := DBMS_SQL.OPEN_CURSOR();

    PERFORM DBMS_SQL.PARSE(cursor, str_sql, 1);

    PERFORM DBMS_SQL.BIND_VARIABLE(cursor, ':H_SMPID', h_smpid);

    PERFORM DBMS_SQL.DEFINE_COLUMN(cursor, 1, v_smpid);
    PERFORM DBMS_SQL.DEFINE_COLUMN(cursor, 2, v_smpnm, 10);
    PERFORM DBMS_SQL.DEFINE_COLUMN(cursor, 3, v_smpage);

    ret := DBMS_SQL.EXECUTE(cursor);
    loop
        if DBMS_SQL.FETCH_ROWS(cursor) = 0 then
            EXIT;
        end if;

        SELECT value,column_error,actual_length INTO v_smpid,errcd,length FROM
DBMS_SQL.COLUMN_VALUE(cursor, 1, v_smpid);
        RAISE NOTICE '-------------------------------------------------------';
        RAISE NOTICE '-------------------------------------------------------';
        RAISE NOTICE 'smpid       = %', v_smpid;
        RAISE NOTICE 'errcd       = %', errcd;
        RAISE NOTICE 'length      = %', length;

        SELECT value,column_error,actual_length INTO v_smpnm,errcd,length FROM
DBMS_SQL.COLUMN_VALUE(cursor, 2, v_smpnm);
        RAISE NOTICE '-------------------------------------------------------';
        RAISE NOTICE 'smpnm       = %', v_smpnm;
        RAISE NOTICE 'errcd       = %', errcd;
        RAISE NOTICE 'length      = %', length;

        select value,column_error,actual_length INTO v_smpage,errcd,length FROM
DBMS_SQL.COLUMN_VALUE(cursor, 3, v_smpage);
        RAISE NOTICE '-------------------------------------------------------';
        RAISE NOTICE 'smpage      = %', v_smpage;
        RAISE NOTICE 'errcd       = %', errcd;
        RAISE NOTICE 'length      = %', length;
        RAISE NOTICE '';
    end loop;

    cursor := DBMS_SQL.CLOSE_CURSOR(cursor);
    RETURN 0;
END;
$$ LANGUAGE plpgsql;
```

Chapter 8 Application Connection Switch Feature

The application connection switch feature enables automatic connection to the target server when there are multiple servers with redundant configurations.

When using this feature, specify the primary server and secondary server as the connected servers in the application connection information. A standby server can optionally be prioritized over the primary server as the target server.

If an application connection switch occurs, explicitly close the connection and then reestablish the connection or reexecute the application. Refer to "Errors when an Application Connection Switch Occurs and Corresponding Actions" of the relevant client interface for information on how to confirm the switch.

8.1 Connection Information for the Application Connection Switch Feature

To use the application connection switch feature, set the information shown below when connecting the database.

IP address or host name

Specify the IP address or host name that will be used to configure the database multiplexing system.

Port number

A port number used by each database server to listen for connections from applications.
In each client interface, multiple port numbers can be specified, however in the format shown below, for example:

host1,host2:port2

JDBC

If only one port number is specified, it will be assumed that host1: 27500 (the default value) and host2:port2 were specified.
Omit all port numbers, or specify only one per server.

Others

If only one port number is specified, it will be assumed that the same port is used for all the hosts.

Target server

From the specified connection destination server information, specify the selection sequence of the servers to which the application will connect. The values specified for the target server have the meanings shown below. If a value is omitted, "any" will be assumed.

Primary server

The primary server is selected as the connection target from the specified "IP addresses or host names". Specify this to perform tasks that can be performed only on the primary server, such as applications in line with updates, or management tasks such as REINDEX and VACUUM.

Standby server

The standby server is selected as the connection target from the specified "IP addresses or host names". On standby server, the update will always fail. If the target server is not standby, the JDBC driver will throw an error stating that it is unable to find a server with the specified targetServerType.

Priority given to a standby server

The standby server is selected preferentially as the connection target from the specified "IP addresses or host names". If there is no standby server, the application will connect to the primary server.

Any

This method is not recommended in database multiplexing systems. This is because, although the connection destination server is selected in the specified sequence from the specified "IP addresses or host names", if the server that was successfully connected to first is the standby server, the write operations will always fail.

The table below shows the server selection order values to set for each driver:

Server selection order	JDBC drivers	Other drivers
Primary server	"primary"(*1)	"read-write"(*1) "primary"(*2)
Standby server	"secondary"(*2)	"standby" "read-only"(*2)
Priority given to a standby server	"preferSecondary"(*2)	"prefer-standby"(*3)
Any	"any"	"any"

*1: The primary server whose default transaction mode is read-only is not selected.

*2: The primary server whose default transaction mode is read-only is also selected.

*3: While it is possible to specify "prefer-read" instead of "prefer-standby" for compatibility with FUJITSU Enterprise Postgres 13 and earlier, this is not recommended.

SSL server certificate Common Name (CN)

To perform SSL authentication by creating the same server certificate for each server in a multiplexing system, specify the SSL server certificate Common Name (CN) in this parameter. Accordingly, SSL authentication using the CN can be performed without having to consider the names of the multiple servers contained in the multiplexing system.

8.2 Using the Application Connection Switch Feature

This section explains how to set the connection destination server using the application connection switch feature.

Of the parameters used as connection information for each client interface, only the parameters specific to the application connection switch feature are explained here. Refer to "Setup" and "Connecting to the Database" for information on the other parameters of each client interface.

8.2.1 Using the JDBC Driver

Set the following information in the connection string of the DriverManager class, or in the data source.

Table 8.1 Information to be set

Argument	Explanation
host1 host2	Specify the IP address or host name.
port1 port2	Specify the port number for the connection. The port number can be omitted. If omitted, the default is 27500.
database_name	Specify the database name.
targetServerType	Specify the selection sequence of the servers to which the application will connect. Refer to "Target server" for details.
sslmode	Specify this to encrypt communications. By default, this is disabled. The setting values for sslmode are as follows: disable: Connect without SSL require: Connect always with SSL verify-ca: Connect with SSL, using a certificate issued by a trusted CA (*1) verify-full: Connect with SSL, using a certificate issued by a trusted CA to verify if the server host name matches the certificate (*1)
sslservercertcn	This parameter is enabled only to perform SSL authentication (sslmode=verify-full). Specify the server certificate CN. If this is omitted, the value will be null, and the server certificate CN will be authenticated using the host name specified in host.

*1: If specifying either "verify-ca" or "verify-full", the CA certificate file can be specified using connection string sslrootcert.

When using Driver Manager

Specify the following URL in the API of the DriverManager class:

```
jdbc:postgresql://host1[:port1],host2[:port2]/dbName[?targetServerType={primary | secondary|
preferSecondary | any}][&sslmode=verify-
full&sslrootcert=cACertificateFile&sslservercertcn=targetServerCertificateCN]
```

- If the target server is omitted, the default value "any" is used.
- When using IPV6, specify the host in the "[*host*]" (with square brackets) format.

  [Example]

  ```
  jdbc:postgresql://[2001:Db8::1234]:27500,192.168.1.1:27500/dbName
  ```

When using the data source

Specify the properties of the data source in the following format:

```
source.setServerName("host1[:port1],host2[:port2]");
source.setTargetServerType("primary");
source.setSslmode("verify-full");
source.setSslrootcert("cACertificateFile");
source.setSslservercertcn("targetServerCertificateCN");
```

- If the port number is omitted, the value specified in the portNumber property will be used. Also, if the portNumber property is omitted, the default is 27500.
- If the target server is omitted, the value will be "any".
- When using IPV6, specify the host in the "[*host*]" (with square brackets) format.

  [Example]

  ```
  source.setServerName("[2001:Db8::1234]:27500,192.168.1.1:27500");
  ```

If using the connection parameter loginTimeout, the value will be applied for the time taken attempting to connect to all of the specified hosts.

8.2.2 Using the ODBC Driver

Set the following information in the connection string or data source.

Table 8.2 Information to be set

Parameter	Explanation
Servername	Specify IP address 1 and IP address 2, or the host name, using a comma as the delimiter. Based on ODBC rules, it is recommended to enclose the whole string containing comma delimiters with {}. Format: {host1,host2}
Port	Specify the connection destination port numbers, using a comma as the delimiter. Based on ODBC rules, it is recommended to enclose the whole string containing comma delimiters with {}.

Parameter	Explanation
	Format: {port1,port2} Specify the port number corresponding to the IP address or host specified for the nth Servername as the nth Port. The port number can be omitted. If omitted, the default is 27500. If *n* server names are specified, and m ports are specified then there will be error reported. The only exceptions are where m=n or m=1. In case only one port is specified, then the same is applied for all the hosts.
target_session_attrs	Specify the selection sequence of the servers to which the application will connect. Refer to "Target server" for details.
SSLMode	Specify this to encrypt communications. By default, this is disabled. The setting values for SSLMode are as follows: disable: Connect without SSL allow: Connect without SSL, and if it fails, connect with SSL prefer: Connect with SSL, and if it fails, connect without SSL require: Connect always with SSL verify-ca: Connect with SSL, using a certificate issued by a trusted CA (*1) verify-full: Connect with SSL, using a certificate issued by a trusted CA to verify if the server host name matches the certificate (*1)
SSLServerCertCN	This parameter is enabled only to perform SSL authentication (SSLMode=verify-full). Specify the server certificate CN. If this is omitted, the value will be null, and the server certificate CN will be authenticated using the host name specified in Servername.

*1: If specifying either "verify-ca" or "verify-full", use the system environment variable PGSSLROOTCERT of your operating system to specify the CA certificate file as shown below.

Example)
Variable name: PGSSLROOTCERT
Variable value: *cACertificateFile*

When specifying a connection string

Specify the following connection string:

```
...;Servername={host1,host2};Port={port1,port2};[target_session_attrs={any | read-write | read-
only | primary | standby | prefer-standby}];[ SSLMode=verify-
full;SSLServerCertCN=targetServerCertificateCN]...
```

- When using IPV6, specify the host in the "*host*" format.

  [Example]

```
Servername={2001:Db8::1234,192.168.1.1};Port={27500,27500};
```

When using the data source

Specify the properties of the data source in the following format:

```
Servername={host1,host2}
Port={port1,port2}
target_session_attrs={any | read-write | read-only | primary | standby | prefer-standby}
SSLMode=verify-full
SSLServerCertCN=targetServerCertificateCN
```

- When using IPV6, specify the host in the "*host*" format.

  [Example]

```
Servername={2001:Db8::1234,192.168.1.1}
```

Note

If using the connection parameter login_timeout, this value is applied for connections to each of the specified hosts. If both multiplexed database servers have failed, the connection will time out when a time equal to double the login_timeout value elapses.

8.2.3 Using a Connection Service File

Set the connection parameters as follows.

Table 8.3 Information to be set

Parameter	Explanation
host	Specify the host names, using a comma as the delimiter.
hostaddr	Specify IP address 1 and IP address 2, using a comma as the delimiter.
port	Specify the connection destination port numbers, using a comma as the delimiter. Specify the port number for the server specified for the nth host or hostaddr as the nth port. The port number can be omitted. If omitted, the default is 27500. If *n* server names are specified, and m ports are specified then there will be error reported. The only exceptions are where m=n or m=1. In case only one port is specified, then the same is applied for all the hosts.
target_session_attrs	Specify the selection sequence of the servers to which the application will connect. Refer to "Target server" for details.
sslmode	Specify this to encrypt communications. By default, this is disabled. The setting values for sslmode are as follows: disable: Connect without SSL allow: Connect without SSL, and if it fails, connect with SSL prefer: Connect with SSL, and if it fails, connect without SSL require: Connect always with SSL verify-ca: Connect with SSL, using a certificate issued by a trusted CA (*1) verify-full: Connect with SSL, using a certificate issued by a trusted CA to verify if the server host name matches the certificate (*1)
sslservercertcn	This parameter is enabled only to perform SSL authentication (sslmode=verify-full). Specify the server certificate CN. If this is omitted, the value will be null, and the server certificate CN will be authenticated using the host name specified in host.

*1: If specifying either "verify-ca" or "verify-full", use the system environment variable PGSSLROOTCERT (connection parameter sslrootcert) of your operating system to specify the CA certificate file as shown below.

Example)
Variable name: PGSSLROOTCERT
Variable value: *cACertificateFile*

Note

If using the connection parameter connect_timeout, this value is applied for connections to each of the specified hosts. If both multiplexed database servers have failed, the connection will time out when a time equal to double the connect_timeout value elapses.

Point

If using the C Library, embedded SQL or psql commands (including other client commands that specify connection destinations), it is recommended to use a connection service file to specify connection destinations.

In the connection service file, a name (service name) is defined as a set, comprising information such as connection destination information and various types of tuning information set for connections. By using the service name defined in the connection service file when connecting to databases, it is no longer necessary to modify applications when the connection information changes.

8.2.4 Using the C Library (libpq)

It is recommended that you use a connection service file. Refer to "8.2.3 Using a Connection Service File" for details.

If a connection service file will not be used, set the following information for the database connection control functions (PQconnectdbParams, PQconnectdb, and so on) or environment variables.

Table 8.4 Information to be set

Parameter (environment variable name)	Explanation
host(PGHOST)	Specify the host names, using a comma as the delimiter.
hostaddr(PGHOSTADDR)	Specify IP address 1 and IP address 2, using a comma as the delimiter.
port(PGPORT)	Specify the connection destination port numbers, using a comma as the delimiter. Specify the port number for the server specified for the nth host or hostaddr as the nth port. The port number can be omitted. If omitted, the default is 27500. If *n* server names are specified, and m ports are specified then there will be error reported. The only exceptions are where m=n or m=1. In case only one port is specified, then the same is applied for all the hosts.
target_session_attrs(PGTARGETSESSIONATTRS)	Specify the selection sequence of the servers to which the application will connect. Refer to "Target server" for details.
sslmode(PGSSLMODE)	Specify this to encrypt communications. By default, this is disabled. The setting values for sslmode are as follows: disable: Connect without SSL allow: Connect without SSL, and if it fails, connect with SSL prefer: Connect with SSL, and if it fails, connect without SSL require: Connect always with SSL verify-ca: Connect with SSL, using a certificate issued by a trusted CA (*1) verify-full: Connect with SSL, using a certificate issued by a trusted CA to verify if the server host name matches the certificate (*1)
sslservercertcn(PGXSSLSERVERCERTCN)	This parameter is enabled only to perform SSL authentication (sslmode=verify-full). Specify the server certificate CN. If this is omitted, the value will be null, and the server certificate CN will be authenticated using the host name specified in host.

*1: If specifying either "verify-ca" or "verify-full", use the system environment variable PGSSLROOTCERT (connection parameter sslrootcert) of your operating system to specify the CA certificate file as shown below.

Example)
Variable name: PGSSLROOTCERT
Variable value: *cACertificateFile*

When using URI

```
postgresql://host1[:port1],host2[:port2][,...]/database_name
[?target_session_attrs={read-write | read-only | primary | standby | prefer-standby | any }]
```

- When using IPV6, specify the host in the "[*host*]" (with square brackets) format.

  [Example]

```
postgresql://postgres@[2001:Db8::1234]:27500,192.168.1.1:27500/database_name
```

When using key-value

```
host=host1[,host2] port=port1[,port2] user=user1 password=pwd1 dbname=mydb
[target_session_attrs={read-write | read-only | primary | standby | prefer-standby | any }]
```

- When using IPV6, specify the host in the "*host*" format.

  [Example]

```
host=2001:Db8::1234,192.168.1.1 port=27500,27500
```

Note

If using the connection parameter connect_timeout, this value is applied for connections to each of the specified hosts. If both multiplexed database servers have failed, the connection will time out when a time equal to double the connect_timeout value elapses.

Information

If using a password file (.pgpass), describe the entries matching each server.

- Example 1:

```
host1:port1:dbname:user:password
host2:port2:dbname:user:password
```

- Example 2:

```
*:port:dbname:user:password
```

8.2.5 Using Embedded SQL

It is recommended that you use a connection service file. Refer to "8.2.3 Using a Connection Service File" for details.

Point

If using a connection service file, either of the following methods is available:

- Set the service name as a string literal or host variable, as follows:

  tcp:postgresql://?service=my_service

- Set the service name in the environment variable PGSERVICE, and use CONNECT TO DEFAULT

If a connection service file will not be used, use a literal or variable to specify the connection destination server information for target in the SQL statement below:

```
EXEC SQL CONNECT TO target [AS connection-name] [USER user-name];
```

Method used

```
dbname@host1,host2[:[port1][,port2]]
tcp:postgresql://host1,host2[:[port1][,port2]] [/dbname] [?target_session_attrs={read-write |
read-only | primary | standby | prefer-standby | any}][&sslmode=verify-
full&sslservercertcn=targetServerCertificateCN]
```

- The above format cannot be specified directly without using a literal or variable.

Table 8.5 Information to be set

Argument	Explanation
host1 host2	Specify the IP address or host name. IPv6 format addresses cannot be specified.
port1 port2	Specify the connection destination port numbers, using a comma as the delimiter. The port number can be omitted. If omitted, the default is 27500.
dbname	Specify the database name.
target_session_attrs	Specify the selection sequence of the servers to which the application will connect. Refer to "Target server" for details.
sslmode	Specify this to encrypt communications. By default, this is disabled. The setting values for sslmode are as follows: disable: Connect without SSL allow: Connect without SSL, and if it fails, connect with SSL prefer: Connect with SSL, and if it fails, connect without SSL require: Connect always with SSL verify-ca: Connect with SSL, using a certificate issued by a trusted CA (*1) verify-full: Connect with SSL, using a certificate issued by a trusted CA to verify if the server host name matches the certificate (*1)
sslservercertcn	This parameter is enabled only to perform SSL authentication (sslmode=verify-full). Specify the server certificate CN. If this is omitted, the value will be null, and the server certificate CN will be authenticated using the host name specified in host.

*1: If specifying either "verify-ca" or "verify-full", use the system environment variable PGSSLROOTCERT (connection parameter sslrootcert) of your operating system to specify the CA certificate file as shown below.

Example)
Variable name: PGSSLROOTCERT
Variable value: *cACertificateFile*

Point

Environment variables can also be used. Refer to "8.2.4 Using the C Library (libpq)" for information on environment variables.

Note

If using the connection parameter connect_timeout, this value is applied for connections to each of the specified hosts. If both multiplexed database servers have failed, the connection will time out when a time equal to double the connect_timeout value elapses.

8.2.6 Using the psql Command

It is recommended that you use a connection service file. Refer to "8.2.3 Using a Connection Service File" for details.

If a connection service file will not be used, specify the following information in the psql command option/environment variable.

Table 8.6 Information to be set

Option (environment variable)	Explanation
-h/--host(PGHOST/ PGHOSTADDR)	Specify IP address 1 and IP address 2, or the host name, using a comma as the delimiter. This can also be specified for the environment variable PGHOST or PGHOSTADDR.
-p/--port(PGPORT)	Specify the connection destination port numbers, using a comma as the delimiter. This can also be specified for the environment variable PGPORT. Specify the port number corresponding to the IP address specified for the nth -h option as the nth -p option. The port number can be omitted. If omitted, the default is 27500. If *n* -h options are specified, and m -p options are specified then there will be error reported. The only exception is where m=n or m=1. In case only one port is specified, then the same is applied for all the hosts.
(PGTARGETSESSIONATTRS)	Specify the selection sequence of the servers to which the application will connect. Refer to "Target server" for details.
(PGSSLMODE)	Specify this to encrypt communications. By default, this is disabled. The setting values for PGSSLMODE are as follows: disable: Connect without SSL allow: Connect without SSL, and if it fails, connect with SSL prefer: Connect with SSL, and if it fails, connect without SSL require: Connect always with SSL verify-ca: Connect with SSL, using a certificate issued by a trusted CA (*1) verify-full: Connect with SSL, using a certificate issued by a trusted CA to verify if the server host name matches the certificate (*1)
(PGXSSLSERVERCERTCN)	This environment variable is enabled only to perform SSL authentication (PGSSLMODE=verify-full). Specify the server certificate CN. If this is omitted, the value will be null, and the server certificate CN will be authenticated using the host name specified in host.

*1: If specifying either "verify-ca" or "verify-full", use the system environment variable PGSSLROOTCERT (connection parameter sslrootcert) of your operating system to specify the CA certificate file as shown below.

Example)
Variable name: PGSSLROOTCERT
Variable value: *cACertificateFile*

Note

If using the connection parameter connect_timeout, this value is applied for connections to each of the specified hosts. If both multiplexed database servers have failed, the connection will time out when a time equal to double the connect_timeout value elapses.

Information

Use the same method as for psql commands to specify connection destination server information for other client commands used to specify connection destinations.

Chapter 9 Performance Tuning

This chapter explains how to tune application performance.

9.1 Enhanced Query Plan Stability

FUJITSU Enterprise Postgres estimates the cost of query plans based on SQL statements and database statistical information, and selects the least expensive query plan. However, like other databases, FUJITSU Enterprise Postgres does not necessarily select the most suitable query plan. For example, it may suddenly select unsuitable query plan due to changes in the data conditions.

In mission-critical systems, stable performance is more important than improved performance, and changes in query plans case to be avoided. In this situation, by stabilizing the SQL statement query plan so that it does not change, deterioration of the application performance is suppressed.

9.1.1 Optimizer Hints

This section explains the basic feature content of the optimizer hint (pg_hint_plan).

Refer to the open-source software webpage for information on pg_hint_plan.

In FUJITSU Enterprise Postgres, the optimizer hints can be specified in all application interfaces.

Description

You can specify a query plan in each SQL statement.

List of Features

The main query plans that can be specified using this feature are as follows:

- Query methods
- Join methods
- Join sequences

Query methods

Specify which method to use to query the specified table.

The main features are as follows:

- SeqScan (*tableName*)
- BitMapScan (*tableName* [*indexName* ...])
- IndexScan (*tableName* [*indexName* ...])
- IndexOnlyScan (*tableName* [*indexName* ...])

Note

- If the specified index does not exist, or is not related to the search condition column specified in the WHERE clause, for example, SeqScan will be used.
- Even if IndexOnlyScan is specified, IndexScan may be used if it is necessary to access the table because a row was updated, for example.
- If multiple query methods were specified for the same table, the method specified last will be used.

Join methods

Specify the join method.

The main features are as follows:

- NestLoop (*tableName tableName* [*tableName* ...])
- MergeJoin (*tableName tableName* [*tableName* ...])
- HashJoin (*tableName tableName* [*tableName* ...])

Note

- These cannot be specified for view tables and subqueries.
- If multiple methods were specified for the same table combination, the method specified last will be used.

Join sequences

The tables will be joined in the specified table sequence.

Specify the information using the following method:

- Leading ((*table table*))

  The method used to specify [*table*] is as follows:

  table = *tableName* or (*table table*)

Note

If multiple sequences were specified for the same table combination, the sequence specified last will be used.

Usage method

The use of this feature is explained below.

Method used to define this feature

Define this feature by specifying the format (block comment) " /*+ ... */".

- To specify hint clauses in each SELECT statement, for example when there are multiple SELECT statements in the SQL statement, define all hint clauses in the first block comment.

Example

Specifying hint clauses for the emp table and the dept table

```
WITH /*+ IndexScan(emp emp_age_index) IndexScan(dept dept_deptno_index) */ age30
AS (SELECT * FROM emp WHERE age BETWEEN 30 AND 39)
SELECT * FROM age30, dept WHERE age30.deptno = dept.deptno;
```

- To specify separate hint clauses for the same object in the SQL statement, define aliases in each object, and then specify hint clauses for those aliases.

Example

Specifying separate hint clauses for the emp table

```
WITH /*+ SeqScan(ta) IndexScan(tb) */ over100
AS (SELECT empno FROM emp ta WHERE salary > 1000000)
SELECT * FROM emp tb, over100 WHERE tb.empno = over100.empno AND tb.age < 30
```

- When using embedded SQL in C, the locations in which the hint clause block comment is specified are restricted. Refer to "5.4.2 Compiling Applications" for details.

Usage notes

- If a hint clause was specified in multiple block comments in the SQL statement, the hint clause specified in the second block comment and thereafter will be ignored.
- If characters other than those listed below appear before the hint clause in the SQL statement, they will be invalid even for hint clause block comments.
  - Space, tab, line feed
  - Letter (uppercase and lowercase), number
  - Underscore, comma
  - Brackets ()

9.1.2 Locked Statistics

This section explains the basic feature content for locked statistics (pg_dbms_stats).

Refer to the open-source software webpage for information on pg_dbms_stats.

Description

Locks the statistics.

By using this feature to lock the statistics for performance obtained in job load testing in an environment that simulates a production environment, performance degradation caused by changes to the query plan after go-live can be suppressed.

Additionally, by using the export and import features, statistics that were checked in the test environment can also be reproduced in the production environment.

Note that since PostgreSQL9.3, in addition to statistics, the height of Btree indexes has been changed to affect performance, so that even if statistics are fixed, the query plan might change. Therefore, in addition to traditional statistics, FUJITSU Enterprise Postgres supports fixed height for Btree indexes to provide more stable performance. Fixing the height of a btree index is available when applying the bug fix that includes the PH23544. Refer to "Compatibility" for more information.

List of Features

The main features that can be specified using this feature are as follows.

[Features]

Feature	Details	Description
Lock/unlock of the statistics	Lock	Locks the statistics so that the currently selected query plan remains selected.
	Unlock	Unlocks the statistics.
Backup/restore of the statistics	Backup	Backs up the current statistics.
	Restore	Restores the statistics to the point when they were backed up, and then locks them.
	Purge	Deletes backups that are no longer necessary.
Backup/restore using external files	Export	Outputs the current statistics to an external file (binary format).

Feature	Details	Description
	Import	Reads the statistics from an external file created by the export feature, and then locks them.

[Target object]

Target resource	Range of feature
Database	In the database
Schema	In the schema
Table	In the table
Column	ID column

Usage method

The use of this feature is explained below.

Method used to specify this feature

Specify this feature as an SQL function.

The methods used to specify the main features are shown in the table below.

Feature	Object	Function specified
Lock	Database	dbms_stats.lock_database_stats()
	Schema	dbms_stats.lock_schema_stats('*schemaName*')
	Table	dbms_stats.lock_table_stats('*schemaName.tableName*')
Unlock	Database	dbms_stats.unlock_database_stats()
	Schema	dbms_stats.unlock_schema_stats('*schemaName*')
	Table	dbms_stats.unlock_table_stats('*schemaName.tableName*')
Import	Database	dbms_stats.import_database_stats('*fullPathOfExportedFile*')
Import(for compatibility)	Database	dbms_stats.import_database_stats_no_tree_height ('*fullPathOfExportedFile*')
Backup	Database	dbms_stats.backup_database_stats('*commentUsedForIdentification*')
Restore	Database	[Format 1] dbms_stats.restore_database_stats('*timestamp*') [Timestamp] Specify in the same format as the time column of the backup_history table. Backups earlier than the specified time will be restored. [Format 2] dbms_stats.restore_stats(*backupId*) [Backup ID] Specify a value in the id column of the backup_history table. The specified backup will be restored.
Purge	Backup	dbms_stats.purge_stats(*backupId,flagUsedForDeletion*) [Backup ID] Specify a value in the id column of the backup_history table.

Feature	Object	Function specified
		[Flag used for deletion] true: The target backup is forcibly deleted. false: The target backup is deleted only when there are also backups for the entire database.

Remark 1: The export feature is executed using the COPY statement, not the SQL function.

Remark 2: Because the output of the export function is different from that of open source software, you need to use the import function differently. Refer to "Compatibility" for more information.

Example

Example 1: Locking the statistics of the entire database

```
userdb=# SELECT dbms_stats.lock_database_stats();
  lock_database_stats
-----------------------
  tbl1
  tbl1_pkey
```

Note that the locked information can be referenced as follows:

```
userdb=# select relname  from dbms_stats.relation_stats_locked;
  relname
-----------------------
  tbl1
  tbl1_pkey
```

Example 2: Unlocking the statistics of the entire database

```
userdb=# SELECT dbms_stats.unlock_database_stats();
  unlock_database_stats
-----------------------
  tbl1
  tbl1_pkey
```

Example 3: Backing up the statistics of the entire database

```
userdb=# SELECT dbms_stats.backup_database_stats('backup1');
  backup_database_stats
-----------------------
                      1
```

Note that the backed up statistics can be referenced as follows:

```
userdb=# select id,comment,time,unit from dbms_stats.backup_history;
  id | comment  |             time              | unit
 ----+----------+-------------------------------+------
   1 | backup1  | 2014-03-04 11:08:40.315948+09 | d
```

The ID:1 backup "backup1" is obtained for each database at "2014-03-04 11:08:40.315948+09".
[Meaning of unit] d: database s: schema t: table c: column

Example 4: Exporting the statistics of the entire database

```
$ psql -d userdb -f export.sql
BEGIN
COMMIT
```

export.sql is the file in which the COPY statement is defined.
Refer to "export_effective_stats-<*x*>.sql_sample" for information on the content of the COPY statement. "<*x*>" indicates the product version.

"export_effective_stats-<*x*>.sql_sample" is stored as follows:
fujitsuEnterprisePostgresInstallDir/share/doc/extension

Example 5: Importing the statistics of the entire database

```
$ psql -d userdb -c  "SELECT dbms_stats.import_database_stats ('$PWD/export_stats.dmp')"
 import_database_stats
-----------------------

(1 row)
```

Compatibility

If you apply a bug fix that includes the PH23544, in FUJITSU Enterprise Postgres, when statistics are fixed, the height of the Btree index is also fixed. This is a different behavior than the open source software pg_dbms_stats or when the bug fix that includes the PH23544 is not applied.

Therefore, note the following:

Compatibility with import and export features

The format of the file output by this version of the export function is different from the previous format. Therefore, statistics exported from the open source software pg_dbms_stats or from FUJITSU Enterprise Postgres that has not been issued the bug fix, including the PH23544, cannot be imported using the traditional import facility (dbms_stats.import_database_stats function).

Use the compatible dbms_stats.import_<*obj*>_no_tree_height function. "<*obj*>" indicates the type of object (database, schema, etc.).

Compatibility when fixing statistics

This is a different behavior than the open source software pg_dbms_stats or when the bug fix that includes the PH23544 is not applied, when fixing statistics.

For compatibility, specify the pg_dbms_stats.use_tree_height and pg_dbms_stats.lock_tree_height parameters if you want the same behavior as in the legacy environment.

The following are the specified values and their meanings:

Parameter	Specified value	Default
pg_dbms_stats.use_tree_height	Specify whether the height of the Btree index is included in cost calculations and plan generation when statistics are pinned. on: Include index height in cost calculation and plan generation, as specified in PostgreSQL9.3 and later. off: The index height is ignored and does not affect cost calculations or plan generation. (PostgreSQL9.2 and earlier compatibility)	on
pg_dbms_stats.lock_tree_height	Specify whether the height of the btree index is fixed when statistics are fixed. It is enabled only when pg_dbms_stats.use_tree_height is set to on. on: Fixes the height of the btree index at its lock height.	on

Parameter	Specified value	Default
	off: The height of a btree index is not fixed, but varies depending on the amount of data in the index.	

If you want PostgreSQL9.2 to work, set it up as shown in the following example:

```
userdb=# SET pg_dbms_stats.use_tree_height TO off;
```

If you want PostgreSQL9.3 or later to work, use the following example:

```
userdb=# SET pg_dbms_stats.lock_tree_height TO off;
```

If you want the pg_dbms_stats.lock_tree_height and pg_dbms_stats.lock_tree_height parameter settings to take effect in all sessions, set them in postgresql.conf and then reload the settings.

Usage notes

- You must run the ANALYZE command once for the target tables of this feature. If the ANALYZE command is not run, the statistics cannot be locked.
  Refer to "SQL Commands" in "Reference" in the PostgreSQL Documentation for information on the ANALYZE command.
- To use this feature to delete an object that has locked the statistics, use the unlock feature to delete the object lock information first.
- This feature does not specify the statistics value directly. It reproduces the status that has actually occurred. For this reason, if the text format is specified in the COPY statement when the export occurs, restore will not be possible. Always use the binary format when performing the export.
- If the import function used is incorrect, an error message containing the following HINT is printed. Check the combination of the input file and the import function type and use the correct import function.

```
HINT:  The import function may be incorrectly combined with the format of the exported data. Please
check the documentation for the relationship between the import function and the available data.
```

Chapter 10 Scan Using a Vertical Clustered Index (VCI)

This chapter describes scanning using a VCI.

10.1 Operating Conditions

Faster aggregation can be achieved by using a VCI defined for all columns to be referenced.

This section describes the conditions under which a scan can use a VCI.

Whether to use VCI is determined based on cost estimation in the same way as normal indexes. Therefore, another execution plan will be selected if it is cheaper than a VCI even if a VCI is available.

SQL statements that can use VCIs

In addition to general SELECT statements, VCIs can be used for the SQL statements below (as long as they do not specify any of the elements listed in "SQL statements that cannot use VCIs" below):

- SELECT INTO
- CREATE TABLE AS SELECT
- CREATE MATERIALIZED VIEW ... AS SELECT
- CREATE VIEW ... AS SELECT
- COPY (SELECT ...) TO

SQL statements that cannot use VCIs

VCIs cannot be used for SQL statements that specify any of the following:

- Subquery to reference the column in which the parent query is referencing is specified
- Lock clause (such as FOR UPDATE)
- Cursor declared with WITH HOLD or scrollable
- SERIALIZABLE transaction isolation level
- Function or operator listed in "Functions and operators that do not use a VCI"
- User-defined function

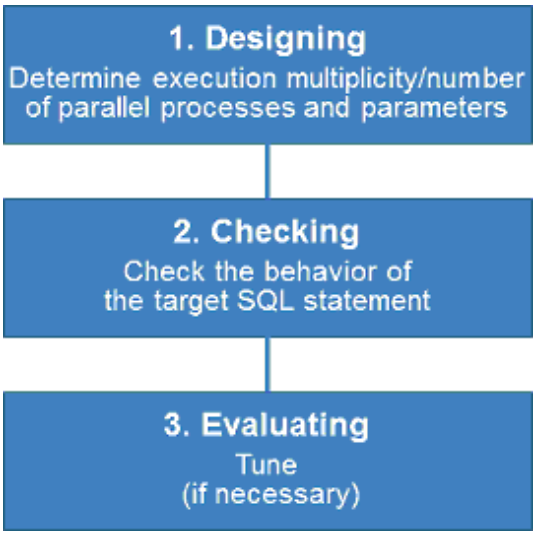
Table 10.1 Functions and operators that cannot use VCIs

Classification		Function/operator
Mathematical functions and operators	Random functions	random and setseed
String functions and operators	String functions	format (if the *format* argument is specified), regexp_matches, regexp_split_to_array and regexp_split_to_table
Date/time functions and operators	Date/time functions	age(timestamp), current_date, current_time, current_timestamp, localtime, localtimestamp, statement_timestamp and transaction_timestamp
	Delaying execution functions	pg_sleep, pg_sleep_for, and pg_sleep_until
Enum support functions		All functions and operators
Geometric functions and operators		All functions and operators
Network address functions and operators		All functions and operators
Text search functions and operators		All functions and operators
XML functions		All functions

Classification		Function/operator
JSON functions and operators		All functions and operators
Sequence manipulation functions		All functions
Array functions and operators		All functions and operators
Range functions and operators		All functions and operators
Aggregate functions	General-purpose aggregate functions	array_agg, json_agg, json_object_agg, string_agg and xmlagg
	Aggregate functions for statistics	corr, covar_pop, covar_samp, regr_avgx, regr_avgy, regr_count, regr_intercept, regr_r2, regr_slope, regr_sxx, regr_sxy and regr_syy
	Ordered-set aggregate functions	All functions
	Hypothetical-set aggregate functions	All functions
Window functions		All functions
Subquery expressions		Subquery expressions with its row constructor specified on the left side
Row and array comparisons		Row constructor and composite type comparisons
Set returning functions		All functions
System information functions		All functions
System administration functions		All functions
Trigger functions		All functions
Session information functions		current_role and current_user

10.2 Usage

This section describes how to use a VCI in line with the following steps:



10.2.1 Designing

Design as follows before using a VCI.

- Execution multiplicity and number of parallel processes

- Parameters

Execution multiplicity and number of parallel processes

Determine the maximum number of SQL statements that can be executed simultaneously and the number of parallel processes based on the number of CPU cores that can be allocated for scans that use VCI to perform aggregate processing. Design in advance the multiplicity of SQL statements for executing scans that use VCI and the number of parallel processes for scans that use VCI.

For example, if the number of CPUs that can be allocated is 32 cores, then the maximum number of SQL statements that can be executed simultaneously is 8 and the number of parallel processes is 4.

Note

A temporary file is created in /dev/shm or in a directory specified for the vci.smc_directory parameter as the dynamic shared memory for each SQL statement during a scan using a VCI.

Ensure that this directory has sufficient space to meet the memory requirements estimated for the execution multiplicity and number of parallel processes of SQL statements (refer to "Memory used per scanning" in "VCI Memory Requirements" in the Installation and Setup Guide for Server for details). If it does not have sufficient space when a scan is performed, SQL statements will return errors due to the insufficient memory.

Parameters

The VCI parallel scan feature cannot be used for setting parameters immediately after creating an instance.

Therefore, set the parameters below based on the values determined in "Execution multiplicity and number of parallel processes of SQL statements" above.

Parameter name	Description	Default	Value index
vci.max_parallel_degree	Maximum number of VCI parallel processes (background processes) to be used per SQL statement.	0	Specify the number of parallel processes.
vci.smc_directory	Directory name in which a temporary file is created as the dynamic shared memory during a scan using a VCI.	/dev/shm	Specify a directory that has enough free space for the memory used for each query during the scan.
max_worker_processes	Maximum number of background processes that the system supports.	8	Add the value of the maximum number of SQL statements that can be executed simultaneously for scans that use VCI multiplied by vci.max_parallel_degree.

See

Refer to "Parameters" in the Operation Guide for information on the details of and how to set the parameters.

10.2.2 Checking

Execute the SQL statement with "EXPLAIN ANALYZE" to check the following:

- If a VCI was used
  "Custom Scan (VCI...)" is displayed in the plan if a VCI was used.
- Number of parallel processes
  The number of parallel processes when the SQL statement is executed is displayed in "Allocated Workers". Check that it is running the designed number of parallel processes.

- Response
  Check if the execution time displayed in "Execution time" is as estimated.

The following shows an example of the output result of EXPLAIN ANALYZE:

```
EXPLAIN ANALYZE SELECT COUNT(*) FROM test WHERE x > 10000;
                                                  QUERY PLAN
-------------------------------------------------------------------------------------------------------------
--------------
Custom Scan (VCI Aggregate)  (cost=19403.15..19403.16 rows=1 width=0) (actual time=58.505..58.506
rows=1 loops=1)
       Allocated Workers: 4
   ->  Custom Scan (VCI Scan) using test_x_idx on test (cost=0.00..16925.00 rows=991261 width=0)
(never executed)
         Filter: (x > 10000)
Planning time: 0.151 ms
Execution time: 86.910 ms
(6 rows)
```

Note

A cost output by the execution plan that uses a VCI may be inaccurate. A VCI works if all or part of the best execution plan when the SQL statement was executed is replaced with an execution plan that uses a VCI. If the cost of the execution plan to be replaced is lower than a certain value (vci.cost_threshold parameter), it will not be replaced or recalculated. Therefore, the cost of the original execution plan is output as is.

10.2.3 Evaluating

If the results in "10.2.2 Checking" is any of the following, tune accordingly:

If a VCI is not used

- Check if the "10.1 Operating Conditions" are met.
- Check if vci.enable is set to "on".
- A VCI may not be appropriately used when statistics are outdated, such as immediately after inserting a large amount of data. In such cases, execute the VACUUM ANALYZE statement or the ANALYZE statement.
- A VCI is not used if there is insufficient memory for VCI scan. This may occur during time-consuming transactions involving tables for which VCIs were defined. Set vci.log_query to "on", and check if either "could not use VCI: local ROS size (%zu) exceeds limit (%zu)" or "out of memory during local ROS generation" is output. If it is, then increase the value of the vci.max_local_ros.

Response is not as expected

Tuning may improve response. Check the following:

- If vci.max_parallel_degree is not set or is set to 0, set an appropriate value according to "10.2.1 Designing".
- If there is a margin in the CPU usage, increase the value of vci.max_parallel_degree and check again. In addition, if the value that of max_worker_processes is lower than the maximum number of SQL statements that can be executed simultaneously for parallel scan multiplied by vci.max_parallel_degree, increase it and check again.

10.3 Usage Notes

This section provides notes on using VCI.

- Regardless of whether VCI is used, the content of the result does not change. However, records may be returned in a different order if the ORDER BY clause is not specified.
- To reduce resource consumption, edit postgresql.conf or use the SET statement to enable/disable vci.enable when you use this feature only for specific times or jobs (SQL applications).

- The optimizer hint (pg_hint_plan) cannot be specified for a VCI. The hint clause is ignored if it is specified.
- If a plan other than VCI is specified for the optimizer hint (pg_hint_plan), a VCI may be used. Therefore, if you specify a query plan with the hint clause, use the SET statement to set vci.enable to "off".
- The message below may be output when a scan that uses VCI is performed on the streaming replication standby server:

```
"LOG: recovery has paused"
"HINT: Execute pg_wal_replay_resume() to continue."
```

  This message is output because application of the WAL to the VCI temporarily pauses due to the scan being performed.

- Even if a scan is performed using a VCI, information in the idx_scan, idx_tup_read, and idx_tup_fetch columns of the collected statistics views, pg_stat_all_indexes and pg_stat_user_indexes, will not be updated.
- Currently, it is not possible to replace the query plan for parallel aggregation with the query plan using VCI. Therefore, if you create a VCI on a column of a partition table and aggregate (sum () etc.) on that column, one of the following plans will be selected. Use different setting parameters according to the situation of the target table.
  - Plan of the parallel aggregations using scan methods other than VCI scan

    It is selected when max_parallel_workers_per_gather is 1 or more.

```
explain select sum(value) from test;
                                        QUERY PLAN
-------------------------------------------------------------------------------
 Finalize Aggregate  (cost=99906.30..99906.31 rows=1 width=8)
   ->  Gather  (cost=99906.08..99906.29 rows=2 width=8)
         Workers Planned: 2
         ->  Partial Aggregate  (cost=98906.08..98906.09 rows=1 width=8)
               ->  Parallel Append  (cost=0.00..94739.83 rows=1666500 width=4)
                     ->  Parallel Seq Scan on test_1  (cost=0.00..43203.67 rows=833250 width=4)
                     ->  Parallel Seq Scan on test_2  (cost=0.00..43203.67 rows=833250 width=4)
```

    This plan is fast when the number of records to be aggregated (number of records that hit the search conditions) is very large. This is because the benefit of parallelizing aggregation is important, not the performance of scanning. For example, each parallel worker will perform a sequential scan and aggregate most of the scanned records.

  - Plan that aggregates VCI scan results by a single aggregator node

    It is selected by setting max_parallel_workers_per_gather to 0 and not creating a query plan of parallel aggregate.

```
explain select sum(value) from test;
                                        QUERY PLAN
-------------------------------------------------------------------------------
 Aggregate  (cost=145571.00..145571.01 rows=1 width=8)
   ->  Append  (cost=0.00..135572.00 rows=3999600 width=4)
         ->  Custom Scan (VCI Scan) using test_1_id_value_idx on test_1  (cost=0.00..57787.00
rows=1999800 width=4)
               Allocated Workers: 2
         ->  Custom Scan (VCI Scan) using test_2_id_value_idx on test_2  (cost=0.00..57787.00
rows=1999800 width=4)
               Allocated Workers: 2
```

    This plan is fast when the number of aggregated items is not large or when the size of the aggregated column is smaller than the record size. This is because the scan performance is more important, so it is faster to aggregate the results of VCI scans of each partition.

- Originally, if there is only one partition to be accessed, the following VCI aggregation plan can be used. Below is an example of scanning only one partition with partition pruning.

```
explain select sum(value) from test where id < 1000001;
                                        QUERY PLAN
-------------------------------------------------------------------------------
 Custom Scan (VCI Aggregate)  (cost=62786.50..62786.51 rows=1 width=8)
   Allocated Workers: 2
```

```
   ->  Custom Scan (VCI Scan) using test_1_id_value_idx on test_1  (cost=0.00..57787.00
rows=1999800 width=4)
         Filter: (id < 1000001)
```

However, the current planner does not try to choose VCI aggregation because it creates a plan for parallel aggregation if the table is partitioned. So in this case, set max_parallel_workers_per_gather to 0 to force the planner to choose VCI aggregation.

Appendix A Precautions when Developing Applications

This appendix describes precautions when developing applications with FUJITSU Enterprise Postgres.

A.1 Precautions when Using Functions and Operators

This section describes notes for using functions and operators.

A.1.1 General rules of Functions and Operators

This section describes general rules for using functions and operators. Ensure the general rules are followed when using functions and operators to develop applications.

General rules

- Specify the stated numbers for arguments when specifying numbers for arguments in functions.
- Specify the stated data types when specifying data types for functions. If you use a data type other than the stated data types, use CAST to explicitly convert the data type.
- Specify data types that can be compared when specifying data types for operators. If you use a data type that cannot be compared, use CAST to explicitly convert the data type.

See

Refer to "Functions and Operators" under "The SQL Language" in the PostgreSQL Documentation for information on the functions and operators available with FUJITSU Enterprise Postgres.

A.1.2 Errors when Developing Applications that Use Functions and/or Operators

This section provides examples of problems that may occur when developing applications that use functions and/or operators, and describes how to deal with them.

The error "Function ***** does not exist" occurs when executing SQL

The following error will occur when executing an SQL statement that does not abide by the general rules for functions:

```
ERROR:  Function ****** does not exist
```

Note: "*****" denotes the function for which the error occurred, and the data type of its arguments.

The cause of the error will be one of the following:

- The specified function does not exist.
- The wrong number of arguments or wrong argument data type was specified

Corrective action

Check the following points and correct any errors:

- Check if there are any errors in the specified function name, number of arguments, or argument data type, and revise accordingly.
- Check the argument data type of the function displayed in the message. If an unintended data type is displayed, use a function such as CAST to convert it.

The error "Operator does not exist" occurs when executing SQL

The following error will occur when executing an SQL statement that specifies a data type in the operator that cannot be compared:

```
ERROR:  Operator does not exist: *****
```

Note: "*****" denotes the operator for which the error occurred, and the data type of the specified value.

Corrective action

Ensure the data type of the expressions specified on the left and right sides of the operator can be compared. If required, revise to ensure these data types can be compared by using a function such as CAST to explicitly convert them.

A.2 Notes when Using Temporary Tables

In standard SQL, a temporary table can be defined in advance to enable an empty temporary table to be created automatically when the application connects to the database. However, in FUJITSU Enterprise Postgres, a temporary table must be created when the application connects to the database by explicitly using the CREATE TABLE statement.

If the same temporary table is repeatedly created and deleted during the same session, the system table might expand, and memory usage might increase. To prevent this, specify the CREATE TABLE statement to ensure the temporary table is reused.

For example, in cases where a temporary table would be created and deleted for repeatedly executed transactions, specify the CREATE TABLE statement as shown below:

- Specify "IF NOT EXISTS" to create a temporary table only if none exists when the transaction starts.
- Specify "ON COMMIT DELETE ROWS" to ensure all rows are deleted when the transaction ends.

 See

Refer to "SQL Commands" under "Reference" in the PostgreSQL Documentation for information on the CREATE TABLE statement.

Examples of SQL using a temporary table are shown below:

Example of bad use (creating and deleting a temporary table)

```
BEGIN;
CREATE TEMPORARY TABLE mytable(col1 CHAR(4), col2 INTEGER) ON COMMIT DROP;
     (mytable processes)

COMMIT;
```

Example of good use (reusing a temporary table)

```
BEGIN;
CREATE TEMPORARY TABLE IF NOT EXISTS mytable(col1 CHAR(4), col2 INTEGER) ON COMMIT DELETE ROWS;
     (mytable processes)

COMMIT;
```

A.3 Implicit Data Type Conversions

An implicit data type conversion refers to a data type conversion performed automatically by FUJITSU Enterprise Postgres, without the need to explicitly specify the data type to convert to.

The combination of possible data type conversions differs, depending on whether the expression in the conversion source is a literal.

For non-literals, data types can only be converted to other types within the same range.

For literals, character string literal types can be converted to the target data type. Numeric literals are implicitly converted to specific numeric types. These implicitly converted numeric literals can then have their types converted to match the conversion target data type within the numeric type range. For bit character string literals, only the bit column data type can be specified. The following shows the range of type conversions for literals.

Table A.1 Data type combinations that contain literals and can be converted implicitly

Conversion target		Conversion source		
		Character literal (*1)	Numeric literal(*2)	Bit character string literal
Numeric type	SMALLINT	Y	N	N
	INTEGER	Y	Y (*3)	N
	BIGINT	Y	Y (*4)	N
	DECIMAL	Y	Y (*5)	N
	NUMERIC	Y	Y (*5)	N
	REAL	Y	N	N
	DOUBLE PRECISION	Y	N	N
	SMALLSERIAL	Y	N	N
	SERIAL	Y	Y (*3)	N
	BIGSERIAL	Y	Y (*4)	N
Currency type	MONEY	Y	N	N
Character type	CHAR	Y	N	N
	VARCHAR	Y	N	N
	NCHAR	Y	N	N
	NCHAR VARYING	Y	N	N
	TEXT	Y	N	N
Binary data type	BYTEA	Y	N	N
Date/time type	TIMESTAMP WITHOUT TIME ZONE	Y	N	N
	TIMESTAMP WITH TIME ZONE	Y	N	N
	DATE	Y	N	N
	TIME WITHOUT TIME ZONE	Y	N	N
	TIME WITH TIME ZONE	Y	N	N
	INTERVAL	Y	N	N
Boolean type	BOOLEAN	Y	N	N
Geometric type	POINT	Y	N	N
	LSEG	Y	N	N
	BOX	Y	N	N
	PATH	Y	N	N
	POLYGON	Y	N	N
	CIRCLE	Y	N	N
Network address type	CIDR	Y	N	N
	INET	Y	N	N
	MACADDR	Y	N	N
	MACADDR8	Y	N	N
Bit string type	BIT	Y	N	Y

Conversion target		Conversion source		
		Character literal (*1)	Numeric literal(*2)	Bit character string literal
	BIT VARYING	Y	N	Y
Text search type	TSVECTOR	Y	N	N
	TSQUERY	Y	N	N
UUID type	UUID	Y	N	N
XML type	XML	Y	N	N
JSON type	JSON	Y	N	N

Y: Can be converted
N: Cannot be converted

*1: Only strings that can be converted to the data type of the conversion target can be specified (such as "1" if the conversion target is a numeric type)

*2: "Y" indicates specific numeric types that are converted first.

*3: Integers that can be expressed as INTEGER types can be specified

*4: Integers that cannot be expressed as INTEGER types, but can be expressed as BIGINT types, can be specified

*5: Integers that cannot be expressed as INTEGER or BIGINT types, but that can be expressed as NUMERIC types, or numeric literals that contain a decimal point or the exponent symbol (e), can be specified

Implicit data type conversions can be used when comparing or storing data.

The conversion rules differ, depending on the reason for converting. Purpose-specific explanations are provided below.

A.3.1 Function Argument

Value expressions specified in a function argument will be converted to the data type of that function argument.

See

Refer to "Functions and Operators" under "The SQL Language" in the PostgreSQL Documentation for information on data types that can be specified in function arguments.

A.3.2 Operators

Comparison operators, BETWEEN, IN

Combinations of data types that can be compared using comparison operators, BETWEEN, or IN are shown below.

Table A.2 Combinations of comparable data type

Left side	Right side		
	Numeric type	Character string type	Date/time type
Numeric type	Y	N	N
Character type	N	Y	N
Date/time type	N	N	Y

Y: Can be compared
N: Cannot be compared

When strings with different lengths are compared, the shorter one is padded with spaces to make the lengths match.

When numeric values with different precisions are compared, data will be converted to the type with the higher precision.

Set operation and CASE also follow the same rules.

Other operators

Value expressions specified in operators will be converted to data types that are valid for that operator.

Refer to "Functions and Operators" under "The SQL Language" in the PostgreSQL Documentation for information on data types that can be specified in operators.

A.3.3 Storing Values

Value expressions specified in the VALUES clause of the INSERT statement or the SET clause of the UPDATE statement will be converted to the data type of the column in which they will be stored.

A.4 Notes on Using Index

This section explains the notes on using the following indexes:

- SP-GiST index

A.4.1 SP-GiST Index

If more than 2 concurrent updates are performed on a table in which the SP-GiST index is defined, applications may stop responding. When this occur, all system processes including the Check Pointer process will also be in the state of no response. For these reasons, use of the SP-GiST index is not recommended.

A.5 Notes on Using Multibyte Characters in Definition Names

Multibyte characters must not be used in database names or user names, because certain conditions may apply or it may not be possible to connect to some clients.

Related notes and constraints are described below.

1) Configuring the client encoding system

The client encoding system must be configured when the names are created.

Refer to "Character Set Support" in "Server Administration" in the PostgreSQL Documentation for information on how to configure the client encoding system.

2) Encoding system of names used for connection

Ensure that the encoding system of names used for connection is the same as that of the database that was connected when these names were created.

The reasons for this are as follows:

- Storage system for names in FUJITSU Enterprise Postgres

  The system catalog saves encoded names by using the encoding system of the database at the time the names were created.

- Encoding conversion policy when connected

  When connected, names sent from the client are matched with names in the system catalog without performing encoding conversion.

Accordingly, if the database that was connected when the names were defined uses the EUC_JP encoding system, but the database name is specified using UTF-8 encoding, then the database will be considered to be non-existent.

3) Connection constraints

The table below shows the connection constraints for each client type, based on the following assumptions:

- The conditions described in 1) and 2) above are satisfied.
- The database name and user names use the same encoding system.

Client type	Client operating system
JDBC driver	Cannot be connected
ODBC driver	No connection constraints
SQLEmbedded SQL in C	No connection constraints
psql command	No connection constraints

Appendix B Conversion Procedures Required due to Differences from Oracle Database

This appendix explains how to convert from an Oracle database to FUJITSU Enterprise Postgres, within the scope noted in "Chapter 7 Compatibility with Oracle Databases" from the following perspectives:

- Feature differences
- Specification differences

This document assumes that the version of the Oracle database to be converted is 7-10.2g.

B.1 Outer Join Operator (Perform Outer Join)

Features

In the WHERE clause conditional expression, by adding the plus sign (+), which is the outer join operator, to the column of the table you want to add as a table join, it is possible to achieve an outer join that is the same as a joined table (OUTER JOIN).

B.1.1 Comparing with the ^= Comparison Operator

Oracle database

```
SELECT *
  FROM t1, t2
  WHERE t1.col1(+) ^= t2.col1;
```

Note: col1 is assumed to be CHAR(4) type

FUJITSU Enterprise Postgres

```
SELECT *
  FROM t1, t2
  WHERE t1.col1(+) != t2.col1;
```

Note: col1 is assumed to be CHAR(4) type

Feature differences

Oracle database

The ^= comparison operator can be specified.

FUJITSU Enterprise Postgres

The ^= comparison operator cannot be specified.

Conversion procedure

Convert using the following procedure:

1. Locate the places where the keyword "^=" is used.
2. Ensure that the keyword, "(+)", is either on the right or left-hand side.
3. Change "^=" to " !=".

B.2 DECODE (Compare Values and Return Corresponding Results)

Features

DECODE compares values of the conversion target value expression and the search values one by one, and if the values of the conversion target value expression and the search values match, a corresponding result value is returned.

B.2.1 Comparing Numeric Data of Character String Types and Numeric Characters

Oracle database

```
SELECT DECODE( col1,
               1000, 'ITEM-A',
               2000, 'ITEM-B',
               'ITEM-C')
  FROM t1;
```

Note: col1 is assumed to be CHAR(4) type

FUJITSU Enterprise Postgres

```
SELECT DECODE( CAST(col1 AS INTEGER),
               1000, 'ITEM-A',
               2000, 'ITEM-B',
               'ITEM-C')
  FROM t1;
```

Note: col1 is assumed to be CHAR(4) type

Feature differences

Oracle database

When the value expression is a string and the search value is a numeric, the string value will be converted to the data type of the comparison target numeric, so that they can be compared.

FUJITSU Enterprise Postgres

If the conversion target value expression is a string value, then no search value can be specified with numbers.

Conversion procedure

Since the data type that can be specified for the conversion target value expression is unknown, use CAST to explicitly convert the conversion target value expression (col1 in the example) to a numeric (INTEGER type in the example).

B.2.2 Obtaining Comparison Result from more than 50 Conditional Expressions

Oracle database

```
SELECT DECODE(col1,
               1,'A',
               2,'B',
               ...
               78,'BZ',
               NULL,'UNKNOWN',
               'OTHER')
   FROM t1;
```

Note: col1 is assumed to be INTEGER type

FUJITSU Enterprise Postgres

```
SELECT CASE
           WHEN col1 = 1 THEN 'A'
           WHEN col1 = 2 THEN 'B'
           ...
           WHEN col1 = 78 THEN 'BZ'
           WHEN col1 IS NULL THEN 'UNKNOWN'
           ELSE 'OTHER'
         END
    FROM t1;
```

Note: col1 is assumed to be INTEGER type

Feature differences

Oracle database

Search value with a maximum of 127 items (up to 255 arguments in total) can be specified.

FUJITSU Enterprise Postgres

Search value with a maximum of 49 items (up to 100 arguments in total) only can be specified.

Conversion procedure

Convert to the CASE expression using the following procedure:

1. Specify the DECODE conversion target value expression (col1 in the first argument, in the example) and the search value (1 in the second argument, in the example) for the CASE expression search condition. Specify the DECODE result value ('A' in the third argument, in the example) for the CASE expression THEN (WHEN col1 = 1 THEN 'A', in the example). Note that if the search value is NULL, specify "IS NULL" for the search condition for the CASE expression.
2. If the DECODE default value ('OTHER' in the last argument, in the example) is specified, specify the default value for the CASE expression ELSE (ELSE 'OTHER', in the example).

B.2.3 Obtaining Comparison Result from Values with Different Data Types

Oracle database

```
SELECT DECODE( col1,
               '1000', 'A',
               '2000', 1,
               'OTHER')
FROM t1;
```

Note: col1 is assumed to be CHAR(4) type

FUJITSU Enterprise Postgres

```
SELECT DECODE( col1,
              '1000', 'A',
              '2000', '1',
              'OTHER')
FROM t1;
```

Note: col1 is assumed to be CHAR(4) type

Feature differences

Oracle database

The data types of all result values are converted to the data type of the first result value.

FUJITSU Enterprise Postgres

Results in an error.

Conversion procedure

Convert using the following procedure:

1. Check the literal data type for the first result value specified.
2. Change the literals specified for each result value to the literal data type checked in the step 1.

B.3 SUBSTR (Extract a String of the Specified Length from Another String)

Features

SUBSTR returns the number of characters specified in the third argument (starting from the position specified in the second argument) from the string specified in the first argument.

Refer to "7.2.1 Notes on SUBSTR" for details on precautions when using SUBSTR.

B.3.1 Specifying a Value Expression with a Data Type Different from the One that can be Specified for Function Arguments

Oracle database

```
SELECT SUBSTR( col1,
               1,
               col2)
  FROM DUAL;
```

Note: col1 and col2 are assumed to be CHAR type

FUJITSU Enterprise Postgres

```
CREATE CAST (CHAR AS INTEGER) WITH INOUT AS IMPLICIT;

SELECT SUBSTR( col1,
               1,
               col2)
  FROM DUAL;
# No changes to SELECT statement;
```

Note: col1 and col2 are assumed to be CHAR type

Feature differences

Oracle database

If the type can be converted to a data type that can be specified for function arguments, conversion is performed implicitly.

FUJITSU Enterprise Postgres

If the data types are different from each other, or if loss of significance occurs, implicit conversion is not performed.

Conversion procedure

Since the data type of the string length is clear, first execute the following CREATE CAST only once so that the CHAR type value (col2 in the example) specified for the string length is implicitly converted to INTEGER type.

```
CREATE CAST (CHAR AS INTEGER) WITH INOUT AS IMPLICIT;
```

B.3.2 Extracting a String with the Specified Format from a Datetime Type Value

Oracle database

```
SELECT SUBSTR( CURRENT_TIMESTAMP,
               1,
               8)
  FROM DUAL;
```

FUJITSU Enterprise Postgres

```
SELECT SUBSTR( TO_CHAR(CURRENT_TIMESTAMP,
               'DD-MON-YY HH.MI.SS.US PM')
                1,
                8)
  FROM DUAL;
```

Feature differences

Oracle database

A datetime value such as CURRENT_TIMESTAMP can be specified for character value expressions.

FUJITSU Enterprise Postgres

A datetime value such as CURRENT_TIMESTAMP cannot be specified for character value expressions.

Conversion procedure

First, specify TO_CHAR for the SUBSTR character value expression.
Specify datetime type (CURRENT_TIMESTAMP, in the example) in firstArg of TO_CHAR, and specify the format template pattern ('DD-MON-YY HH.MI.SS.US PM', in the example) for secondArg to match with the result of SUBSTR before conversion.

TO_CHAR specification format: TO_CHAR(*firstArg, secondArg*)

Information

Refer to "Data Type Formatting Functions" in the PostgreSQL Documentation for information on format template patterns that can be specified for TO_CHAR in FUJITSU Enterprise Postgres.

B.3.3 Concatenating a String Value with a NULL value

Oracle database

```
SELECT SUBSTR( col1 || col2,
               2,
               5)
  FROM t1;
```

Note: col1 and col2 are assumed to be character string type, and col2 may contain NULL

FUJITSU Enterprise Postgres

```
SELECT SUBSTR( col1 || NVL(col2, '')
               2,
               5)
  FROM t1;
```

Note: col1 and col2 are assumed to be character string type, and col2 may contain NULL

Feature differences

Oracle database

NULL is handled as an empty string, and strings are joined.

FUJITSU Enterprise Postgres

NULL is not handled as an empty string, and the result of joining the strings becomes NULL.

Conversion procedure

Convert using the following procedure:

1. Locate the places where the keyword "||" is used.
2. Check if any of the value expressions can contain NULL - if they can, then execute step 3.
3. Modify to NVL(*valExpr,*'').

B.4 NVL (Replace NULL)

Features

NVL converts NULL values.

B.4.1 Obtaining Result from Arguments with Different Data Types

Oracle database

```
SELECT NVL( col1,
            col2)
  FROM t1;
```

Note: col1 is assumed to be VARCHAR(100) type, and col2 is assumed to be CHAR(100) type

FUJITSU Enterprise Postgres

```
SELECT NVL( col1,
            CAST(col2 AS VARCHAR(100))
  FROM t1;
```

Note: col1 is assumed to be VARCHAR(100) type, and col2 is assumed to be CHAR(100) type

Feature differences

Oracle database

Value expressions with different data types can be specified. If the first argument is a string value, then VARCHAR2 is returned, and if it is a numeric, then a numeric type with greater range is returned.

FUJITSU Enterprise Postgres

Value expressions with different data types cannot be specified.

Conversion procedure

Since the data types that can be specified for the expressions in the two arguments are unknown, use the following steps to convert:

1. Check the data types specified for each of the two expressions.
2. Using the data type that is to be received as a result, explicitly convert the other argument with CAST.

B.4.2 Operating on Datetime/Numeric, Including Adding Number of Days to a Particular Day

Oracle database

```
SELECT NVL( col1 + 10, CURRENT_DATE)
  FROM t1;
```

Note: col1 is assumed to be TIMESTAMP WITHOUT TIME ZONE type or TIMESTAMP WITH TIME ZONE type

FUJITSU Enterprise Postgres

```
SELECT NVL( CAST(col1 AS DATE) + 10, CURRENT_DATE)
  FROM t1;
```

Note: col1 is assumed to be TIMESTAMP WITHOUT TIME ZONE type or TIMESTAMP WITH TIME ZONE type

Feature differences

Oracle database

Numbers can be operated (added to or subtracted from) with either TIMESTAMP WITHOUT TIME ZONE type or TIMESTAMP WITH TIME ZONE type. Operation result will be DATE type.

FUJITSU Enterprise Postgres

Numbers cannot be operated (added to or subtracted from) with neither TIMESTAMP WITHOUT TIME ZONE type nor TIMESTAMP WITH TIME ZONE type. However, numbers can be operated (added to or subtracted from) with DATE type.

Conversion procedure

Convert using the following procedure:

1. Search locations where the keyword "+" or "-" is used in addition or subtraction, and check if these operations are between numbers and TIMESTAMP WITHOUT TIME ZONE type or TIMESTAMP WITH TIME ZONE type.
2. If they are, use CAST to explicitly convert TIMESTAMP WITHOUT TIME ZONE type or TIMESTAMP WITH TIME ZONE type to DATE type.

B.4.3 Calculating INTERVAL Values, Including Adding Periods to a Date

Oracle database

```
SELECT NVL( CURRENT_DATE + (col1 * 1.5), col2)
  FROM t1;
```

Note: col1 and col2 are assumed to be INTERVAL YEAR TO MONTH types

FUJITSU Enterprise Postgres

```
SELECT NVL( CURRENT_DATE +
        CAST(col1 * 1.5 AS
          INTERVAL YEAR TO MONTH), col2)
  FROM t1;
```

Note: col1 and col2 are assumed to be INTERVAL YEAR TO MONTH types

Feature differences

Oracle database

INTERVAL YEAR TO MONTH type multiplication and division result in INTERVAL YEAR TO MONTH type and any fraction (number of days) will be truncated.

FUJITSU Enterprise Postgres

INTERVAL YEAR TO MONTH type multiplication and division result in INTERVAL type and fractions (number of days) will not be truncated.

Conversion procedure

Convert using the following procedure:

1. Search locations where the keywords "*" or "/" are used in multiplication or division, and check if the specified value is INTERVAL YEAR TO MONTH type.
2. If the value is INTERVAL YEAR TO MONTH type, use CAST to explicitly convert the operation result to INTERVAL YEAR TO MONTH type.

B.5 DBMS_OUTPUT (Output Messages)

Features

DBMS_OUTPUT sends messages to clients such as psql from PL/pgSQL.

B.5.1 Outputting Messages Such As Process Progress Status

Oracle database

```
set serveroutput on;...(1)

DECLARE
  v_col1        CHAR(20);
  v_col2        INTEGER;
  CURSOR c1 IS
    SELECT col1, col2 FROM t1;
BEGIN
  DBMS_OUTPUT.PUT_LINE('-- BATCH_001 Start --');
  OPEN c1;
  DBMS_OUTPUT.PUT_LINE('-- LOOP Start --');
  LOOP
    FETCH c1 INTO v_col1, v_col2;
    EXIT WHEN c1%NOTFOUND;
    DBMS_OUTPUT.PUT('.');
  END LOOP;
  DBMS_OUTPUT.NEW_LINE; ...(2)
  DBMS_OUTPUT.PUT_LINE('-- LOOP End --');
  CLOSE c1;

  DBMS_OUTPUT.PUT_LINE('-- BATCH_001 End --');


EXCEPTION
  WHEN OTHERS THEN
     DBMS_OUTPUT.PUT_LINE('-- SQL Error --');
     DBMS_OUTPUT.PUT_LINE('ERROR : ' || SQLERRM );
END;
/
```

FUJITSU Enterprise Postgres

```
DO $$
DECLARE
    v_col1      CHAR(20);
    v_col2      INTEGER;
    c1 CURSOR FOR
        SELECT col1, col2 FROM t1;
BEGIN
    PERFORM DBMS_OUTPUT.SERVEROUTPUT(TRUE); ...(1)
    PERFORM DBMS_OUTPUT.ENABLE(NULL); ...(1)

    PERFORM DBMS_OUTPUT.PUT_LINE('-- BATCH_001 Start --');

    OPEN c1;
    PERFORM DBMS_OUTPUT.PUT_LINE('-- LOOP Start --');
    LOOP
        FETCH c1 INTO v_col1, v_col2;
        EXIT WHEN FOUND = false;
        PERFORM DBMS_OUTPUT.PUT('.');
    END LOOP;
    PERFORM DBMS_OUTPUT.NEW_LINE(); ...(2)

    PERFORM DBMS_OUTPUT.PUT_LINE('-- LOOP End --');
    CLOSE c1;

    PERFORM DBMS_OUTPUT.PUT_LINE('-- BATCH_001 End --');

EXCEPTION
    WHEN OTHERS THEN
        PERFORM DBMS_OUTPUT.PUT_LINE('-- SQL Error --');
        PERFORM DBMS_OUTPUT.PUT_LINE('ERROR : ' || SQLERRM );
END;
$$
;
```

(1) SERVEROUTPUT/ENABLE

Specification differences

Oracle database

Use SET statement and specify SERVEROUTPUT ON.

FUJITSU Enterprise Postgres

Specify DBMS_SQL.SERVEROUTPUT(TRUE).

Conversion procedure

Convert using the following procedure:

1. Check if a SET SERVEROUTPUT statement is specified before the PL/SQL block of a stored procedure.
2. If a SET SERVEROUTPUT statement is specified, specify DBMS_SQL.SERVEROUTPUT straight after BEGIN of PL/pgSQL. If ON is specified to have messages output to a window, then specify TRUE. If OFF is specified, then specify FALSE.
3. Specify DBMS_SQL.ENABLE only if SET SERVEROUTPUT is ON. The values to be specified for the argument are as follows:
   - If SIZE is specified for the SET SERVEROUTPUT statement, specify this size for the argument.
   - If SIZE is not specified for the SET SERVEROUTPUT statement, then specify 2000 for Oracle10.1g or earlier, NULL for Oracle10.2g or later.

   If DBMS_SQL.ENABLE is specified for the PL/SQL block of the stored procedure, specify the same value as that argument.

(2) NEW_LINE

Specification differences

Oracle database

If there is no argument for *packageName.featureName*, parenthesis can be omitted.

FUJITSU Enterprise Postgres

Even if there is no argument for *packageName.featureName*, parenthesis cannot be omitted.

Conversion procedure

Convert using the following procedure:

1. Locate the places where the keyword "DBMS_OUTPUT.NEW_LINE" is used in the stored procedure.
2. If there is no parenthesis after *packageName.featureName*, add the parenthesis.

B.5.2 Receiving a Return Value from a Procedure (PL/SQL) Block (For GET_LINES)

Oracle database

```
set serveroutput off;

DECLARE
    v_num        INTEGER;
BEGIN

    DBMS_OUTPUT.DISABLE; ...(3)
    DBMS_OUTPUT.ENABLE(20000); ...(4)
    DBMS_OUTPUT.PUT_LINE('-- ITEM CHECK --');


    SELECT count(*) INTO v_num FROM t1;

    IF v_num = 0 THEN
        DBMS_OUTPUT.PUT_LINE('-- NO ITEM --');

    ELSE
        DBMS_OUTPUT.PUT_LINE('-- IN ITEM(' || v_num || ') --');
    END IF;
END;
/

set serveroutput on;

DECLARE
    v_buffs      DBMSOUTPUT_LINESARRAY; ...(5)
    v_num        INTEGER := 10;
BEGIN

    DBMS_OUTPUT.GET_LINES(v_buffs, v_num); ...(5)

    FOR i IN 1..v_num LOOP
        DBMS_OUTPUT.PUT_LINE('LOG : ' || v_buffs(i)); ...(5)
    END LOOP;
END;
/
```

FUJITSU Enterprise Postgres

```
DO $$
DECLARE
    v_num        INTEGER;
BEGIN
    PERFORM DBMS_OUTPUT.SERVEROUTPUT(FALSE);
    PERFORM DBMS_OUTPUT.DISABLE(); ...(3)
    PERFORM DBMS_OUTPUT.ENABLE(20000); ...(4)
PERFORM DBMS_OUTPUT.PUT_LINE('-- ITEM CHECK --');

    SELECT count(*) INTO v_num FROM t1;

    IF v_num = 0 THEN
        PERFORM DBMS_OUTPUT.PUT_LINE('-- NO ITEM --');
    ELSE
        PERFORM DBMS_OUTPUT.PUT_LINE('-- IN ITEM(' || v_num || ') --');
    END IF;
END;
$$
;

DO $$
DECLARE
    v_buffs      VARCHAR[]; ...(5)
    v_num        INTEGER := 10;
BEGIN
    PERFORM DBMS_OUTPUT.SERVEROUTPUT(TRUE);
    SELECT lines, numlines INTO v_buffs, v_num FROM DBMS_OUTPUT.GET_LINES(v_num); ...(5)

    FOR i IN 1..v_num LOOP
        PERFORM DBMS_OUTPUT.PUT_LINE('LOG : ' || v_buffs[i]); ...(5)
    END LOOP;
END;
$$
;
```

(3) DISABLE

Same as the NEW_LINE in the DBMS_OUTPUT package. Refer to NEW_LINE for information on specification differences and conversion procedures associated with specification differences.

(4) ENABLE

Same as NEW_LINE in the DBMS_OUTPUT package. Refer to NEW_LINE for information on specification differences and conversion procedures associated with specification differences.

(5) GET_LINES

Specification format for Oracle database

DBMS_OUTPUT.GET_LINES(*firstArg, secondArg*)

Specification differences

Oracle database

Obtained values are received with variables specified for arguments.

FUJITSU Enterprise Postgres

Since obtained values are the search results for DBMS_OUTPUT.GET_LINES, they are received with variables specified for the INTO clause of the SELECT statement.

Conversion procedure

Convert using the following procedure:

1. Locate the places where the keyword "DBMS_OUTPUT.GET_LINES" is used in the stored procedure.
2. Change the data type (DBMSOUTPUT_LINESARRAY in the example) of the variable (v_buffs in the example) specified as *firstArg* of DBMS_OUTPUT.GET_LINES into a VARCHAR type array (VARCHAR[] in the example).
3. Replace the DBMS_OUTPUT.GET_LINES location called with a SELECT INTO statement.
   - Use the literal "lines, numlines" in the select list.
   - Specify *firstArg* (v_buffs in the example) and *secondArg* (v_num in the example) configured in DBMS_OUTPUT.GET_LINES, in the INTO clause.
   - Use DBMS_OUTPUT.GET_LINES in the FROM clause. Specify only *secondArg* (v_num in the example) before modification.
4. Identify the location that references *firstArg* (v_buffs in the example), and change it to the PL/pgSQL array reference format (v_buffs[i] in the example).

B.5.3 Receiving a Return Value from a Procedure (PL/SQL) Block (For GET_LINE)

Oracle database

```
set serveroutput on;

DECLARE
    v_buff1       VARCHAR2(100);
    v_buff2       VARCHAR2(1000);
    v_num        INTEGER;
BEGIN

    v_buff2 := '';
    LOOP
        DBMS_OUTPUT.GET_LINE(v_buff1, v_num); ...(6)
        EXIT WHEN v_num = 1;
        v_buff2 := v_buff2 || v_buff1;
    END LOOP;

    DBMS_OUTPUT.PUT_LINE(v_buff2);
END;
/
```

Note: Only the process to obtain a value is stated

FUJITSU Enterprise Postgres

```
DO $$
DECLARE
    v_buff1       VARCHAR(100);
    v_buff2       VARCHAR(1000);
    v_num        INTEGER;
BEGIN
    PERFORM DBMS_OUTPUT.SERVEROUTPUT(TRUE);
    v_buff2 := '';
    LOOP
        SELECT line, status INTO v_buff1, v_num FROM DBMS_OUTPUT.GET_LINE(); ...(6)
        EXIT WHEN v_num = 1;
        v_buff2 := v_buff2 || v_buff1;
    END LOOP;
```

```
    PERFORM DBMS_OUTPUT.PUT_LINE(v_buff2);
END;
$$
;
```

Note: Only the process to obtain a value is stated

(6) GET_LINE

Specification format for Oracle database

DBMS_OUTPUT.GET_LINE(*firstArg, secondArg*)

Specification differences

Oracle database

Obtained values are received with variables specified for arguments.

FUJITSU Enterprise Postgres

Since obtained values are the search results for DBMS_OUTPUT.GET_LINES, they are received with variables specified for the INTO clause of the SELECT statement.

Conversion procedure

Convert using the following procedure:

1. Locate the places where the keyword "DBMS_OUTPUT.GET_LINE" is used in the stored procedure.
2. Replace the DBMS_OUTPUT.GET_LINE location called with a SELECT INTO statement.
   - Use the literal "line, status" in the select list.
   - Specify *firstArg* (v_buff1 in the example) and *secondArg* (v_num in the example) configured in DBMS_OUTPUT.GET_LINE, in the INTO clause.
   - Use DBMS_OUTPUT.GET_LINE in the FROM clause. Although arguments are not specified, parenthesis must be specified.

B.6 UTL_FILE (Perform File Operation)

Features

UTL_FILE reads and writes text files from PL/pgSQL.

B.6.1 Registering a Directory to Load and Write Text Files

Oracle database

```
[Oracle9i or earlier]
Configure the following with initialization parameter
   UTL_FILE_DIR='/home/fsep' ...(1)

[Oracle9.2i or later]
   Configure the following with CREATE DIRECTORY statement
   CREATE DIRECTORY DIR AS '/home/fsep'; ...(1)
```

FUJITSU Enterprise Postgres

```
INSERT INTO UTL_FILE.UTL_FILE_DIR(dir)
       VALUES('/home/fsep'); ...(1)
```

(1) UTL_FILE_DIR/CREATE DIRECTORY

Feature differences

Oracle database

Configure the directory to be operated, using the CREATE DIRECTORY statement or the initialization parameter UTL_FILE_DIR.

FUJITSU Enterprise Postgres

The directory to be operated cannot be configured using the CREATE DIRECTORY statement or the initialization parameter UTL_FILE_DIR.

Conversion procedure

Configure the target directory information in the UTL_FILE.UTL_FILE_DIR table using the INSERT statement. Note that this conversion procedure should be performed only once before executing the PL/pgSQL function.

- When using the initialization parameter UTL_FILE_DIR:

  1. Check the initialization parameter UTL_FILE_DIR value ('/home/fsep' in the example).
  2. Using the INSERT statement, specify and execute the directory name checked in step 1.
     - Specify UTL_FILE.UTL_FILE_DIR(dir) for the INTO clause.
     - Using the character string literal ('/home/fsep' in the example), specify the target directory name for the VALUES clause.
     - If multiple directories are specified, execute the INSERT statement for each directory.

- When using the CREATE DIRECTORY statement:

  1. Check the directory name ('/home/fsep' in the example) registered with the CREATE DIRECTORY statement. To check, log in SQL*Plus as a user with DBA privileges, and execute "show ALL_DIRECTORIES;".
  2. Using the INSERT statement, specify and execute the directory name checked in step 1. Same steps are used to specify the INSERT statement as when using the initialization parameter UTL_FILE_DIR.

B.6.2 Checking File Information

Oracle database

```
CREATE PROCEDURE read_file(fname VARCHAR2) AS


    v_file      UTL_FILE.FILE_TYPE;
    v_exists    BOOLEAN;
    v_length    NUMBER;
    v_bsize     INTEGER;
    v_rbuff     VARCHAR2(1024);
BEGIN


    UTL_FILE.FGETATTR('DIR', fname, v_exists, v_length, v_bsize); ...(2)


    IF v_exists <> true THEN
        DBMS_OUTPUT.PUT_LINE('-- FILE NOT FOUND --');
        RETURN;
    END IF;

    DBMS_OUTPUT.PUT_LINE('-- FILE DATA --');

    v_file := UTL_FILE.FOPEN('DIR', fname, 'r', 1024); ...(3)
    FOR i IN 1..3 LOOP
        UTL_FILE.GET_LINE(v_file, v_rbuff, 1024); ...(4)
        DBMS_OUTPUT.PUT_LINE(v_rbuff);
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('... more');
    DBMS_OUTPUT.PUT_LINE('-- READ END --');
```

```
    UTL_FILE.FCLOSE(v_file); ...(5)
    RETURN;

EXCEPTION
    WHEN NO_DATA_FOUND THEN
        DBMS_OUTPUT.PUT_LINE('-- FILE END --');

        UTL_FILE.FCLOSE(v_file);
        RETURN;
    WHEN OTHERS THEN
        DBMS_OUTPUT.PUT_LINE('-- SQL Error --');

        DBMS_OUTPUT.PUT_LINE('ERROR : ' || SQLERRM );
        UTL_FILE.FCLOSE_ALL; ...(6)
        RETURN;
END;
/

set serveroutput on

call read_file('file01.txt');
```

FUJITSU Enterprise Postgres

```
CREATE FUNCTION read_file(fname VARCHAR) RETURNS void AS $$
DECLARE
    v_file      UTL_FILE.FILE_TYPE;
    v_exists    BOOLEAN;
    v_length    NUMERIC;
    v_bsize     INTEGER;
    v_rbuff     VARCHAR(1024);
BEGIN
    PERFORM DBMS_OUTPUT.SERVEROUTPUT(TRUE);

    SELECT fexists, file_length, blocksize
       INTO v_exists, v_length, v_bsize
       FROM UTL_FILE.FGETATTR('/home/fsep', fname); ...(2)
    IF v_exists <> true THEN
        PERFORM DBMS_OUTPUT.PUT_LINE('-- FILE NOT FOUND --');
        RETURN;
    END IF;

    PERFORM DBMS_OUTPUT.PUT_LINE('-- FILE DATA --');
    v_file := UTL_FILE.FOPEN('/home/fsep', fname, 'w', 1024); ...(3)
    FOR i IN 1..3 LOOP
        v_rbuff := UTL_FILE.GET_LINE(v_file, 1024); ...(4)
        PERFORM DBMS_OUTPUT.PUT_LINE(v_rbuff);
    END LOOP;
    PERFORM DBMS_OUTPUT.PUT_LINE('... more');
    PERFORM DBMS_OUTPUT.PUT_LINE('-- READ END --');

    v_file := UTL_FILE.FCLOSE(v_file); ...(5)
    RETURN;

EXCEPTION
    WHEN NO_DATA_FOUND THEN
        PERFORM DBMS_OUTPUT.PUT_LINE('-- FILE END --');
        v_file := UTL_FILE.FCLOSE(v_file);
        RETURN;
    WHEN OTHERS THEN
        PERFORM DBMS_OUTPUT.PUT_LINE('-- SQL Error --');
        PERFORM DBMS_OUTPUT.PUT_LINE('ERROR : ' || SQLERRM );
```

```
        PERFORM UTL_FILE.FCLOSE_ALL(); ...(6)
        RETURN;
END;
$$
LANGUAGE plpgsql;

SELECT read_file('file01.txt');
```

(2) FGETATTR

Specification format for Oracle database

UTL_FILE.FGETATTR(*firstArg, secondArg*, *thirdArg*, *fourthArg*, *fifthArg*)

Feature differences

Oracle database

If using a CREATE DIRECTORY statement (Oracle9.2i or later), specify a directory object name for the directory name.

FUJITSU Enterprise Postgres

A directory object name cannot be specified for the directory name.

Specification differences

Oracle database

Obtained values are received with variables specified for arguments.

FUJITSU Enterprise Postgres

Since obtained values are the search results for UTL_FILE.FGETATTR, they are received with variables specified for the INTO clause of the SELECT statement.

Conversion procedure

Convert using the following procedure. Refer to UTL_FILE_DIR/CREATE DIRECTORY for information on how to check if the directory object name corresponds to the actual directory name.

1. Locate the places where the keyword "UTL_FILE.FOPEN" is used in the stored procedure.
2. Check the actual directory name ('/home/fsep' in the example) that corresponds to the directory object name ('DIR' in the example).
3. Replace the directory object name ('DIR' in the example) in *firstArg* with the actual directory name ('/home/fsep' in the example) verified in step 2.
4. Replace the UTL_FILE.FGETATTR location called with a SELECT INTO statement.
   - Use the literal "fexists, file_length, blocksize" in the select list.
   - Specify *thirdArg*, *fourthArg*, and *fifthArg* (v_exists, v_length, v_bsize, in the example) specified for UTL_FILE.FGETATTR to the INTO clause in the same order as that of the arguments.
   - Use UTL_FILE.FGETATTR in the FROM clause. Specify only the actual directory name for *firstArg* ('/home/fsep' in the example) and *secondArg* (fname in the example) before modification for the arguments.

(3) FOPEN

Specification format for Oracle

UTL_FILE.FOPEN(*firstArg, secondArg*, *thirdArg*, *fourthArg*, *fifthArg*)

Feature differences

Oracle database

If using a CREATE DIRECTORY statement (Oracle9.2i or later), specify a directory object name for the directory name.

FUJITSU Enterprise Postgres

A directory object name cannot be specified for the directory name.

Conversion procedure

Convert using the following procedure. Refer to UTL_FILE_DIR/CREATE DIRECTORY for information on how to check if the directory object name corresponds to the actual directory name.

1. Locate the places where the keyword "UTL_FILE.FOPEN" is used in the stored procedure.
2. Check the actual directory name ('/home/fsep' in the example) that corresponds to the directory object name ('DIR' in the example).
3. Replace the directory object name ('DIR' in the example) in *firstArg* with the actual directory name ('/home/fsep' in the example) checked in step 1.

(4) GET_LINE

Specification format for Oracle database

UTL_FILE.GET_LINE(*firstArg*, *secondArg*, *thirdArg*, *fourthArg*)

Specification differences

Oracle database

Obtained values are received with variables specified for arguments.

FUJITSU Enterprise Postgres

Since obtained values are the returned value of UTL_FILE.GET_LINE, they are received with variables specified for substitution statement.

Conversion procedure

Convert using the following procedure:

1. Locate the places where the keyword "UTL_FILE.GET_LINE" is used in the stored procedure.
2. Replace the UTL_FILE.GET_LINE location called with a value assignment (:=).
   - On the left-hand side, specify *secondArg* (v_rbuff in the example) specified for UTL_FILE.GET_LINE.
   - Use UTL_FILE.GET_LINE in the right-hand side. Specify only *firstArg* (v_file in the example) and *thirdArg* (1024 in the example) before modification.

(5) FCLOSE

Specification format for Oracle database

UTL_FILE.FCLOSE(*firstArg*)

Specification differences

Oracle database

After closing, the file handler specified for the argument becomes NULL.

FUJITSU Enterprise Postgres

After closing, set the file handler to NULL by assigning the return value of UTL_FILE.FCLOSE to it.

Conversion procedure

Convert using the following procedure:

1. Locate the places where the keyword "UTL_FILE.FCLOSE" is used in the stored procedure.

2. Replace the UTL_FILE.FCLOSE location called with a value assignment (:=) so that the file handler (v_file in the example) becomes NULL.

   - On the left-hand side, specify the argument (v_file in the example) specified for UTL_FILE.FCLOSE.
   - Use UTL_FILE.FCLOSE in the right-hand side. For the argument, specify the same value (v_file in the example) as before modification.

(6) FCLOSE_ALL

Same as NEW_LINE in the DBMS_OUTPUT package. Refer to NEW_LINE in the DBMS_OUTPUT for information on specification differences and conversion procedures associated with specification differences.

B.6.3 Copying Files

Oracle database

```
CREATE PROCEDURE copy_file(fromname VARCHAR2, toname VARCHAR2) AS
BEGIN


    UTL_FILE.FCOPY('DIR1', fromname, 'DIR2', toname, 1, NULL); ...(7)

    RETURN;

EXCEPTION
    WHEN OTHERS THEN
        DBMS_OUTPUT.PUT_LINE('-- SQL Error --');

        DBMS_OUTPUT.PUT_LINE('ERROR : ' || SQLERRM );
        RETURN;
END;
/

set serveroutput on

call copy_file('file01.txt','file01_bk.txt');
```

FUJITSU Enterprise Postgres

```
CREATE FUNCTION copy_file(fromname VARCHAR, toname VARCHAR) RETURNS void AS $$
BEGIN
    PERFORM DBMS_OUTPUT.SERVEROUTPUT(TRUE);

    PERFORM UTL_FILE.FCOPY('/home/fsep', fromname, '/home/backup', toname, 1, NULL); ...(7)
    RETURN;

EXCEPTION
    WHEN OTHERS THEN
        PERFORM DBMS_OUTPUT.PUT_LINE('-- SQL Error --');
        PERFORM DBMS_OUTPUT.PUT_LINE('ERROR : ' || SQLERRM );
        RETURN;
END;
$$
LANGUAGE plpgsql;


SELECT copy_file('file01.txt','file01_bk.txt');
```

(7) FCOPY

Specification format for Oracle database

UTL_FILE.FCOPY(*firstArg, secondArg*, *thirdArg*, *fourthArg*, *fifthArg, sixthArg*)

Feature differences

Oracle database

If using a CREATE DIRECTORY statement (Oracle9.2i or later), specify a directory object name for the directory name.

FUJITSU Enterprise Postgres

A directory object name cannot be specified for the directory name.

Conversion procedure

Convert using the following procedure. Refer to UTL_FILE_DIR/CREATE DIRECTORY for information on how to check if the directory object name corresponds to the actual directory name.

1. Locate the places where the keyword "UTL_FILE.FCOPY" is used in the stored procedure.
2. Check the actual directory names ('/home/fsep' and '/home/backup', in the example) that correspond to the directory object names ('DIR1' and 'DIR2', in the example) of *firstArg* and *thirdArg* argument.
3. Replace the directory object name ('DIR1' and 'DIR2', in the example) with the actual directory names ('/home/fsep' in the example) checked in step 1.

B.6.4 Moving/Renaming Files

Oracle database

```
CREATE PROCEDURE move_file(fromname VARCHAR2, toname VARCHAR2) AS
BEGIN


    UTL_FILE.FRENAME('DIR1', fromname, 'DIR2', toname, FALSE); ...(8)
    RETURN;

EXCEPTION
    WHEN OTHERS THEN
        DBMS_OUTPUT.PUT_LINE('-- SQL Error --');

        DBMS_OUTPUT.PUT_LINE('ERROR : ' || SQLERRM );
        RETURN;
END;
/

set serveroutput on

call move_file('file01.txt','file02.txt');
```

FUJITSU Enterprise Postgres

```
CREATE FUNCTION move_file(fromname VARCHAR, toname VARCHAR) RETURNS void AS $$
BEGIN
    PERFORM DBMS_OUTPUT.SERVEROUTPUT(TRUE);

    PERFORM UTL_FILE.FRENAME('/home/fsep', fromname, '/home/backup', toname, FALSE); ...(8)
    RETURN;

EXCEPTION
    WHEN OTHERS THEN
        PERFORM DBMS_OUTPUT.PUT_LINE('-- SQL Error --');
        PERFORM DBMS_OUTPUT.PUT_LINE('ERROR : ' || SQLERRM );
        RETURN;
END;
```

```
$$
LANGUAGE plpgsql;


SELECT move_file('file01.txt','file02.txt');
```

(8) FRENAME

Same as FCOPY for the UTL_FILE package. Refer to FCOPY in the UTL_FILE package for information on specification differences and conversion procedures associated with specification differences.

B.7 DBMS_SQL (Execute Dynamic SQL)

Features

For DBMS_SQL, dynamic SQL can be executed from PL/pgSQL.

B.7.1 Searching Using a Cursor

Oracle database

```
CREATE PROCEDURE search_test(h_where CLOB) AS


    str_sql     CLOB;
    v_cnt       INTEGER;
    v_array     DBMS_SQL.VARCHAR2A;
    v_cur       INTEGER;
    v_smpid     INTEGER;
    v_smpnm     VARCHAR2(20);
    v_addbuff   VARCHAR2(20);
    v_smpage    INTEGER;
    errcd       INTEGER;
    length      INTEGER;
    ret         INTEGER;
BEGIN

    str_sql     := 'SELECT smpid, smpnm FROM smp_tbl WHERE ' || h_where || ' ORDER BY smpid';
    v_smpid     := 0;
    v_smpnm     := '';
    v_smpage    := 0;

    v_cur := DBMS_SQL.OPEN_CURSOR; ...(1)

    v_cnt :=
      CEIL(DBMS_LOB.GETLENGTH(str_sql)/1000);
    FOR idx IN 1 .. v_cnt LOOP
        v_array(idx) :=
            DBMS_LOB.SUBSTR(str_sql,
                            1000,
                            (idx-1)*1000+1);
    END LOOP;
    DBMS_SQL.PARSE(v_cur, v_array, 1, v_cnt, FALSE, DBMS_SQL.NATIVE); ...(2)

    DBMS_SQL.DEFINE_COLUMN(v_cur, 1, v_smpid);

    DBMS_SQL.DEFINE_COLUMN(v_cur, 2, v_smpnm, 10);


    ret := DBMS_SQL.EXECUTE(v_cur);
    LOOP
```

```
        v_addbuff := '';

        IF DBMS_SQL.FETCH_ROWS(v_cur) = 0 THEN
            EXIT;
        END IF;

        DBMS_OUTPUT.PUT_LINE('-----------------------------------------------------------');
        DBMS_SQL.COLUMN_VALUE(v_cur, 1, v_smpid, errcd, length); ...(3)




        IF errcd = 1405 THEN ...(3)

          DBMS_OUTPUT.PUT_LINE('smpid       = (NULL)');
        ELSE
          DBMS_OUTPUT.PUT_LINE('smpid       = ' || v_smpid);
        END IF;

        DBMS_SQL.COLUMN_VALUE(v_cur, 2, v_smpnm, errcd, length);

        IF errcd = 1406 THEN
          v_addbuff := '... [len=' || length || ']';
        END IF;
        IF errcd = 1405 THEN
          DBMS_OUTPUT.PUT_LINE('v_smpnm     = (NULL)');
        ELSE
          DBMS_OUTPUT.PUT_LINE('v_smpnm     = ' || v_smpnm || v_addbuff );
        END IF;

DBMS_OUTPUT.PUT_LINE('-----------------------------------------------------------');

        DBMS_OUTPUT.NEW_LINE;
    END LOOP;

    DBMS_SQL.CLOSE_CURSOR(v_cur); ...(4)

    RETURN;
END;
/

Set serveroutput on

call search_test('smpid < 100');
```

FUJITSU Enterprise Postgres

```
CREATE FUNCTION search_test(h_where text) RETURNS void AS $$
DECLARE
    str_sql     text;


    v_cur       INTEGER;
    v_smpid     INTEGER;
    v_smpnm     VARCHAR(20);
    v_addbuff   VARCHAR(20);
    v_smpage    INTEGER;
    errcd       INTEGER;
    length      INTEGER;
    ret         INTEGER;
BEGIN
    PERFORM DBMS_OUTPUT.SERVEROUTPUT(TRUE);
    str_sql     := 'SELECT smpid, smpnm FROM smp_tbl WHERE ' || h_where || ' ORDER BY smpid';
```

```
    v_smpid     := 0;
    v_smpnm     := '';
    v_smpage    := 0;

    v_cur := DBMS_SQL.OPEN_CURSOR(); ...(1)

    PERFORM DBMS_SQL.PARSE(v_cur, str_sql, 1); ...(2)
    PERFORM DBMS_SQL.DEFINE_COLUMN(v_cur, 1, v_smpid);
    PERFORM DBMS_SQL.DEFINE_COLUMN(v_cur, 2, v_smpnm, 10);

    ret := DBMS_SQL.EXECUTE(v_cur);
    LOOP
        v_addbuff := '';

        IF DBMS_SQL.FETCH_ROWS(v_cur) = 0 THEN
            EXIT;
        END IF;

        PERFORM DBMS_OUTPUT.PUT_LINE('-----------------------------------------------------------');
        SELECT value,column_error,actual_length
          INTO v_smpid, errcd, length
          FROM DBMS_SQL.COLUMN_VALUE(v_cur,
                                     1,
                                     v_smpid); ...(3)
        IF errcd = 22002 THEN ...(3)
          PERFORM DBMS_OUTPUT.PUT_LINE('smpid       = (NULL)');
        ELSE
          PERFORM DBMS_OUTPUT.PUT_LINE('smpid       = ' || v_smpid);
        END IF;

        SELECT value,column_error,actual_length INTO v_smpnm, errcd, length FROM
DBMS_SQL.COLUMN_VALUE(v_cur, 2, v_smpnm);
        IF errcd = 22001 THEN
          v_addbuff := '... [len=' || length || ']';
        END IF;
        IF errcd = 22002 THEN
          PERFORM DBMS_OUTPUT.PUT_LINE('v_smpnm     = (NULL)');
        ELSE
          PERFORM DBMS_OUTPUT.PUT_LINE('v_smpnm     = ' || v_smpnm || v_addbuff );
        END IF;

        PERFORM DBMS_OUTPUT.PUT_LINE('-----------------------------------------------------------');
        PERFORM DBMS_OUTPUT.NEW_LINE();
    END LOOP;

    v_cur := DBMS_SQL.CLOSE_CURSOR(v_cur); ...(4)
    RETURN;
END;
$$
LANGUAGE plpgsql;


SELECT search_test('smpid < 100');
```

(1) OPEN_CURSOR

Same as NEW_LINE in the DBMS_OUTPUT package. Refer to NEW_LINE in the DBMS_OUTPUT package for information on specification differences and conversion procedures associated with specification differences.

(2) PARSE

Specification format for Oracle database

DBMS_SQL.PARSE(*firstArg, secondArg*, *thirdArg*, *fourthArg*, *fifthArg*)

Feature differences

Oracle database

SQL statements can be specified with string table types (VARCHAR2A type, VARCHAR2S type). Specify this for *secondArg*.

DBMS_SQL.NATIVE, DBMS_SQL.V6, DBMS_SQL.V7 can be specified for processing SQL statements.

FUJITSU Enterprise Postgres

SQL statements cannot be specified with string table types.

DBMS_SQL.NATIVE, DBMS_SQL.V6, DBMS_SQL.V7 cannot be specified for processing SQL statements.

Conversion procedure

Convert using the following procedure:

1. Locate the places where the keyword "DBMS_SQL.PARSE" is used in the stored procedure.
2. Check the data type of the SQL statement specified for *secondArg* (v_array in the example).
   - If the data type is either DBMS_SQL.VARCHAR2A type or DBMS_SQL.VARCHAR2S type, then it is a table type specification. Execute step 3 and continue the conversion process.
   - If the data type is neither DBMS_SQL.VARCHAR2A type nor DBMS_SQL.VARCHAR2S type, then it is a string specification. Execute step 7 and continue the conversion process.
3. Check the SQL statement (str_sql in the example) before it was divided into DBMS_SQL.VARCHAR2A type and DBMS_SQL.VARCHAR2S type.
4. Delete the sequence of the processes (processes near FOR idx in the example) where SQL is divided into DBMS_SQL.VARCHAR2A type and DBMS_SQL.VARCHAR2S type.
5. Replace *secondArg* with the SQL statement (str_sql in the example) before it is divided, that was checked in step 2.
6. Delete *thirdArg*, *fourthArg*, and *fifthArg* (v_cnt, FALSE, DBMS_SQL.NATIVE, in the example).
7. If DBMS_SQL.NATIVE, DBMS_SQL.V6, and DBMS_SQL.V7 are specified, then replace *thirdArg* with a numeric literal 1.
   - If either DBMS_SQL.VARCHAR2A type or DBMS_SQL.VARCHAR2S type is used, then *sixthArg* becomes relevant.
   - If neither DBMS_SQL.VARCHAR2A type nor DBMS_SQL.VARCHAR2S type is used, then *thirdArg* becomes relevant.

(3) COLUMN_VALUE

Specification format for Oracle database

DBMS_SQL.COLUMN_VALUE(*firstArg, secondArg*, *thirdArg*, *fourthArg*, *fifthArg*)

Feature differences

Oracle database

The following error codes are returned for column_error.

- 1406: fetched column value was truncated
- 1405: fetched column value is NULL

FUJITSU Enterprise Postgres

The following error codes are returned for column_error.

- 22001: string_data_right_truncation
- 22002: null_value_no_indicator_parameter

Specification differences

Oracle database

Obtained values are received with variables specified for arguments.

FUJITSU Enterprise Postgres

Since obtained values are the search results for DBMS_SQL.COLUMN_VALUE, they are received with variables specified for the INTO clause of the SELECT statement.

Conversion procedure

Convert using the following procedure:

1. Locate the places where the keyword "DBMS_SQL.COLUMN_VALUE" is used in the stored procedure.
2. Replace the DBMS_SQL.COLUMN_VALUE location called with a SELECT INTO statement.
   - Check the number of arguments (v_smpid, errcd, and length in the example) specified after *secondArg* (1 in the example) of DBMS_SQL.COLUMN_VALUE.
   - Specify "value", "column_error", and "actual_length" in the select list, according to the number of arguments checked in the previous step (for example, if only *thirdArg* is specified, then specify "value" only.)
   - Specify *thirdArg*, *fourthArg*, and *fifthArg* (v_smpid, errcd, length in the example) configured for DBMS_SQL.COLUMN_VALUE, for the INTO clause.
   - Use DBMS_SQL.COLUMN_VALUE in the FROM clause. Specify *firstArg*, *secondArg*, and *thirdArg* (v_cur, 1, v_smpid, in the example) before modification.
3. If the *fourthArg* (column_error value in the example) is used, then check the location of the target variable (errcd in the example).
4. If a decision process is performed in the location checked, then modify the values used in the decision process as below:
   - 1406 to 22001
   - 1405 to 22002

(4) CLOSE_CURSOR

Specification format for Oracle database

DBMS_SQL.CLOSE_CURSOR(*firstArg*)

Specification differences

Oracle database

After closing, the cursor specified in *firstArg* becomes NULL.

FUJITSU Enterprise Postgres

After closing, set the cursor to NULL by assigning the return value of DBMS_SQL.CLOSE_CURSOR to it.

Conversion procedure

Convert using the following procedure:

1. Locate the places where the keyword "DBMS_SQL.CLOSE_CURSOR" is used in the stored procedure.
2. Set the cursor to NULL by assigning (:=) the return value of DBMS_SQL.CLOSE_CURSOR to it.
   - On the left-hand side, specify the argument (v_cur in the example) specified for DBMS_SQL.CLOSE_CURSOR.
   - Use DBMS_SQL.CLOSE_CURSOR in the right-hand side. For the argument, specify the same value (v_cur in the example) as before modification.

Appendix C Tables Used by the Features Compatible with Oracle Databases

This chapter describes the tables used by the features compatible with Oracle databases.

C.1 UTL_FILE.UTL_FILE_DIR

Register the directory handled by the UTL_FILE package in the UTL_FILE.UTL_FILE_DIR table.

Name	Type	Description
dir	text	Name of the directory handled by the UTL_FILE package

Appendix D Quantitative Limits

This appendix lists the quantitative limits of FUJITSU Enterprise Postgres.

Table D.1 Length of identifier

Item	Limit
Database name	Up to 63 bytes (*1) (*2)
Schema name	Up to 63 bytes (*1) (*2)
Table name	Up to 63 bytes (*1) (*2)
View name	Up to 63 bytes (*1) (*2)
Index name	Up to 63 bytes (*1) (*2)
Table space name	Up to 63 bytes (*1) (*2)
Cursor name	Up to 63 bytes (*1) (*2)
Function name	Up to 63 bytes (*1) (*2)
Aggregate function name	Up to 63 bytes (*1) (*2)
Trigger name	Up to 63 bytes (*1) (*2)
Constraint name	Up to 63 bytes (*1) (*2)
Conversion name	Up to 63 bytes (*1) (*2)
Role name	Up to 63 bytes (*1) (*2)
Cast name	Up to 63 bytes (*1) (*2)
Collation sequence name	Up to 63 bytes (*1) (*2)
Encoding method conversion name	Up to 63 bytes (*1) (*2)
Domain name	Up to 63 bytes (*1) (*2)
Extension name	Up to 63 bytes (*1) (*2)
Operator name	Up to 63 bytes (*1) (*2)
Operator class name	Up to 63 bytes (*1) (*2)
Operator family name	Up to 63 bytes (*1) (*2)
Rewrite rule name	Up to 63 bytes (*1) (*2)
Sequence name	Up to 63 bytes (*1) (*2)
Text search settings name	Up to 63 bytes (*1) (*2)
Text search dictionary name	Up to 63 bytes (*1) (*2)
Text search parser name	Up to 63 bytes (*1) (*2)
Text search template name	Up to 63 bytes (*1) (*2)
Data type name	Up to 63 bytes (*1) (*2)
Enumerator type label	Up to 63 bytes (*1) (*2)

*1: This is the character string byte length when converted by the server character set character code.

*2: If an identifier that exceeds 63 bytes in length is specified, the excess characters are truncated and it is processed.

Table D.2 Database object

Item	Limit
Number of databases	Less than 4,294,967,296 (*1)

Item	Limit
Number of schemas	Less than 4,294,967,296 (*1)
Number of tables	Less than 4,294,967,296 (*1)
Number of views	Less than 4,294,967,296 (*1)
Number of indexes	Less than 4,294,967,296 (*1)
Number of table spaces	Less than 4,294,967,296 (*1)
Number of functions	Less than 4,294,967,296 (*1)
Number of aggregate functions	Less than 4,294,967,296 (*1)
Number of triggers	Less than 4,294,967,296 (*1)
Number of constraints	Less than 4,294,967,296 (*1)
Number of conversion	Less than 4,294,967,296 (*1)
Number of roles	Less than 4,294,967,296 (*1)
Number of casts	Less than 4,294,967,296 (*1)
Number of collation sequences	Less than 4,294,967,296 (*1)
Number of encoding method conversions	Less than 4,294,967,296 (*1)
Number of domains	Less than 4,294,967,296 (*1)
Number of extensions	Less than 4,294,967,296 (*1)
Number of operators	Less than 4,294,967,296 (*1)
Number of operator classes	Less than 4,294,967,296 (*1)
Number of operator families	Less than 4,294,967,296 (*1)
Number of rewrite rules	Less than 4,294,967,296 (*1)
Number of sequences	Less than 4,294,967,296 (*1)
Number of text search settings	Less than 4,294,967,296 (*1)
Number of text search dictionaries	Less than 4,294,967,296 (*1)
Number of text search parsers	Less than 4,294,967,296 (*1)
Number of text search templates	Less than 4,294,967,296 (*1)
Number of data types	Less than 4,294,967,296 (*1)
Number of enumerator type labels	Less than 4,294,967,296 (*1)
Number of default access privileges defined in the ALTER DEFAULT PRIVILEGES statement	Less than 4,294,967,296 (*1)
Number of large objects	Less than 4,294,967,296 (*1)
Number of index access methods	Less than 4,294,967,296 (*1)

*1: The total number of all database objects must be less than 4,294,967,296.

Table D.3 Schema element

Item	Limit
Number of columns that can be defined in one table	From 250 to 1600 (according to the data type)
Table row length	Up to 400 gigabytes
Number of columns comprising a unique constraint	Up to 32 columns
Data length comprising a unique constraint	Less than 2,000 bytes (*1) (*2)

Item	Limit
Table size	Up to one terabyte
Search condition character string length in a trigger definition statement	Up to 800 megabytes (*1) (*2)
Item size	Up to 1 gigabyte

*1: Operation might proceed correctly even if operations are performed with a quantity outside the limits.

*2: This is the character string byte length when converted by the server character set character code.

Table D.4 Index

Item	Limit
Number of columns comprising a key (including VCI)	Up to 32 columns
Key length (other than VCI)	Less than 2,000 bytes (*1)

*1: This is the character string byte length when converted by the server character set character code.

Table D.5 Data types and attributes that can be handled

Item			Limit
Character	Data length		Data types and attributes that can be handled (*1)
	Specification length (*n*)		Up to 10,485,760 characters (*1)
Numeric	External decimal expression		Up to 131,072 digits before the decimal point, and up to 16,383 digits after the decimal point
	Internal binary expression	2 bytes	From -32,768 to 32,767
		4 bytes	From -2,147,483,648 to 2,147,483,647
		8 bytes	From -9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
	Internal decimal expression		Up to 13,1072 digits before the decimal point, and up to 16,383 digits after the decimal point
	Floating point expression	4 bytes	From -3.4E+38 to -7.1E-46, 0, or from 7.1E-46 to 3.4E+38
		8 bytes	From -1.7E+308 to -2.5E-324, 0, or from 2.5E-324 to 1.7E+308
bytea			Up to one gigabyte minus 53 bytes
Large object			Up to two gigabytes

*1: This is the character string byte length when converted by the server character set character code.

Table D.6 Function definition

Item	Limit
Number of arguments that can be specified	Up to 100
Number of variable names that can be specified in the declarations section	No limit
Number of SQL statements or control statements that can be specified in a function processing implementation	No limit

Table D.7 Data operation statement

Item	Limit
Maximum number of connections for one process in an application (remote access)	4,000 connections
Number of expressions that can be specified in a selection list	Up to 1,664
Number of tables that can be specified in a FROM clause	No limit
Number of unique expressions that can be specified in a selection list/ DISTINCT clause/ORDER BY clause/GROUP BY clause within one SELECT statement	Up to 1,664
Number of expressions that can be specified in a GROUP BY clause	No limit
Number of expressions that can be specified in an ORDER BY clause	No limit
Number of SELECT statements that can be specified in a UNION clause/INTERSECT clause/EXCEPT clause	Up to 4,000 (*1)
Number of nestings in joined tables that can be specified in one view	Up to 4,000 (*1)
Number of functions or operator expressions that can be specified in one expression	Up to 4,000 (*1)
Number of expressions that can be specified in one row constructor	Up to 1,664
Number of expressions that can be specified in an UPDATE statement SET clause	Up to 1,664
Number of expressions that can be specified in one row of a VALUES list	Up to 1,664
Number of expressions that can be specified in a RETURNING clause	Up to 1,664
Total expression length that can be specified in the argument list of one function specification	Up to 800 megabytes (*2)
Number of cursors that can be processed simultaneously by one session	No limit
Character string length of one SQL statement	Up to 800 megabytes (*1) (*3)
Number of input parameter specifications that can be specified in one dynamic SQL statement	No limit
Number of tokens that can be specified in one SQL statement	Up to 10,000
Number of values that can be specified as a list in a WHERE clause IN syntax	No limit
Number of expressions that can be specified in a USING clause	No limit
Number of JOINs that can be specified in a joined table	Up to 4,000 (*1)
Number of expressions that can be specified in COALESCE	No limit
Number of WHEN clauses that can be specified for CASE in a simple format or a searched format	No limit
Data size per record that can be updated or inserted by one SQL statement	Up to one gigabyte minus 53 bytes
Number of objects that can share a lock simultaneously	Up to 256,000 (*1)

*1: Operation might proceed correctly even if operations are performed with a quantity outside the limits.

*2: The total number of all database objects must be less than 4,294,967,296.

*3: This is the character string byte length when converted by the server character set character code.

Table D.8 Data sizes

Item	Limit
Data size per record for input data files (COPY statement, psql command \copy meta command)	Up to 800 megabytes (*1)
Data size per record for output data files (COPY statement, psql command \copy meta command)	Up to 800 megabytes (*1)

*1: Operation might proceed correctly even if operations are performed with a quantity outside the limits.

Appendix E Reference

E.1 JDBC Driver

See

Refer to the Java API Reference for information on PostgreSQL JDBC driver.

E.2 ODBC Driver

E.2.1 List of Supported APIs

The following table shows the support status of APIs:

Function name	Support status
SQLAllocConnect	Y
SQLAllocEnv	Y
SQLAllocHandle	Y
SQLAllocStmt	Y
SQLBindCol	Y
SQLBindParameter	Y
SQLBindParam	Y
SQLBrowseConnect	Y
SQLBulkOperations	Y
SQLCancel	Y
SQLCancelHandle	N
SQLCloseCursor	Y
SQLColAttribute	Y
SQLColAttributeW	Y
SQLColAttributes	Y
SQLColAttributesW	Y
SQLColumnPrivileges	Y
SQLColumnPrivilegesW	Y
SQLColumns	Y
SQLColumnsW	Y
SQLCompleteAsync	N
SQLConnect	Y
SQLConnectW	Y
SQLCopyDesc	Y
SQLDataSources	Y
SQLDataSourcesW	Y
SQLDescribeCol	Y

Function name	Support status
SQLDescribeColW	Y
SQLDescribeParam	Y
SQLDisconnect	Y
SQLDriverConnect	Y
SQLDriverConnectW	Y
SQLDrivers	Y
SQLEndTran	Y
SQLError	Y
SQLErrorW	Y
SQLExecDirect	Y
SQLExecDirectW	Y
SQLExecute	Y
SQLExtendedFetch	Y
SQLFetch	Y
SQLFetchScroll	Y
SQLForeignKeys	Y
SQLForeignKeysW	Y
SQLFreeConnect	Y
SQLFreeEnv	Y
SQLFreeHandle	Y
SQLFreeStmt	Y
SQLGetConnectAttr	Y
SQLGetConnectAttrW	Y
SQLGetConnectOption	Y
SQLGetConnectOptionW	Y
SQLGetCursorName	Y
SQLGetCursorNameW	Y
SQLGetData	Y
SQLGetDescField	Y
SQLGetDescFieldW	Y
SQLGetDescRec	Y
SQLGetDescRecW	Y
SQLGetDiagField	Y
SQLGetDiagFieldW	Y
SQLGetDiagRec	Y
SQLGetDiagRecW	Y
SQLGetEnvAttr	Y
SQLGetFunctions	Y
SQLGetInfo	Y

Function name	Support status
SQLGetInfoW	Y
SQLGetStmtAttr	Y
SQLGetStmtAttrW	Y
SQLGetStmtOption	Y
SQLGetTypeInfo	Y
SQLGetTypeInfoW	Y
SQLMoreResults	Y
SQLNativeSql	Y
SQLNativeSqlW	Y
SQLNumParams	Y
SQLNumResultCols	Y
SQLParamData	Y
SQLParamOptions	Y
SQLPrepare	Y
SQLPrepareW	Y
SQLPrimaryKeys	Y
SQLPrimaryKeysW	Y
SQLProcedureColumns	Y
SQLProcedureColumnsW	Y
SQLProcedures	Y
SQLProceduresW	Y
SQLPutData	Y
SQLRowCount	Y
SQLSetConnectAttr	Y
SQLSetConnectAttrW	Y
SQLSetConnectOption	Y
SQLSetConnectOptionW	Y
SQLSetCursorName	Y
SQLSetCursorNameW	Y
SQLSetDescField	Y
SQLSetDescRec	Y
SQLSetEnvAttr	Y
SQLSetParam	Y
SQLSetPos	Y
SQLSetScrollOptions	N
SQLSetStmtAttr	Y
SQLSetStmtAttrW	Y
SQLSetStmtOption	Y
SQLSpecialColumns	Y

Function name	Support status
SQLSpecialColumnsW	Y
SQLStatistics	Y
SQLStatisticsW	Y
SQLTablePrivileges	Y
SQLTablePrivilegesW	Y
SQLTables	Y
SQLTablesW	Y
SQLTransact	Y

Y: Supported
N: Not supported

E.3 C Library (libpq)

See

Refer to "libpq - C Library" in "Client Interfaces" in the PostgreSQL Documentation.

E.4 Embedded SQL in C

See

Refer to "ECPG - Embedded SQL in C" in "Client Interfaces" in the PostgreSQL Documentation.

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Fujitsu Enterprise Postgres 14 SP1 on IBM LinuxONE

Operation Guide

SP1

Linux

FUJITSU

J2UL-2748-02ZLZ0(00)
September-2022

Preface

Purpose of this document

The FUJITSU Enterprise Postgres database system extends the PostgreSQL features and runs on the Linux platform.

This document is the FUJITSU Enterprise Postgres Operation Guide.

Intended readers

This document is intended for those who install and operate FUJITSU Enterprise Postgres.

Readers of this document are assumed to have general knowledge of:

- PostgreSQL
- SQL
- Linux

Structure of this document

This document is structured as follows:

Chapter 1 Operating FUJITSU Enterprise Postgres

Describes how to operate FUJITSU Enterprise Postgres.

Chapter 2 Starting an Instance and Creating a Database

Describes how to start a FUJITSU Enterprise Postgres instance, and how to create a database.

Chapter 3 Backing Up the Database

Describes how to back up the database.

Chapter 4 Configuring Secure Communication Using Secure Sockets Layer

Describes communication data encryption between the client and the server.

Chapter 5 Protecting Storage Data Using Transparent Data Encryption

Describes how to encrypt the data to be stored in the database.

Chapter 6 Using Transparent Data Encryption with Key Management Systems as Keystores

Describes the operation of transparent data encryption when a key management system is used as a keystore.

Chapter 7 Data Masking

Describes the data masking feature.

Chapter 8 Periodic Operations

Describes the periodic database operations that must be performed on FUJITSU Enterprise Postgres.

Chapter 9 Streaming Replication Using WebAdmin

Describes how to create a streaming replication cluster using WebAdmin.

Chapter 10 Installing and Operating the In-memory Feature

Describes how to install and operate the in-memory feature.

Chapter 11 Parallel Query

Describes the factors taken into consideration by FUJITSU Enterprise Postgres when performing parallel queries.

Chapter 12 High-Speed Data Load

Describes how to install and operate high-speed data load.

Chapter 13 Global Meta Cache

Describes how to use Grobal Meta Cache feature.

Chapter 14 Local Meta Cache Limit

Describes how to use Local Meta Cache Limit feature.

Chapter 15 Backup/Recovery Using the Copy Command

Describes backup and recovery using the copy command created by the user.

Chapter 16 WAL Compression for Streaming Replication

Describes WAL compression for streaming replications.

Chapter 17 Actions when an Error Occurs

Describes how to perform recovery when disk failure or data corruption occurs.

Appendix A Parameters

Describes the FUJITSU Enterprise Postgres parameters.

Appendix B System Administration Functions

Describes the system administration functions of FUJITSU Enterprise Postgres.

Appendix C System Views

Describes how to use the system view in FUJITSU Enterprise Postgres.

Appendix D Tables Used by Transparent Data Encryption

Describes the tables used by the transparent data encryption feature.

Appendix E Tables Used by Data Masking

Describes the tables used by the data masking feature.

Appendix F Tables Used by High-Speed Data Load

Describes the tables used by high-speed data load.

Appendix G Starting and Stopping the Web Server Feature of WebAdmin

Describes how to start and stop WebAdmin (Web server feature).

Appendix H WebAdmin Wallet

Describes how to use the Wallet feature of WebAdmin.

Appendix I WebAdmin Disallow User Inputs Containing Hazardous Characters

Describes characters not allowed in WebAdmin.

Appendix J Collecting Failure Investigation Data

Describes how to collect information for initial investigation.

Appendix K Operation of Transparent data Encryption in File-based Keystores

Describes operation of transparent data Encription in file-based keystores.

Appendix L Utilize zEnterprise Data Compression (zEDC)

Describes cooperation with zEDC.

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Issue date and version


```
Edition 2.0: September 2022
Edition 1.0: February  2022
```

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Contents

Chapter 1 Operating FUJITSU Enterprise Postgres

This chapter describes how to operate FUJITSU Enterprise Postgres.

1.1 Operating Methods

There are two methods of managing FUJITSU Enterprise Postgres operations:

- Operation management using GUI tools
- Operation management using commands

See

Before performing database multiplexing using database multiplexing, refer to "Database Multiplexing Mode" in the Cluster Operation Guide (Database Multiplexing).

Operation management using GUI tools

This involves managing operations using the WebAdmin.

- Management using WebAdmin

  This removes the requirement for complex environment settings and operational design for backup and recovery that is usually required for running a database. It enables you to easily and reliably monitor the state of the database, create a streaming replication cluster, back up the database, and restore it even if you do not have expert knowledge of databases.

Operation management using commands

You can use commands for configuring and operating the database and managing operations.

Note

- You cannot combine WebAdmin and server commands to perform the following operations:
  - Use commands to operate an instance created using WebAdmin.
  - Use WebAdmin to recover a database backed up using commands.

  For instances created with WebAdmin, however, backup can be obtained with the pgx_dmpall command. Also, WebAdmin can perform recovery by using the backup obtained with the pgx_dmpall command.

  To compress the backup files, use the pgx_dmpall command in WebAdmin operations as well.
- To operate an instance created using the initdb command in WebAdmin, the instance needs to be imported using WebAdmin.

Features used in each phase

The following table lists the features used in each phase for GUI-based operations and command-based operations.

Operation		Operation with the GUI	Operation with commands
Setup	Creating an instance	WebAdmin is used. The server machine capacity, and the optimum parameter for operations using WebAdmin, are set automatically.	The configuration file is edited directly using the initdb command.
	Creating a standby instance	WebAdmin is used.	A standby instance is created using the pg_basebackup command.

Operation		Operation with the GUI	Operation with commands
		WebAdmin performs a base backup of the source instance and creates a standby instance.	
	Changing the configuration files	WebAdmin is used.	The configuration file is edited directly.
Starting and stopping an instance		WebAdmin is used.	The pg_ctl command is used.
Creating a database		None.	This is defined using the psql command or the application after specifying the DDL statement.
Backing up the database		WebAdmin, or the pgx_dmpall command, is used.	It is recommended that the pgx_dmpall command be used. Recovery to the latest database can be performed.
Database recovery		WebAdmin is used.	To use the backup that was performed using the pgx_dmpall command, the pgx_rcvall command is used.
Monitoring	Database errors	The status in the WebAdmin window can be checked.	The messages that are output to the database server log are monitored.
	Disk space	The status in the WebAdmin window can be checked. A warning will be displayed if the free space falls below 20%.	This is monitored using the df command of the operating system, for example.
	Connection status	None.	This can be checked referencing pg_stat_activity of the standard statistics view from psql or the application.

1.2 Starting WebAdmin

This section describes how to start and log in to WebAdmin.

1.2.1 Logging in to WebAdmin

This section describes how to log in to WebAdmin.

User environment

It is recommended to use the following browsers with WebAdmin:

- Microsoft Edge (Build41 or later)

WebAdmin will work with other browsers, such as Firefox and Chrome, however, the look and feel may be slightly different.

Startup URL for WebAdmin

In the browser address bar, type the startup URL of the WebAdmin window in the following format:

```
http://hostNameOrIpAddress:portNumber/
```

- *hostNameOrIpAddress*: The host name or IP address of the server where WebAdmin is installed.
- *portNumber*: The port number of WebAdmin. The default port number is 27515.

Example

For a server with IP address "192.0.2.0" and port number "27515"

```
http://192.0.2.0:27515/
```

Display the startup windows. From this window you can log in to WebAdmin or access the product documentation.

Note

- You must start the Web server feature of WebAdmin before using WebAdmin.
- Refer to "Appendix G Starting and Stopping the Web Server Feature of WebAdmin" for information on how to start the Web server feature of WebAdmin.

Log in to WebAdmin

Click [Launch WebAdmin] in the startup URL window to start WebAdmin and display the login window.

To log in, specify the following values:

- [User name]: User name (OS user account) of the instance administrator
- [Password]: Password corresponding to the user name

Point

Use the OS user account as the user name of the instance administrator. Refer to "Creating an Instance Administrator" in the Installation and Setup Guide for Server for details.

1.3 Operations Using Commands

You can operate and manage the database using the following commands:

- Server commands

  This group of commands includes commands for creating a database cluster and controlling the database. You can run these commands on the server where the database is operating.

  To use these commands, you must configure the environment variables.

  ### See

  - Refer to "PostgreSQL Server Applications" under "Reference" in the PostgreSQL Documentation, or "Reference" for information on server commands.
  - Refer to "Configure the environment variables" in the procedure to create instances in "Using the initdb Command" in the Installation and Setup Guide for Server for information on configuring the environment variables.

- Client commands

  This group of commands includes the psql command and commands for extracting the database cluster to a script file. These commands can be executed on the client that can connect to the database, or on the server on which the database is running.

  To use these commands, you must configure the environment variables.

See

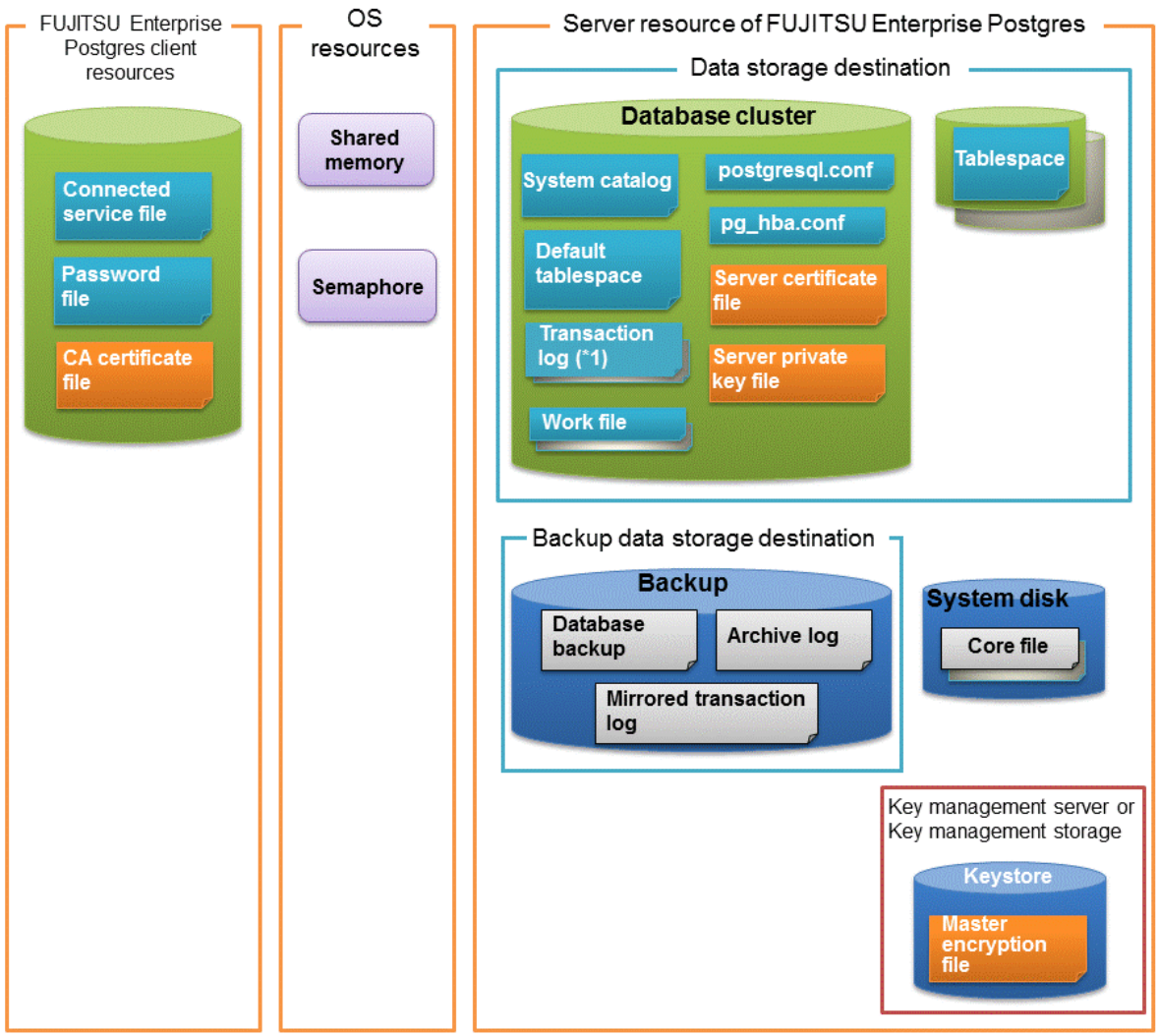
- Refer to "PostgreSQL Client Applications" under "Reference" in the PostgreSQL Documentation, or "Reference" for information on client commands.
- Refer to "Configuring Environment Variables" in the Installation and Setup Guide for Client for information on the values to be set in the environment variables.

1.4 Operating Environment of FUJITSU Enterprise Postgres

This section describes the operating environment and the file composition of FUJITSU Enterprise Postgres.

1.4.1 Operating Environment

The following figure shows the configuration of the FUJITSU Enterprise Postgres operating environment. The tables given below list the roles of the OS resources and FUJITSU Enterprise Postgres resources.



*1: To distribute the I/O load, place the transaction log on a different disk from the data storage destination.

Table 1.1 OS resources

Type	Role
Shared memory	Used when a database process exchanges information with an external process.
Semaphore	

Table 1.2 FUJITSU Enterprise Postgres client resources

Type	Role
Connection service file	Specifies information, such as the host name, user name, and password, for connecting to FUJITSU Enterprise Postgres.
Password file	Securely manages the password for connecting to FUJITSU Enterprise Postgres.
CA certificate file	CA (certificate authority) certificate used for server authentication when encrypting communication data.

Table 1.3 Server resources of FUJITSU Enterprise Postgres

Type	Role
Database cluster	Database storage area on the database storage disk. It is a collection of databases managed by an instance.
System catalog	Contains information required for the system to run, including the database definition information and the operation information created by the user.
Default tablespace	Contains table files and index files stored by default.
Transaction log	Contains log information in case of a crash recovery or rollback. This is the same as the WAL (Write Ahead Log).
Work file	Work file used when executing applications or commands.
postgresql.conf	Contains information that defines the operating environment of FUJITSU Enterprise Postgres.
pg_hba.conf	FUJITSU Enterprise Postgres uses this file to authenticate individual client hosts.
Server certificate file	Contains information about the server certificate to be used when encrypting communication data and authenticating a server.
Server private key file	Contains information about the server private key to be used when encrypting communication data and authenticating a server
Tablespace	Stores table files and index files in a separate area from the database cluster. Specify a space other than that under the database cluster.
Backup	Stores the data required for recovering the database when an error, such as disk failure, occurs.
Database backup	Contains the backup data for the database.
Archive log	Contains the log information for recovery.
Mirrored transaction log (mirrored WAL)	Enables a database cluster to be restored to the state immediately before an error even if both the database cluster and transaction log fail when performing backup/recovery operations using the pgx_dmpall command or WebAdmin.
Core file	FUJITSU Enterprise Postgres process core file that is output when an error occurs during a FUJITSU Enterprise Postgres process.
Key management server or key management storage	Server or storage where the master encryption key file is located.

Type	Role
Master encryption key file	Contains the master encryption key to be used when encrypting storage data. The master encryption key file is managed on the key management server or key management storage.

1.4.2 File Composition

FUJITSU Enterprise Postgres consists of the following files for controlling and storing the database. The table below shows the relationship between the number of such files and their location within a single instance.

Table 1.4 Number of files within a single instance and how to specify their location

File type	Required	Quantity	How to specify the location
Program files	Y	Multiple	Note that "<*x*>" indicates the product version. /opt/fsepv<*x*>server64
Database cluster	Y	1	Specify using WebAdmin or server commands.
Tablespace	Y	Multiple	Specify a space other than that under the database cluster, using the DDL statement.
Backup	Y	Multiple	Specify using WebAdmin or server commands.
Core file	Y	Multiple	Specify using WebAdmin, server commands, or postgresql.conf.
Server certificate file (*1)	N	1	Specify using postgresql.conf.
Server private key file (*1)	N	1	Specify using postgresql.conf.
Master encryption key file (*1)	N	1	Specify the directory created as the key store using postgresql.conf.
Connection service file (*1)	N	1	Specify using environment variables.
Password file (*1)	N	1	Specify using environment variables.
CA certificate file (*1)	N	1	Specify using environment variables.

Y: Mandatory
N: Optional

*1: Set manually when using the applicable feature.

Note

- Do not place files for use with FUJITSU Enterprise Postgres in a directory mounted over the network except when creating a database space in a storage device on a network.
  Examples include NFS (Network File System) and CIFS (Common Internet File System).
  This is because the database might hang if the network fails.
- If anti-virus software is used, set scan exception settings for directories so that none of the files that comprise FUJITSU Enterprise Postgres are scanned for viruses. Alternatively, if the files that comprise FUJITSU Enterprise Postgres are to be scanned for viruses, stop FUJITSU Enterprise Postgres and perform the scan when tasks that use FUJITSU Enterprise Postgres are not operating.

1.5 Notes on Compatibility of Applications Used for Operations

When you upgrade FUJITSU Enterprise Postgres to a newer version, there may be some effect on applications due to improvements or enhancements in functionality.

Take this into account when creating applications so that you can maintain compatibility after upgrading to a newer version of FUJITSU Enterprise Postgres.

See

Refer to "Notes on Application Compatibility" in the Application Development Guide for details.

1.6 Notes on Upgrading Database Instances

When upgrading FUJITSU Enterprise Postgres 11 or newer database instances using pg_upgrade, there are certain steps you need to follow.

Before using pg_upgrade, remove the following extensions from all databases in the instance, except "template0":

- pg_stat_statements
- oracle_compatible
- pg_dbms_stats
- pg_hint_plan

For all databases except "template0", execute the following command to remove these extensions:

```
DROP EXTENSION extensionName;
```

Once the pg_upgrade operation is complete, for all databases except "template0", execute the following command to re-create these extensions as required:

```
CREATE EXTENSION extensionName;
```

Note

- It is strongly recommended to back up the database using pg_dump before performing pg_upgrade or using DROP EXTENSION.
- If there are any columns created in the user tables using a data type from these extensions, then DROP EXTENSION will also drop these columns. Therefore, it is essential that alternate upgrade mechanisms are considered instead of pg_upgrade, in such scenarios. These may include pg_dump/pg_restore.

1.6.1 Additional Steps for upgrading to FUJITSU Enterprise Postgres with Vertical Clustered Index (VCI) Enabled

When upgrading FUJITSU Enterprise Postgres 11 instances that are using the VCI extension to FUJITSU Enterprise Postgres 12 or later using pg_upgrade, additional steps must be performed because of the incompatibility of the VCI extension between FUJITSU Enterprise Postgres 12 or later and FUJITSU Enterprise Postgres 11.

Follow the procedure below in all databases in the FUJITSU Enterprise Postgres 11 instance, except "template0".

Before upgrading

1. Obtain the CREATE INDEX Definitions

   Run the query below to list all the VCI indexes created in the database. Ensure that these indexes are re-created in the FUJITSU Enterprise Postgres 12 or later instance after pg_upgrade has finished.

   ```
   SELECT nspname || '.' || relname AS index_relname,* FROM pg_class, pg_namespace
     WHERE relnamespace = pg_namespace.oid AND relam IN (SELECT oid FROM pg_am WHERE amname='vci');
   ```

For each index_relname listed above, execute the commands below to obtain the CREATE INDEX definition (to use the same SQL syntax while re-creating the indexes on the FUJITSU Enterprise Postgres 12 or later instance).

```
SELECT pg_get_indexdef('indexName'::regclass);
```

2. Drop the VCI indexes and VCI extension along with all its dependencies.

   To remove all the VCI indexes and VCI internal objects that are created in FUJITSU Enterprise Postgres, execute the commands below. VCI internal objects will be created in FUJITSU Enterprise Postgres 12 or later automatically when CREATE EXTENSION for VCI is executed.

   ```
   DROP EXTENSION VCI CASCADE;
   ```

   Note

   To restore the VCI extension in the FUJITSU Enterprise Postgres 11 instance, execute CREATE EXTENSION.

After upgrading

Once the pg_upgrade operation is complete, for all databases except "template0", execute CREATE EXTENSION to create the VCI extension, and then execute CREATE INDEX for all the VCI indexes as required.

Chapter 2 Starting an Instance and Creating a Database

This chapter describes basic operations, from starting an instance to creating a database.

2.1 Starting and Stopping an Instance

This section describes how to start and stop an instance.

- 2.1.1 Using WebAdmin
- 2.1.2 Using Server Commands

Point

To automatically start or stop an instance when the operating system on the database server is started or stopped, refer to "Configuring Automatic Start and Stop of an Instance" in the Installation and Setup Guide for Server and configure the settings.

Note

The collected statistics are initialized if an instance is stopped in the "Immediate" mode or if it is abnormally terminated. To prepare for such initialization of statistics, consider regular collection of the statistics by using the SELECT statement. Refer to "The Statistics Collector" in "Server Administration" in the PostgreSQL Documentation for information on the statistics.

2.1.1 Using WebAdmin

WebAdmin enables you to start or stop an instance and check its operating status.

Starting an instance

Start an instance by using the [Instances] tab in WebAdmin.

 is displayed when an instance is stopped.

To start a stopped instance, click  .

Stopping an instance

Stop an instance by using the [Instances] tab in WebAdmin.

 is displayed when an instance is active.

To stop an active instance, click  .

Stop mode

Select the mode in which to stop the instance. The following describes the operations of the modes:

Stop mode	Connected clients	Backup being executed using the command
Smart mode (*1)	Waits for all connected clients to be disconnected.	Waits for backups being executed using the command to finish.
Fast mode	Rolls back all transactions being executed and forcibly disconnects clients.	Terminates backups being executed using the command.
Immediate mode	All server processes are terminated immediately. Crash recovery is executed the next time the instance is started.	

Stop mode	Connected clients	Backup being executed using the command
Kill process mode	Send SIGKILL to the process and abort all active transactions. This will lead to a crash-recovery run at the next restart.	

*1: When the processing to stop the instance in the Smart mode has started and you want to stop immediately, use the following procedure:

1. Restart the Web server feature of WebAdmin.
2. In the [Instances] tab, click .
3. In the [Instances] tab, click , and select the Immediate mode to stop the instance.

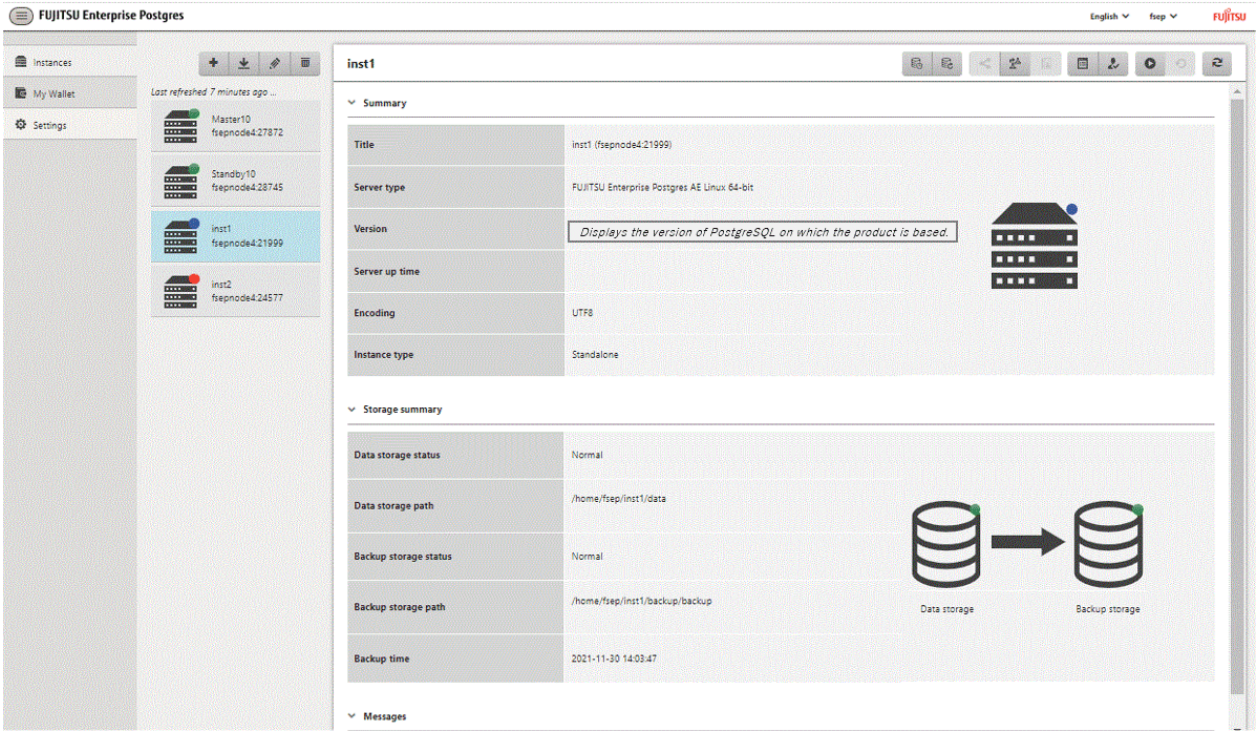
Checking the operating status of an instance

You can check the operating status of an instance by using the [Instances] tab. The following indicators are used to show the status of a resource.

Status indicator	Explanation
	The resource is operating normally.
	The resource is stopped.
	There is an error in the resource.
	An operation is in progress on this resource or the status is being checked.
	The resource is not operating optimally and needs intervention.

If an instance stops abnormally, remove the cause of the stoppage and start the instance by using WebAdmin.

Figure 2.1 Example of operating status indicators



Note

- When operating WebAdmin, click  to update the status. WebAdmin will reflect the latest status of the operation or the instance resources from the server.
- If an error occurs while communicating with the server, there may be no response from WebAdmin. When this happens, close the browser and then log in again. If this does not resolve the issue, check the system log of the server and confirm whether a communication error has occurred.
- The following message is output during startup of an instance when the startup process is operating normally, therefore, the user does not need to be aware of this message:

```
FATAL:  the database system is starting up
```

2.1.2 Using Server Commands

Server commands enable you to start or stop an instance and check its operating status.

To use sever commands, configure the environment variables.

See

Refer to " Configure the environment variables" in the procedure to create instances in " Using the initdb Command" in the Installation and Setup Guide for Server for information on configuring the environment variables.

Starting an instance

Use the pg_ctl command to start an instance.

Specify the following values in the pg_ctl command:

- Specify "start" as the mode.
- Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

If an application, command, or process tries to connect to the database while the instance is starting up, the message "FATAL:the database system is starting up(11189)" is output. However, this message may also be output if the instance is started without the -W option specified. This message is output by the pg_ctl command to check if the instance has started successfully. Therefore, ignore this message if there are no other applications, commands, or processes that connect to the database.

Example

```
> pg_ctl start -D /database/inst1
```

Note

If the -W option is specified, the command will return without waiting for the instance to start. Therefore, it may be unclear as to whether the instance startup was successful or failed.

Stopping an instance

Use the pg_ctl command to stop an instance.

Specify the following values in the pg_ctl command:

- Specify "stop" as the mode.

- Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

Example

```
> pg_ctl stop -D /database/inst1
```

Checking the operating status of an instance

Use the pg_ctl command to check the operating status of an instance.

Specify the following values in the pg_ctl command:

- Specify "status" as the mode.
- Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

Example

When the instance is active:

```
> pg_ctl status -D /database/inst1
pg_ctl: server is running (PID: 1234)
```

When the instance is inactive:

```
> pg_ctl status -D /database/inst1
pg_ctl: no server running.
```

See

Refer to "pg_ctl" under "Reference" in the PostgreSQL Documentation for information on pg_ctl command.

2.2 Creating a Database

This section explains how to create a database.

Follow the procedure below to define a database using client commands.

An example of operations on the server is shown below.

1. Use psql command to connect to the postgres database.
   Execute psql postgres.

   ```
   > psql postgres
   psql (14.0)
   Type "help" for help.
   ```

2. Create the database.
   To create the database, execute the CREATE DATABASE databaseName; statement.

   ```
   postgres=# CREATE DATABASE db01;
   CREATE DATABASE
   ```

3. Confirm that the database is created.
   Execute \l+, and confirm that the name of the database created in step 2 is displayed.

```
postgres=# \l+
```

4. Disconnect from the postgres database.
   Execute \q to terminate the psql command.

```
postgres=# \q
```

You can create a database using the createdb command.

See

Refer to "Creating a Database" in "Tutorial" in the PostgreSQL Documentation for information on creating a database using the createdb command.

Chapter 3 Backing Up the Database

This chapter describes how to back up the database.

Backup methods

The following backup methods enable you to recover data to a backup point or to the state immediately preceding disk physical breakdown or data logical failure.

- Backup using WebAdmin

  This method enables you to back up data through intuitive window operations using the GUI.

  WebAdmin is used for recovery.

- Backup using the pgx_dmpall command

  Execute the pgx_dmpall command with a script to perform automatic backup.

  To back up data automatically, you must register the process in the automation software of the operating system. Follow the procedure given in the documentation for your operating system.

  The pgx_rcvall command is used for recovery.

Information

By using a copy command created by the user, the pgx_dmpall command and the pgx_rcvall command can back up database clusters and tablespaces to any destination and recover them from any destination using any copy method. Refer to "Chapter 15 Backup/Recovery Using the Copy Command" for details.

Approximate backup time

The formula for deriving the approximate backup time when you use WebAdmin or the pgx_dmpall command is as follows:

```
backupTime = dataStorageDestinationUsage / diskWritePerformance x 1.5 x EffectOfCompression
```

- *dataStorageDestinationUsage*: Disk usage at the data storage destination
- *diskWritePerformance*: Maximum data volume (bytes/second) that can be written per second in the system environment where operation is performed
- 1.5: Coefficient to factor in tasks other than disk write (which is the most time-consuming step)
- *EffectOfCompression*: Specify 0.6 to use compression, or 1 to not use compression

If using the copy command with the pgx_dmpall command, the backup time will depend on the implementation of the copy command.

Note

- Backup operation cannot be performed on an instance that is part of a streaming replication cluster in standby mode.
- Use the selected backup method continuously.

  There are several differences, such as the data format, across the backup methods. For this reason, the following restrictions apply:

  - It is not possible to use one method for backup and another for recovery.
  - It is not possible to convert one type of backup data to a different type of backup data.
- Mirrored WALs can be used only for backup/recovery using the pgx_dmpall command or WebAdmin.
- There are several considerations for the backup of the keystore and backup of the database in case the data stored in the database is encrypted. Refer to the following for details:
  - 5.7.5 Backing Up and Recovering the Keystore
  - 5.8 Backing Up and Restoring/Recovering the Database

- If you have defined a tablespace, back it up. If you do not back it up, directories for the tablespace are not created during recovery, which may cause the recovery to fail. If the recovery fails, refer to the system log, create the tablespace, and then perform the recovery process again.

Information

The following methods can also be used to perform backup. Performing a backup using these methods allows you to restore to the point when the backup was performed.

- Backup using an SQL-based dump

  Dump the data by using SQL. This backup method also enables data migration.

- File system level backup

  This backup method requires you to stop the instance and use OS commands to backup database resources as files.

- Backup by continuous archiving

  This is the standard backup method for PostgreSQL.

Refer to "Backup and Restore" in "Server Administration" in the PostgreSQL Documentation for information on these backup methods.

3.1 Periodic Backup

It is recommended that you perform backup periodically.

Backing up data periodically using WebAdmin or the pgx_dmpall command has the following advantages:

- This method reduces disk usage, because obsolete archive logs (transaction logs copied to the backup data storage destination) are deleted. It also minimizes the recovery time when an error occurs.

Backup cycle

The time interval when backup is performed periodically is called the backup cycle. For example, if backup is performed every morning, the backup cycle is 1 day.
The backup cycle depends on the jobs being run, but on FUJITSU Enterprise Postgres it is recommended that operations are run with a backup cycle of at least once per day.

3.2 Backup Methods

This section describes the methods for backing up the database.

3.2.1 Using WebAdmin

You can use WebAdmin to perform backup and check the backup status.

Note

- If backup is disabled for an instance, you will not be able to back up or restore the instance. Refer to "[Backup]" in "Creating an Instance" in the Installation and Setup Guide for Server for details.
- If the data to be stored in the database is to be encrypted, it is necessary to enable the automatic opening of the keystore before doing so. Refer to "5.7.4 Enabling Automatic Opening of the Keystore" for details.

- WebAdmin uses the labels "Data storage path", "Backup storage path" and "Transaction log path" to indicate "data storage destination", "backup data storage destination" and "transaction log storage destination" respectively. In this manual these terms are used interchangeably.
- To compress the backup data, use the pgx_dmpall command with -z or -Z or --compress option specified. Add -z or -Z level to the end of the archive_command arguments that is set automatically by WebAdmin. -z option compresses by the default compression level. -Z option compresses by the level specified.The level can be set to a value from 0 to 9. (0 no compression, 9 high compression)

  For example:

```
archive_command = 'installationDirectory/bin/pgx_walcopy.cmd "%p"
"backupDataStorageDestinationDirectory/archived_wal/%f" discard "DatabaseCulsterPath/
waldiscard.txt" -z'
```

```
archive_command = 'installationDirectory/bin/pgx_walcopy.cmd "%p"
"backupDataStorageDestinationDirectory/archived_wal/%f" discard "DatabaseCulsterPath/
waldiscard.txt" -Z 1'
```

Backup operation

Follow the procedure below to back up the database.

1. Select the database to back up

   In the [Instances] tab, select the instance to be backed up and click  .

2. Back up the database

   The [Backup] dialog box is displayed. To perform backup, click [Yes].
   An instance is automatically started when backup is performed.

Backup status

If an error occurs and backup fails, [Error] is displayed adjacent to [Data storage status] or [Backup storage status] in the [Instances] tab. An error message is also displayed in the message list.

In this case, the backup data is not optimized. Ensure that you check the backup result whenever you perform backup. If backup fails, [Solution] appears to the right of the error message. Clicking this button displays information explaining how to resolve the cause of the error. Remove the cause of failure, and perform backup again.

3.2.2 Using Server Commands

Use the pgx_dmpall command and pgx_rcvall command to perform backup and check the backup result.

Preparing for backup

You must prepare for backup before actually starting the backup process.

Follow the procedure below.

 See

Refer to "Preparing Directories to Deploy Resources" in the Installation and Setup Guide for Server for information on the location of directories required for backup and for points to take into account.

1. Prepare the backup data storage disk

   For backup, prepare a separate disk unit from the database storage disk and mount it using the operating system commands.

2. Create a directory where the backup data will be stored

   Create an empty directory.

Set appropriate permissions so that only the instance administrator can access the directory.

Example

```
# mkdir /backup/inst1
# chown fsepuser:fsepuser /backup/inst1
# chmod 700 /backup/inst1
```

3. Specify the settings required for backup

   Stop the instance, and set the following parameters in the postgresql.conf file.

   Start the instance after editing the postgresql.conf file.

Parameter name	Setting	Description
backup_destination	Name of the directory where the backup data will be stored	Specify the name of the directory where the backup data will be stored. Appropriate privileges that allow only the instance administrator to access the directory must already be set. Place the backup data storage destination directory outside the data storage destination directory, the tablespace directory, and the transaction log storage destination directory.
archive_mode	on	Specify the archive log mode. Specify [on] (execute).
archive_command	'*installationDirectory*/bin/pgx_walcopy.cmd "%p" "*backupDataStorageDestinationDirectory*/archived_wal/%f" [-z | -Z level]'	Specify the path name of the command that will save the transaction log and the storage destination. Use the -z or -Z option to compress the backup data. This allows archive logs to be compressed. -z option compresses by the default compression level. -Z option compresses by the level specified. The level can be set to a value from 0 to 9. (0 no compression, 9 high compression)

   Refer to "Appendix A Parameters" and "Write Ahead Log" under "Server Administration" in the PostgreSQL Documentation for information on the parameters.

Backup operation (file backup)

Use the pgx_dmpall command to perform file backup. You can even embed the pgx_dmpall command in OS automation software to perform backup.

The backup data is stored in the directory specified in the backup_destination parameter of postgresql.conf.

Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

Example

```
> pgx_dmpall -D /database/inst1
```

Note

Backup stores the data obtained during the backup and the backup data of the data obtained during previous backup.

If the data to be stored in the database is encrypted, refer to the following and back up the keystore:

- 5.7.5 Backing Up and Recovering the Keystore

To compress the backup data, specify the -z option, etc. Refer to "pgx_dmpall" in the Reference for information on the pgx_dmpall command.

Backup status

Use the pgx_rcvall command to check the backup status.

Specify the following values in the pgx_rcvall command:

- The -l option indicates backup data information.
- Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

```
> pgx_rcvall -l -D /database/inst1
Date                    Status          Dir
2022-03-01 13:30:40     COMPLETE        /backup/inst1/2022-03-01_13-30-40
```

If an error occurs and backup fails, a message is output to the system log.

In this case, the backup data is not optimized. Ensure that you check the backup result whenever you perform backup. If backup fails, remove the cause of failure and perform backup again.

See

Refer to "pgx_dmpall" and "pgx_rcvall" in the Reference for information on the pgx_dmpall command and pgx_rcvall command.

Setting a restore point

In case you want to recover your database to a certain point in time, you can name this particular point in time, which is referred to as the restore point, by using the psql command.

By setting a restore point before executing an application, it becomes easy to identify up to which point in time the data will be reverted.

A restore point can be set to any point in time after a backup is executed. However, if a restore point is set before a backup is executed, the database cannot be recovered to that point in time. This is because restore points are recorded in the archive logs, and the archive logs are discarded when backups are executed.

Example

The following example uses the psql command to connect to the database and execute the SQL statement to set a restore point.

However, when considering continued compatibility of applications, do not use functions directly in SQL statements. Refer to "Notes on Application Compatibility" in the Application Development Guide for details.

```
postgres=# SELECT pg_create_restore_point('batch_20220303_1');
LOG:  restore point "batch_20220303_1" created at 0/20000E8
STATEMENT:  select pg_create_restore_point('batch_20220303_1');
 pg_create_restore_point
-------------------------
 0/20000E8
(1 row)
```

Refer to "17.3.2 Using the pgx_rcvall Command" for information on using a restore point to recover the database.

Note

- Name restore points so that they are unique within the database. Add the date and time of setting a restore point to distinguish it from other restore points, as shown below:
  - YYMMDD_HHMMSS
    - YYMMDD: Indicates the date
    - HHMMSS: Indicates the time
- There is no way to check restore points you have set. Keep a record in, for example, a file.

See

Refer to "System Administration Functions" under "Functions and Operators" in the PostgreSQL Documentation for information on pg_create_restore_point.

Chapter 4 Configuring Secure Communication Using Secure Sockets Layer

If communication data transferred between a client and a server contains confidential information, encrypting the communication data can protect it against threats, such as eavesdropping on the network.

4.1 Configuring Communication Data Encryption

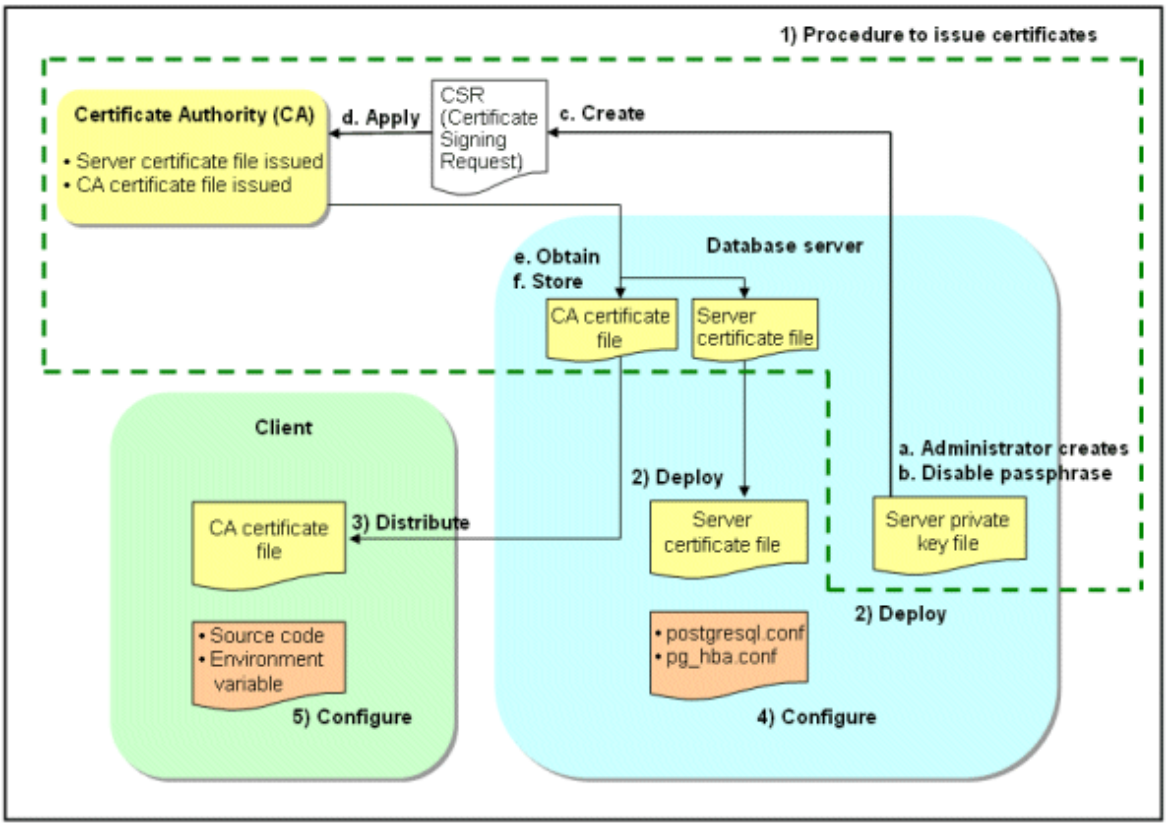
To encrypt communication data transferred between a client and a server, configure communication data encryption as described below. Communication data encryption not only protects the communication content, but it also guards against man-in-the-middle (MITM) attacks (for example, data and password theft through server impersonation).

Table 4.1 Configuration procedure

Configuration procedure
1) Issue a certificate
2) Deploy a server certificate file and a server private key file
3) Distribute a CA certificate file to the client
4) Configure the operating environment for the database server
5) Configure the operating environment for the client

The following figure illustrates the environment for communication data encryption.

Figure 4.1 Environment for communication data encryption



4.1.1 Issuing a Certificate

For authenticating servers, you must acquire a certificate issued by the certificate authority (CA).
FUJITSU Enterprise Postgres supports X.509 standard PEM format files. If the certificate authority issues a file in DER format, use a tool such as the openssl command to convert the DER format file to PEM format.

The following provides an overview of the procedure. Refer to the procedure published by the public or independent certificate authority (CA) that provides the certificate file for details.

a. Create a server private key file

b. Disable the passphrase for the server private key file

c. Create a CSR (signing request for obtaining a server certificate) from the server private key file

d. Apply to the certificate authority (CA) for a server certificate

e. Obtain a server certificate file and a CA certificate file from the certificate authority (CA)

f. Store the server certificate file and the CA certificate file
   Note: If you lose or destroy the certificates, you will need to have them re-issued.

The above procedure enables you to prepare the following files:

- Server private key file
- Server certificate file
- CA certificate file

4.1.2 Deploying a Server Certificate File and a Server Private Key File

Create a directory on the local disk of the database server and store the server certificate file and the server private key file in it.
Use the operating system features to set access privileges for the server certificate file and the server private key file so that only the database administrator has load privileges.
Back up the server certificate file and the server private key file in the event that data corruption occurs and store them securely.

4.1.3 Distributing a CA Certificate File to the Client

Create a directory on the local disk of the client and place the distributed CA certificate file there. Use the operating system features to set load privileges to protect the CA certificate file against accidental deletion.

4.1.4 Configuring the Operating Environment for the Database Server

See

Refer to "Secure TCP/IP Connections with SSL" under "Server Administration" in the PostgreSQL Documentation for details.

4.1.5 Configuring the Operating Environment for the Client

See

Refer to the following sections in the Application Development Guide for details, depending on your application development environment:

- "Settings for Encrypting Communication Data" under "Setup" in "JDBC Driver"
- "Settings for Encrypting Communication Data" under "Setup" in "C Library (libpq)"
- "Settings for Encrypting Communication Data" under "Setup" in "Embedded SQL in C"

4.1.6 Performing Database Multiplexing

When you perform communication that uses database multiplexing and a Secure Socket Layer server certificate, take one of the following actions:

- Create one server certificate, replicate it, and place a copy on each server used for database multiplexing.
  If sslmode is set to verify-full, add all domain names in subjectAltName.
- Create server certificate for each server used for database multiplexing.

See

Refer to "Using the Application Connection Switch Feature" in the Application Development Guide for information on how to specify applications on the client.

Chapter 5 Protecting Storage Data Using Transparent Data Encryption

This chapter describes how to encrypt data to be stored in the database.

5.1 Protecting Data Using Encryption

With PostgreSQL, data in a database is protected from access by unauthorized database users through the use of authentication and access controls. However, the OS file is not protected from attackers who bypass the database server's authentication and access controls.

With FUJITSU Enterprise Postgres, data inside the OS file is encrypted, so valuable information is protected even if the file or disk is stolen.

Data to be stored in a database is encrypted when it is written to the data file, and decrypted when it is read.

This is performed automatically by the instance, so the user and the application need not be aware of key management and encryption or decryption. This process is called TDE (Transparent Data Encryption).

The characteristics of TDE are described below.

Encryption mechanisms

Two-layer encryption key and the keystore

In each tablespace, there is a tablespace encryption key that encrypts and decrypts all the data within. The tablespace encryption key is encrypted by the master encryption key and saved.
There is only one master encryption key in the database cluster, which is encrypted and stored in the keystore.
Therefore, an attacker cannot read the master encryption key from the keystore.

Keystore management

FUJITSU Enterprise Postgres works in conjunction with the IBM Z Hardware Security Module (HSM) to provide hardware management of master encryption keys for robust security. The master encryption key is encrypted based on the master key in the HSM and is never leaked out over its lifetime. Use hardware-stored keystores to reduce deployment and operating costs for keystore management.

File-based keystores that do not work with the HSM are also possible. The master encryption key is then encrypted based on the passphrase that you specify and stored in the keystore. For information on how to use transparent data encryption when using a key management system as a keystore, refer to "Chapter 6 Using Transparent Data Encryption with Key Management Systems as Keystores". Also, refer to "Appendix K Operation of Transparent data Encryption in File-based Keystores" for information about the operation of transparent data encryption in file-based.

Strong encryption algorithms

TDE uses the Advanced Encryption Standard (AES) as its encryption algorithm. AES was adopted as a standard in 2002 by the United States Federal Government, and is used throughout the world.

Faster hardware-based encryption/decryption

Take advantage of the CPACF (CP Assist for Cryptographic Functions) in the IBM Z processor to minimize encryption and decryption overhead. This means that even in situations where previously the minimum encryption target was selected as a tradeoff between performance and security, it is now possible to encrypt all the data of an application.

Zero overhead storage areas

Encryption does not change the size of data stored in tables, indexes, or WAL. There is, therefore, no need for additional estimates or disks.

Scope of encryption

All user data within the specified tablespace

The tablespace is the unit for specifying encryption. All tables, indexes, temporary tables, and temporary indexes created in the encrypted tablespace are encrypted. There is no need for the user to consider which tables and strings to encrypt.

Refer to "5.5 Encrypting a Tablespace" for details.

Backup data

The pgx_dmpall command and pg_basebackup command create backup data by copying the OS file. Backups of the encrypted data are, therefore, also encrypted. Information is protected from leakage even if the backup medium is stolen.

WAL and temporary files

WAL, which is created by updating encrypted tables and indexes, is encrypted with the same security strength as the update target. When large merges and sorts are performed, the encrypted data is written to a temporary file in encrypted format.

Streaming replication support

You can combine streaming replication and transparent data encryption. The data and WAL encrypted on the primary server is transferred to the standby server in its encrypted format and stored.

Note

The following are not encrypted:

- pg_dump and pg_dumpall output files
- Files output by the COPY command
- Notification event payloads that communicate using the LISTEN or NOTIFY command

5.2 Preparing for HSM Collaboration

FUJITSU Enterprise Postgres manages master encryption keys with the IBM Z Crypto Express Adapter Card. To work with the Crypto Express Adapter Card, use openCryptoki, a PKCS#11 compliant API implementation. Use the openCryptoki CCA token or the EP 11 token.

FUJITSU Enterprise Postgres uses the slot assigned to each instance to access the token through a user pin. You must configure Crypto Express Adapter Cardo and openCryptoki to access the token.

Refer to the IBM documentation for the IBM Z Crypto Express Adapter Card configuration.

Refer to the openCryptoki project documentation for openCryptoki configuration. Note that the tokname attribute must be specified because FUJITSU Enterprise Postgres requires a unique token directory.

5.3 Setting the Master Encryption Key

To use transparent data encryption, you must create a keystore and set the master encryption key.

1. Set postgresql.conf parameters.

   Set the keystore_location parameter to the directory where you want to store the keystore.

   Specify a different location for each database cluster.

   The shared_preload_libraries parameter also sets the extension to be enabled.

   The tde_z.SLOT_ID parameter specifies the slot ID that was set in "5.2 Preparing for HSM Collaboration".

   ```
   keystore_location = '/key/store/location'
   shared_preload_libraries = 'tde_z'
   tde_z.SLOT_ID = 5
   ```

   When the token model "CCA" is used, it is necessary to take care of multi-coprocessor and multi-domain selection. Specify the postgresql.conf parameter for CCA configuration so that FUJITSU Enterprise Postgres can use the specific coprocessor and domain.

   - tde_z.IBM_CCA_CSU_DEFAULT_ADAPTER: this parameter enables to change a default CCA coprocessor.
   - tde_z.IBM_CCA_CSU_DEFAULT_DOMAIN: this parameter enables to select a single domain.

   The values of these parameters are taken over to CCA service via CCA environment variable CSU_DEFAULT_ADAPTER or CSU_DEFAULT_DOMAIN.

```
tde_z.IBM_CCA_CSU_DEFAULT_ADAPTER = 'CRP01'
tde_z.IBM_CCA_CSU_DEFAULT_DOMAIN = '3'
```

Refer to "Appendix A Parameters" for information on postgresql.conf.

Refer to IBM documentaion for CCA environment variable CSU_DEFAULT_ADAPTER, CSU_DEFAULT_DOMAIN, the multi-coprocessor selection capabilities and domain selection capabilities.

After editing the postgresql.conf file, either start or restart the instance.

- Using WebAdmin

  Refer to "2.1.1 Using WebAdmin", and restart the instance.

- Using the pg_ctl command

  Specify the following in the pg_ctl command:

  - Specify "restart" as the mode.
  - Specify the data storage destination directory in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.
  - Specify the -w option. This means that the command returns after waiting for the instance to start. If the -w option is not specified, it may not be possible to determine if the starting of the instance completed successfully or if it failed.

  Example

  ```
  > pg_ctl restart -w -D /database/inst1
  ```

2. Execute an SQL function, such as the one below, to set the master encryption key. This must be performed by the database superuser.

   ```
   SELECT pgx_set_master_key('user pin');
   ```

   The argument should be the user pin set in "5.2 Preparing for HSM Collaboration".

5.4 Opening the Keystore

To create encrypted tablespaces and access the encrypted data, you must first open the keystore. When you open the keystore, the master encryption key in the token becomes accessible and becomes usable for encryption and decryption.

You need to open the keystore each time you start the instance. To open the keystore, the database superuser must execute the following SQL function.

```
SELECT pgx_open_keystore('user pin');
```

user pin is the user pin configured in "5.2 Preparing for HSM Collaboration".

Refer to "B.2 Transparent Data Encryption Control Functions" for information on the pgx_open_keystore function.

Note that, in the following cases, the user pin must be entered when starting the instance, because the encrypted WAL must be decrypted for recovery. In this case, the above-mentioned pgx_open_keystore function cannot be executed.

- If performing crash recovery at the time of starting the instance
- If performing recovery using continuous archiving

For the above cases, specify the --user-pin option in the pg_ctl command, and then start the instance. This will display the prompt for the user-pin to be entered, as shown below.

```
> pg_ctl --user-pin start
Enter User PIN:
The server is starting
>
```

Point

When using an automatically opening keystore, you do not need to enter the user pin and you can automatically open the keystore when the database server starts. Refer to "5.7.4 Enabling Automatic Opening of the Keystore" for details.

5.5 Encrypting a Tablespace

The keystore must be open before you can create an encrypted tablespace.

When creating a tablespace that will be encrypted, configure the encryption algorithm in the runtime parameters. For example, to create a tablespace with the name secure_tablespace using AES with a key length of 256 bits as the encryption algorithm, configure as shown below.

```
-- Specify the encryption algorithm for the tablespace to be created below
SET tablespace_encryption_algorithm = 'AES256';
CREATE TABLESPACE secure_tablespace LOCATION '/My/Data/Dir';
-- Specify that the tablespace to be created below is not to be encrypted
SET tablespace_encryption_algorithm = 'none';
```

Or

```
CREATE TABLESPACE secure_tablespace LOCATION '/My/Data/Dir' WITH (tablespace_encryption_algorithm =
'AES256' );
```

When the tablespace is empty and not set with encryption algorithm, the encryption algorithm can be set with the command below.

```
ALTER TABLESPACE db_tablespace SET (tablespace_encryption_algorithm=AES256);
```

Trying to set the encryption algorithm for a non-empty tablespace causes an error.

You can use AES with a key length of 128 bits or 256 bits as the encryption algorithm. It is recommended that you use 256-bit AES. Refer to "Appendix A Parameters" for information on how to specify the runtime parameters.

If user provides both GUC and command line options while creating the tablespace, the preference is given to the command line option.

The pg_default and pg_global tablespaces cannot be encrypted.

Create tables and indexes in the encrypted tablespace that you created. Relations created in the encrypted tablespace are automatically encrypted.

Example

Example 1: Specifying an encrypted tablespace when creating it

```
CREATE TABLE my_table (...)
    TABLESPACE secure_tablespace;
```

Example 2: Not explicitly specifying a tablespace when creating it and instead using the default tablespace

```
SET default_tablespace = 'secure_tablespace';
CREATE TABLE my_table (...);
```

The process is the same for encrypting temporary tables and temporary indexes. In other words, either explicitly specify the TABLESPACE clause or list encrypted tablespaces in the temp_tablespaces parameter, and then execute CREATE TEMPORARY TABLE or CREATE INDEX.

Point

If an encrypted tablespace is specified in the TABLESPACE clause of the CREATE DATABASE statement, relations created in the database without explicitly specifying a tablespace will be encrypted. Furthermore, the system catalog will also be encrypted, so the source code of user-defined functions is also protected.

Example: Specifying a tablespace in a database definition statement

```
CREATE DATABASE DB01 TABLESPACE=SP01 ... ;
```

Part of the data is also stored in the system catalog - to encrypt this data as well, specify an encrypted tablespace as above and create a database.

5.6 Checking an Encrypted Tablespace

The pgx_tablespaces system view displays information about whether each tablespace has been encrypted, and about the encryption algorithm. Refer to "C.1 pgx_tablespaces" for information on strings.

You can discover which tablespaces have been encrypted by executing the following SQL statements.

However, when considering continued compatibility of applications, do not reference system catalogs (pg_tablespace) directly in SQL statements.

```
SELECT spcname, spcencalgo
FROM pg_tablespace ts, pgx_tablespaces tsx
WHERE ts.oid = tsx.spctablespace;
```

Example

```
postgres=# SELECT spcname, spcencalgo FROM pg_tablespace ts, pgx_tablespaces tsx WHERE ts.oid =
tsx.spctablespace;
      spcname      | spcencalgo
-------------------+------------
 pg_default        | none
 pg_global         | none
 secure_tablespace | AES256
(3 rows)
```

See

Refer to "Notes on Application Compatibility" in the Application Development Guide for information on how to maintain application compatibility.

5.7 Managing the Keystore

This section describes how to manage the keystore and the master encryption key to guard against the threat of theft.

5.7.1 Changing the Master Encryption Key

Using the same encryption key for an extended period gives attackers an opportunity to decipher the encrypted data. It is recommended that you change the key at regular intervals, or whenever the key is exposed to risk.

Adhere to the industry's best practices for encryption algorithms and key management when considering how often the key should be changed. For example, the NIST in the United States has published "NIST Special Publication 800-57". The PCI DSS also refers to this publication. This publication recommends changing the master encryption key once a year.

To change the master encryption key, execute the pgx_set_master_key function, which is the same function used for configuring the key. Refer to "5.3 Setting the Master Encryption Key" for details.

After changing the master encryption key, you must immediately back up the keystore and the entire opencryptoki token directory of the slot you assigned to FUJITSU Enterprise Postgres. (This token directory has same name as was set to the tokname attribute in "5.2 Preparing for HSM Collaboration").

5.7.2 Changing the HSM master key

The master encryption key is encrypted with the master key hidden by the HSM, and the master key is highly secure, but the HSM master key can be changed. Refer to the IBM documentation for instructions on how to do this. First, stop the database server. As soon as you have change the HSM master key, back up the entire opencryptoki token directory of the slot assigned to FUJITSU Enterprise Postgres.

5.7.3 Changing User Pins

You can change the user pin used for authentication when the keystore is opened.

Refer to the openCryptoki project documentation for instructions on how to do this.

You must then either reopen the keystore with the following SQL or restart the database server.

```
SELECT pgx_open_keystore('newUserpin');
```

As soon as you change the user pin, back up the entire opencryptoki token directory of the slot you assigned to FUJITSU Enterprise Postgres.

5.7.4 Enabling Automatic Opening of the Keystore

Auto-open keystores allow you to automatically open a keystore when you start an instance without entering user pins. To enable automatic keystore opening, specify the following postgresql.conf parameters:

Example

```
tde_z.USER_PIN = 'user pin'
```

Specify the user pin as set in "5.2 Preparing for HSM Collaboration".

5.7.5 Backing Up and Recovering the Keystore

Back up the keystore and the entire opencryptoki token directory of the slot allocated to FUJITSU Enterprise Postgres at the following times in case they are corrupted or lost.

- When the master encryption key is first configured
- When the master encryption key is changed
- When the database is backed up
- When the HSM master key is changed
- When a user pin is changed

Point

Do not overwrite an old keystore when backing up a keystore. This is because during database recovery, you must restore the keystore to its state at the time of database backup. When the backup data of the database is no longer required, delete the corresponding keystore.

Example

- Back up the database and the keystore on May 1, 2020.

```
> pgx_dmpall -D /database/inst1
> cp -p /key/store/location/keystore.ks /keybackup/keystore_20200501.ks
> tar -cf token_directory_fep_20200501.tar /var/lib/opencryptoki/fep
```

Specify the following in the pgx_dmpall command:

- Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

- Change the master encryption key, and back up the keystore on May 5, 2020.

```
> psql -c "SELECT pgx_set_master_key('user pin')" postgres
> cp -p /key/store/location/keystore.ks /keybackup/keystore_20200505.ks
> tar -cf token_directory_fep_20200505.tar /var/lib/opencryptoki/fep
```

  Specify the following in the psql command:

  - Specify the SQL function that sets the master encryption key in the -c option.
  - Specify the name of the database to be connected to as the argument.

If the keystore is corrupted or lost, restore the keystore (containing the latest master encryption key) and the entire opencryptoki token directory of the slot allocated to FUJITSU Enterprise Postgres. If there is no keystore containing the latest master encryption key, restore the keystore and the entire opencryptoki token directory of the slot assigned to FUJITSU Enterprise Postgres to their state at the time of database backup, and recover the database from the database backup. This action recovers the keystore to its latest state.

Example

- Restore the keystore containing the latest master encryption key as of May 5, 2020.

```
> cp -p /keybackup/keystore_20200505.ks /key/store/location/keystore.ks
> tar -xf token_directory_fep_20200505.tar
```

- If there is no backup of the keystore containing the latest master encryption key, recover the keystore by restoring the keystore that was backed up along with the database on 1 May 2020.

```
> cp -p /keybackup/keystore_20200501.ks /key/store/location/keystore.ks
> tar -xf token_directory_fep_20200501.tar
> pgx_rcvall -B /backup/inst1 -D /database/inst1 --user-pin
```

  Specify the following in the pgx_rcvall command:

  - Specify the data storage directory in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.
  - Specify the backup data storage directory in the -B option.
  - The --user-pin option prompts you to enter the user pin to open the keystore.

See

Refer to "pgx_rcvall" and "pgx_dmpall" in the Reference for information on the pgx_rcvall and pgx_dmpall commands.

Refer to "psql" under "Reference" in the PostgreSQL Documentation for information on the psql command.

Refer to "B.2 Transparent Data Encryption Control Functions" for information on the pgx_set_master_key function.

Refer to "5.7.4 Enabling Automatic Opening of the Keystore" for information on how to enable automatic opening of the keystore.

5.8 Backing Up and Restoring/Recovering the Database

FUJITSU Enterprise Postgres enables you to use the five backup and recovery methods described below. Regardless of the method you use, you must back up the keystore and the entire opencryptoki token directory of the slot allocated to FUJITSU Enterprise Postgres at the same time.

Note that you must store the database and the keystore on separate data storage media. Storing both on the same data storage medium risks the danger of the encrypted data being deciphered if the medium is stolen.

Note

When recoverying the database, it is necessary to restore the configuration of both Crypto Express Adapter Card and openCryptoki which contains the same key as was set at the time of taking backup so that the recovered database can cooperate with hardware security module.

Backup and recovery using WebAdmin

- Backup

  WebAdmin backs up encrypted data.

  Back up the key store and the entire opencryptoki token directory of the slot allocated to FUJITSU Enterprise Postgres after backing up the database.

- Recovery

  Restore the keystore and the entire opencryptoki token directory of the slot allocated to FUJITSU Enterprise Postgres to their state at the time of database backup. Refer to "5.7.5 Backing Up and Recovering the Keystore" for details.

  Enable automatic opening of the keystore in accordance with the procedure described in "5.7.4 Enabling Automatic Opening of the Keystore". Then, use WebAdmin to recover the database.

Backup and recovery using the pgx_dmpall and pgx_rcvall commands

- Backup

  The pgx_dmpall command backs up the encrypted data.

  Back up the key store and the entire opencryptoki token directory of the slot allocated to FUJITSU Enterprise Postgres after backing up the database.

- Recovery

  Restore the keystore and the entire opencryptoki token directory of the slot allocated to FUJITSU Enterprise Postgres to their state at the time of the database backup.

  Configure automatic opening of the key store as necessary.

  If automatic opening of the keystore is not enabled, execute the pgx_rcvall command with the --user-pin option specified. This will display the prompt for the user pin to be entered.

Example

- Back up the database and the keystore on May 1, 2020.

```
> pgx_dmpall -D /database/inst1
> cp -p /key/store/location/keystore.ks /keybackup/keystore_20200501.ks
> tar -cf token_directory_fep_20200501.tar /var/lib/opencryptoki/fep
```

  Specify the following in the pgx_dmpall command:

  - Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

- Recover the database and the keystore from the backup taken on May 1, 2020.

```
> cp -p /keybackup/keystore_20200501.ks /key/store/location/keystore.ks
> pgx_rcvall -B /backup/inst1 -D /database/inst1 --user-pin
```

  Specify the following in the pgx_rcvall command:

  - Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.
  - Specify the backup data storage directory in the -B option.

- The --user-pin option prompts you to enter the user pin to open the keystore.

Dump and restore using SQL

- Backup

  The files output by the pg_dump and pg_dumpall commands are not encrypted. You should, therefore, encrypt the files using OpenSSL commands or other means before saving them, as described in "5.9 Importing and Exporting the Database" below.

  Back up the key store and the entire opencryptoki token directory of the slot allocated to FUJITSU Enterprise Postgres after backing up the database.

- Restore

  If the backup data has been encrypted using, for example Open SSL commands, decrypt that data.

  The data generated by the pg_dumpall command includes a specification to encrypt tablespaces by default. For this reason, the psql command encrypts tablespaces during restoration.

File system level backup and restore

- Backup

  Stop the instance and backup the data directory and the tablespace directory using the file copy command of the operating system. The files of encrypted tablespaces are backed up in the encrypted state.

  Back up the key store and the entire opencryptoki token directory of the slot allocated to FUJITSU Enterprise Postgres after performing the backup.

- Restore

  Restore the keystore and the entire opencryptoki token directory of the slot allocated to FUJITSU Enterprise Postgres to their state at the time of the database backup.

  Stop the instance and restore the data directory and the tablespace directory using the file copy command of the operating system.

Continuous archiving and point-in-time recovery

- Backup

  The pg_basebackup command backs up the encrypted data as is.

  Back up the key store and the entire opencryptoki token directory of the slot allocated to FUJITSU Enterprise Postgres after performing the backup.

- Recovery

  Restore the keystore and the entire opencryptoki token directory of the slot allocated to FUJITSU Enterprise Postgres to their state at the time of the database backup.

  Configure automatic opening of the key store as necessary.

  If automatic opening of the keystore is not enabled, execute the pg_ctl command to start the instance with the --user-pin option specified. This will display the prompt for the user pin to be entered.

 See

- Refer to "pg_ctl" under "Reference" in the PostgreSQL Documentation for information on the pg_ctl command.
- Refer to "Reference" in the PostgreSQL Documentation for information on the following commands:
  - psql
  - pg_dump
  - pg_basebackup

- Refer to the Reference for information on the following commands:
  - pgx_rcvall
  - pgx_dmpall
  - pg_dumpall

5.9 Importing and Exporting the Database

The files output by the COPY TO command are not encrypted. Therefore, when transferring files to other systems, you should encrypt files using OpenSSL commands or other means and use scp or sftp to encrypt the data being transferred.

Use a safe method to delete obsolete plain text files.

You can use the following methods to safely delete files:

- shred command

 Example

```
# Export the contents of the table my_table to a CSV file.
> psql -c "COPY my_table TO '/tmp/my_table.csv' (FORMAT CSV)" postgres

# Encrypt the exported file.
> openssl enc -e -aes256 -in my_table.csv -out my_table.csv.enc
(The user is prompted to enter the passphrase to be used for encryption)

# Safely delete plain text files.
> shred -u -x my_table.csv
 (Transfer encrypted files to other systems)

# Decrypt the encrypted files on other systems.
> openssl enc -d -aes256 -in my_table.csv.enc -out my_table.csv
(The user is prompted to enter the passphrase to be used for decryption)
```

If you use COPY FROM to import data to tables and indexes in an encrypted tablespace, the imported data is automatically encrypted before being stored.

5.10 Encrypting Existing Data

You cannot encrypt existing unencrypted tablespaces. In addition, you cannot change encrypted tablespaces so that they do not encrypt.

As an alternative, transfer the tables and indexes to other tablespaces. You can use the following SQL commands for this.

```
ALTER TABLE table_name SET TABLESPACE new_tablespace;
ALTER INDEX index_name SET TABLESPACE new_tablespace;
ALTER DATABASE database_name SET TABLESPACE new_tablespace;
```

 See

Refer to "SQL Commands" under "Reference" in the PostgreSQL Documentation for information on SQL commands.

5.11 Operations in Cluster Systems

This section describes how to use transparent data encryption on cluster systems such as streaming replication, and database multiplexing.

5.11.1 Database Multiplexing Mode

Note the following when using transparent data encryption in environments that use streaming replication, or database multiplexing with streaming replication.

HSM Master Key Configuration

Because the master encryption key is encrypted with the HSM master key, you must load the same HSM master key on all servers that will be part of the database multiplexing operation.

For instructions on loading the primary server's HSM master key on the standby server, refer to the IBM documentation.

Placing the keystore file

Place a copy of the primary server keystore file on the standby server.

This is required as the keystore file cannot be shared, and both servers may need to access it simultaneously.

Copy procedure for the opencryptoki token directory

Execute the following operations as the system administrator (root).

1. On source machine
    a. Backup the token directory of the source machine (retain file owners and groups) in the backup
2. On target machine
    a. Update the opencryptoki.conf file

       Add new Slot/tokname to use on the target machine
    b. Restart Slot Manager daemon (pkcsslotd)

       This will create the openCryptoki token folders including a new one for new slot
    c. Copy all the backed-up token directory files into this new token directory (preserving the file owners and groups)
    d. Be sure to remove any shared memory files in /dev/shm which are associated with the new tokname
    e. Restart Slot Manager daemon (pkcsslotd)
    f. New token should be ready to use.

       (The SO PIN and User PIN are same as they were on the source machine)

Automatically opening the keystore

You must enable automatic opening of the keystore.

To do this, enable automatic opening of the keystore in all servers that make up database multiplexing.

Building and starting a standby server

Before using the pg_basebackup command or pgx_rcvall command to build a standby server, copy the keystore file and the entire opencryptoki token directory of the slot assigned to FUJITSU Enterprise Postgres from the primary server to the standby server.

Open the keystore each time you start the standby server. This step is necessary for decrypting and restoring encrypted WAL received from the primary server. To open the keystore, specify the --user-pin option in the pg_ctl command or pgx_rcvall command and enter the user pin, or use an automatically opening keystore.

- If you start a standby server without copying the openCryptoki token directory from the primary server to the standby server, an error occurs during the following operations.
    - Accessing tables defined in an encrypted tablespace on the standby server
    - Changing the master encryption key on the primary server

- If an error occurs, you can recover by copying the opencryptoki token directory from the primary server to the standby server and restarting the standby server.

Changing the master encryption key

Change the master encryption key on the primary server. You need not copy the keystore from the primary server to the standby server. You need not even restart the standby server or reopen the keystore. Changes to the master encryption key are reflected in the keystore on the standby server.

See

Refer to "pgx_rcvall " in the Reference for information on pgx_rcvall command.

Refer to "pg_ctl" under "Reference" in the PostgreSQL Documentation for information on pg_ctl command.

Refer to "pg_basebackup" under "Reference" in the PostgreSQL Documentation for information on pg_basebackup command.

Refer to "High Availability, Load Balancing, and Replication" under "Server Administration" in the PostgreSQL Documentation for information on how to set up streaming replication.

5.12 Security-Related Notes

- Decrypted data is cached in the database server memory (shared buffer). As a result, unencrypted data is stored in a core file, which is a process memory dump. You should, therefore, safely delete the memory dump.
  You can safely delete files by using the following command:
  - shred command
- Unencrypted data may be written from the database server memory to the operating system's swap area. To prevent leakage of information from the swap area, consider either disabling the use of swap area or encrypting the swap area using a full-disk encryption product.
- The content of the server log file is not encrypted. Therefore, in some cases the value of a constant specified in a SQL statement is output to the server log file. To prevent this, consider setting a parameter such as log_min_error_statement.
- When executing an SQL function that opens the keystore and modifies the master encryption key, ensure that the SQL statement containing the passphrase is not output to the server log file. To prevent this, consider setting a parameter such as log_min_error_statement. If you are executing this type of SQL function on a different computer from the database server, encrypt the communication between the client and the database server with SSL.
- The logical replication is available which allows non-backed up clusters to subscribe to databases where transparent data encryption is enabled. Logical replication does not need to have the same encryption strategy between publisher and subscriber.

  In this scenario, if the user wants to encrypt the subscribed copy of data as well, then it is the user's responsibility to create encryption policies to the subscribed databases. By default, published encrypted tablespace data will not be encrypted in the subscriber side.

5.13 Tips for Installing Built Applications

With transparent data encryption, you can easily encrypt all the data in an application without modifying the application. Database administrators install built applications in the following manner. However, this procedure stores data to the default tablespace, so take necessary action if processing differs from the original design.

1. (Normal procedure) Create an owner and a database for the built application.

```
CREATE USER crm_admin ...;
CREATE DATABASE crm_db ...;
```

2. (Procedure for encryption) Create an encrypted tablespace to store the data for the built application.

```
SET tablespace_encryption_algorithm = 'AES256';
CREATE TABLESPACE crm_tablespace LOCATION '/crm/data';
```

3. (Procedure for encryption) Configure an encrypted tablespace as the default tablespace for the owner of the built application.

```
ALTER USER crm_admin SET default_tablespace = 'crm_tablespace';
ALTER USER crm_admin SET temp_tablespaces = 'crm_tablespace';
```

4. (Normal procedure) Install the built application. The application installer prompts you to enter the host name and the port number of the database server, the user name, and the database name. The installer uses the entered information to connect to the database server and execute the SQL script. For applications that do not have an installer, the database administrator must manually execute the SQL script.

Normally, the application's SQL script includes logic definition SQL statements, such as CREATE TABLE, CREATE INDEX, and GRANT or REVOKE, converted from the entity-relationship diagram. It does not include SQL statements that create databases, users, and tablespaces. Configuring the default tablespace of the users who will execute the SQL script deploys the objects generated by the SQL script to the tablespace.

Chapter 6 Using Transparent Data Encryption with Key Management Systems as Keystores

This chapter describes the operation of transparent data encryption when a key management system is used as a keystore.

See

Refer to "Key Management System Requirements" in the Installation and Setup Guide for Server for the key management system requirements that can be used with FUJITSU Enterprise Postgres.

6.1 Protecting Data Using Encryption

Refer to "5.1 Protecting Data Using Encryption". The following describes the differences from the transparent data encryption operation linked with the Hardware Security Module (HSM) described in "5.1 Protecting Data Using Encryption".

Encryption mechanisms

Keystore management

By linking with a product/service (key management system) for managing encryption keys and managing the master encryption key with the key management system, you can simplify the operation of encryption keys.

6.2 Setting the Master Encryption Key

To use transparent data encryption, you must create a keystore and set the master encryption key.

1. Load the shared_preload_libraries parameter in postgresql.conf with the library name "tde _ kms"

```
shared_preload_libraries = 'tde_kms'
```

2. Set the tde_kms.kms_conninfo_file parameter in postgresql.conf to a file that contains key management system connection information. Refer to "Appendix A Parameters" for information.

   Example for the key management system connection information file kms_conninfo.conf

```
tde_kms.kms_conninfo_file = 'kms_conninfo.conf'
```

   Example of key management system connection information file

```
kmip   mykmipsvr  mykmipsvr.example.com   5696   cert   sslcert=postgres.crt
sslkey=postgres.key sslrootcert=root.crt
```

3. Execute a CREATE EXTENSION statement to install the extension.

```
CREATE EXTENSION tde_kms;
```

4. To enable transparent data encryption, call the pgx_declare_external_master_key function to declare the encryption key to use as the master encryption key. Refer to "B.2.3 pgx_declare_external_master_key" for information on the pgx_declare_external_master_key function.

```
SELECT pgx_declare_external_master_key( kms_name => 'mykmipsvr', key_id =>
'a0eebc99-9c0b-0000-0000-000000000000', sslpassphrase => 'mykmippassphrase' );
```

6.3 Opening the Keystore

To create encrypted tablespaces and access the encrypted data, you must first open the keystore. When you open the keystore, the master encryption key is available for encryption and decryption.

You need to open the keystore each time you start the instance. To open the keystore, the database superuser must execute the following SQL function.

```
SELECT pgx_open_keystore( sslpassphrase => 'passphrase');
```

passphrase is the passphrase of the private key file for the client certificate.

Refer to "B.2 Transparent Data Encryption Control Functions" for information on the pgx_open_keystore function.

Note that, in the following cases, the passphrase must be entered when starting the instance, because the encrypted WAL must be decrypted for recovery. In this case, the above-mentioned pgx_open_keystore function cannot be executed.

- If performing crash recovery at the time of starting the instance
- If performing recovery using continuous archiving

For the above cases, specify the --kms-secret option in the pg_ctl command, and then start the instance. This will display the prompt for the passphrase to be entered, as shown below.

```
> pg_ctl --kms-secret start
Enter secret:
```

Point

When using an automatically opening keystore, you do not need to enter the passphrase and you can automatically open the keystore when the database server starts. Refer to "6.6.2 Enabling Automatic Opening of the Keystore" for details.

6.4 Encrypting a Tablespace

Refer to "5.5 Encrypting a Tablespace".

6.5 Checking an Encrypted Tablespace

Refer to "5.6 Checking an Encrypted Tablespace".

6.6 Managing the Keystore

Describes how to manage master encryption keys when a key management system is used.

6.6.1 Changing the Master Encryption Key

To change the master encryption key, run the pgx_declare_external_master_key function as you originally set it. Refer to "6.2 Setting the Master Encryption Key" for more information.

Note

Specify the same key management system name as the key management system name specified during installation.

6.6.2 Enabling Automatic Opening of the Keystore

You can automatically open a keystore at instance startup without entering a passphrase by specifying all credentials, including those that should be kept secret, in the key management system connection information file. To enable automatic keystore opening, run the pgx_keystore command.

Example of storing obfuscated credentials in the file sslkeypasprase.ksc

```
> pgx_keystore -s -o sslkeypassphrase.ksc
Enter secret:
```

Specify obfuscated credentials in the key management system connection information file.

```
kmip    mykmipsvr    kmip.example.com    5696    cert    sslcert=postgres.crt    sslkey=postgres.key
sslrootcert=root.crt    sslkeypassphrase-obf=sslkeypassphrase.ksc
```

The key management system connection information file is valid only on the computer on which it was created.

To disable automatic keystore opening, delete the file containing obfuscated credentials for the private key specified in sslkeypasserase-obf and delete the sslkeypasserase-obf option in the key management system connection information file.

See

Refer to "pgx_keystore" in the Reference for information on pgx_keystore command.

Refer to "Appendix A Parameters" for information on the key management system connection information file.

6.6.3 Changing Credentials for Key Management Systems

If the credentials for the key management service change, you must also change the credentials that FUJITSU Enterprise Postgres uses to connect to the key management system.

You can change the credentials used by FUJITSU Enterprise Postgres using the pgx_open_keystore function. The new credentials are used to connect to the new key management system.

If you have a streaming replication configuration, you must change credentials on all replicas.

Refer to "B.2.1 pgx_open_keystore" for information on the pgx_open_keystore function.

6.6.4 Verifying the Master Encryption Key

The view pgx_tde_master_key shows information about your master encryption key. For more information about columns, Refer to "D.1 pgx_tde_master_key" for more information about columns..

6.7 Backing Up and Restoring/Recovering the Database

FUJITSU Enterprise Postgres enables you to use the five backup and recovery methods described below.

Backup and recovery using WebAdmin

- Backup

  WebAdmin backs up encrypted data.

- Recovery

  If you recover to a point in time when the old master encryption key was in use, change to the most recent master encryption key immediately after recovery.

  Enable automatic opening of the keystore in accordance with the procedure described in "6.6.2 Enabling Automatic Opening of the Keystore". Then, use WebAdmin to recover the database.

Backup and recovery using the pgx_dmpall and pgx_rcvall commands

- Backup

  The pgx_dmpall command backs up the encrypted data.

- Recovery

  If you recover to a point in time when the old master encryption key was in use, change to the most recent master encryption key immediately after recovery.

  Configure automatic opening of the key store as necessary.

If automatic opening of the keystore is not enabled, execute the pgx_rcvall command with the --kms-secret option specified. This will display the prompt for the passphrase to be entered.

Dump and restore using SQL

- Backup

  The files output by the pg_dump and pg_dumpall commands are not encrypted. You should, therefore, encrypt the files using OpenSSL commands or other means before saving them, as described in "5.9 Importing and Exporting the Database" below.

- Restore

  If the backup data has been encrypted using, for example Open SSL commands, decrypt that data.

  The data generated by the pg_dumpall command includes a specification to encrypt tablespaces by default. For this reason, the psql command encrypts tablespaces during restoration.

File system level backup and restore

- Backup

  Stop the instance and backup the data directory and the tablespace directory using the file copy command of the operating system. The files of encrypted tablespaces are backed up in the encrypted state.

- Restore

  Stop the instance and use the OS file copy command to restore the data storage directory or tablespace directory.

  If you recover to a point in time when the old master encryption key was in use, change to the most recent master encryption key immediately after recovery.

Continuous archiving and point-in-time recovery

- Backup

  The pg_basebackup command backs up the encrypted data as is.

- Recovery

  If you recover to a point in time when the old master encryption key was in use, change to the most recent master encryption key immediately after recovery.

  Configure automatic opening of the key store as necessary.

  If automatic opening of the keystore is not enabled, execute the pg_ctl command to start the instance with the --kms-secret option specified. This will display the prompt for the passphrase to be entered.

See

- Refer to "pg_ctl" under "Reference" in the PostgreSQL Documentation for information on the pg_ctl command.
- Refer to "Reference" in the PostgreSQL Documentation for information on the following commands:
  - psql
  - pg_dump
  - pg_basebackup
- Refer to the Reference for information on the following commands:
  - pgx_rcvall
  - pgx_dmpall
  - pg_dumpall

6.8 Importing and Exporting the Database

Refer to "5.9 Importing and Exporting the Database".

6.9 Encrypting Existing Data

Refer to "5.10 Encrypting Existing Data".

6.10 Operations in Cluster Systems

This section describes how to use transparent data encryption on cluster systems such as high-availability systems, streaming replication, and database multiplexing.

6.10.1 HA Clusters that do not Use Database Multiplexing

Take the following points into account when using transparent data encryption in an HA cluster environment that does not use database multiplexing.

Key ID of the encryption key

Declare the same key ID on the primary server in the operation center and the standby server in the standby center.

6.10.2 Database Multiplexing Mode

Note the following when using transparent data encryption in environments that use streaming replication, or database multiplexing with streaming replication.

Automatically opening the keystore

You must enable automatic opening of the keystore.

To do this, enable automatic opening of the keystore in all servers that make up database multiplexing.

6.11 Security-Related Notes

Refer to "5.12 Security-Related Notes".

6.12 Tips for Installing Built Applications

Refer to "5.13 Tips for Installing Built Applications".

Chapter 7 Data Masking

Data masking is a feature that can change the returned data for queries generated by applications, so that it can be referenced by users. For example, for a query of employee data, digits except the last four digits of an eight-digit employee number can be changed to "*" so that it can be used for reference.

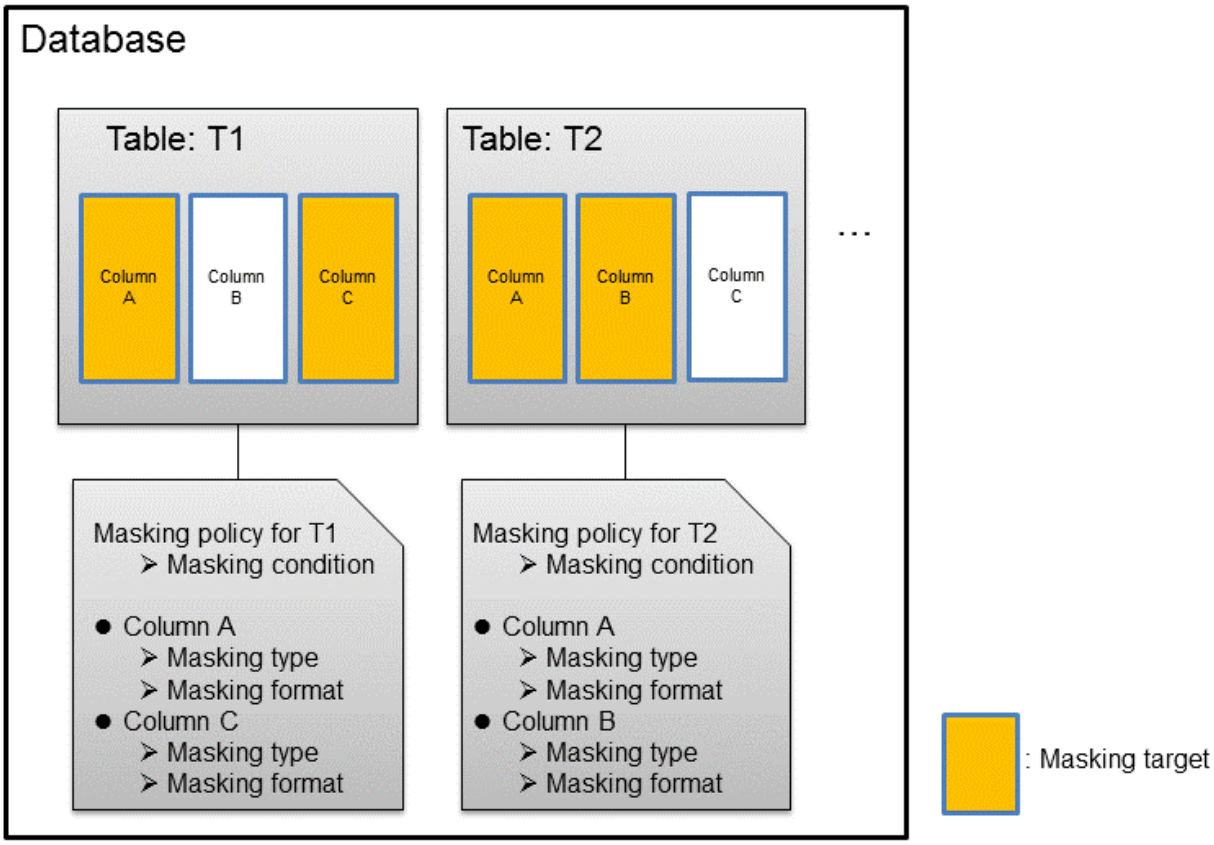
Note

When using this feature, it is recommended that the changed data be transferred to another medium for users to reference. This is because, if users directly access the database to extract the masked data, there is a possibility that they can deduce the original data by analyzing the masking policy or query result to the masking target column.

7.1 Masking Policy

Masking policy is a method of changing data under specific conditions when it is returned for a query from an application. One masking policy can be created per table. You can configure masking target, masking type, masking condition and masking format in a masking policy.

Figure 7.1 Masking policy



Note

When a masking policy is defined, the search performance for the corresponding table may deteriorate.

7.1.1 Masking Target

Masking target refers to a column to which a masking policy will be applied. When referring to a masking target or a function that includes a masking target, the execution result will be changed and obtained.

The following commands can change the execution result:

- SELECT
- COPY
- pg_dump
- pg_dumpall

- If a masking target is specified to INSERT...SELECT target columns, processing will be performed using data before change.
- If a masking target other than SELECT target columns is specified, processing will be performed using data before change.
- If a masking target is specified in a function where the data type will be converted, an error will occur.

7.1.2 Masking Type

Masking type is a method to change column data that is returned from queries. Specify the masking type in the function_type parameter. The following masking types can be specified and selected depending on the masking target data type.

Full masking

All the data in the specified column is changed. The changed value returned to the application that made the query varies depending on the column data type.
For example, 0 is used for a numeric type column and a space is used for a character type column.

Partial masking

The data in the specified column is partially changed.
For example, digits except the last four digits of an employee number can be changed to "*".

Regular expression masking

The data in the specified column is changed via a search that uses a regular expression.
For example, for strings such as email address that can have variable length, "*" can be used to change characters preceding "@" by using a regular expression. Regular expression masking can only be used for character type data.

- If multiple valid masking targets are specified for a function, the masking type for the left-most masking target will be applied.
  For example, if "SELECT GREATEST(c1, c2) FROM t1" is executed for numeric type masking target c1 and c2, the masking type for c1 will be applied.
- When masking the data that includes multibyte characters, do not specify partial masking for masking type. The result may not be as expected.

7.1.3 Masking Condition

Masking condition refers to the conditions configured to perform masking. Specify the masking condition in the expression parameter. Changed or actual data can be displayed for different users by defining masking condition. An expression that returns a boolean type result needs to be specified in masking condition and masking is performed only when TRUE is returned. Refer to "Value Expressions" in the PostgreSQL Documentation for information on the expressions that can be specified. Note that expressions that include a column cannot

be specified.
For example, when masking data only for "postgres" users, specify 'current_user = "postgres"' in the masking condition.

Information

Specify '1=1' so the masking condition is always evaluated to be TRUE and masking is performed all the time.

7.1.4 Masking Format

Masking format is a combination of change method and displayed characters when the masking condition is met. Masking format varies depending on the masking type. The following describes the masking format.

Full masking

With full masking, all characters are changed to values as determined by the database. Changed characters can be referenced in the pgx_confidential_values table. Also, replacement characters can be changed using the pgx_update_confidential_values system management function.

See

Refer to "7.3 Data Types for Masking" for information on the data types for which data masking can be performed.

Partial masking

With partial masking, data is changed according to the content in the function_parameters parameter. The method of specifying function_parameters varies depending on the data type.

Category	Method of specifying function_parameters
Numeric type	'*replacementCharacter*, *startPosition*, *endPosition*' - *replacementCharacter*: Specify the number to display. Specify a value from 0 to 9. - *startPosition*: Specify the start position of masking. Specify a positive integer. - *endPosition*: Specify the end position of masking. Specify a positive integer that is greater than *startPosition*. **Example** Specify as below to change the values from the 1st to 5th digits to 9. function_parameters := '9, 1, 5' In this example, if the original data is "123456789", it will be changed to "999996789".
Character type	*'inputFormat*, *outputFormat*, *replacementCharacter*, *startPosition*, *endPosition'* - *inputFormat*: Specify the current format of the data. Specify "V" for characters that will potentially be masked, and specify "F" for values such as spaces or hyphens that will not be masked. - *outputFormat*: Define the method to format the displayed data. Specify "V" for characters that will potentially be masked. Any character to be output can be specified for each character "F" in *inputFormat*. If you want to output a single quotation mark, specify two of them consecutively. - *replacementCharacter*: Specify any single character. If you want to output a single quotation mark, specify two of them consecutively. - *startPosition*: Specify the position of "V" as the start position of masking. For example, to specify the position of the 4th "V" from the left, specify 4. Specify a positive integer.

Category	Method of specifying function_parameters
	- *endPosition*: Specify the position of "V" as an end position of masking. When working out the end position, do not include positions of "F". For example, to specify the position of the 11th "V" from the left, specify 11. Specify a positive integer that is greater than *startPosition*. **Example** Specify as below to mask a telephone number other than the first three digits using *. function_parameters := 'VVVFVVVVFVVVV, VVV-VVVV-VVVV, *, 4, 11' In this example, if the original data is "012-3156-7890", it will be changed to "012-****-****".
Date/timestamp type	'MDYHMS' - M: Masks month. To mask month, enter the month from 1 to 12 after a lowercase letter m. Specify an uppercase letter M to not mask month. - D: Masks date. To mask date, enter the date from 1 to 31 after a lowercase letter d. If a value bigger than the last day of the month is entered, the last day of the month will be displayed. Specify an uppercase letter D to not mask date. - Y: Masks year. To mask year, enter the year from 1 to 9999 after a lowercase letter y. Specify an uppercase letter Y to not mask year. - H: Masks hour. To mask hour, enter the hour from 0 to 23 after a lowercase letter h. Specify an uppercase letter H to not mask hour. - M: Masks minute. To mask minute, enter the minute from 0 to 59 after a lowercase letter m. Specify an uppercase letter M to not mask minute. - S: Masks second. To mask second, enter the second from 0 to 59 after a lowercase letter s. Specify an uppercase letter S to not mask second. **Example** Specify as below to mask hour, minute, and second and display 00:00:00. function_parameters := 'MDYh0m0s0' In this example, if the original data is "2022-02-10 10:10:10", it will be changed to "2022-02-10 00:00:00".

See

- Refer to "B.3.2 pgx_create_confidential_policy" for information on function_parameters.
- Refer to "7.3 Data Types for Masking" for information on the data types for which masking can be performed.

Regular expression masking

With regular expression masking, data is changed according to the content of the regexp_pattern, regexp_replacement and regexp_flags parameters. For regexp_pattern, specify the search pattern using a regular expression. For regexp_replacement, specify the replacement character to use when data matches the search pattern. For regexp_flags, specify the regular expression flags.

Example

Specify as below to change all three characters starting from b to X.

regexp_pattern := 'b..'

regexp_replacement:= 'X'

regexp_flags := 'g'

In this example, if the original data is "foobarbaz", it will be changed to "fooXX".

See

- Refer to "POSIX Regular Expressions" in the PostgreSQL Documentation and check pattern, replacement, and flags for information on the values that can be specified for regexp_pattern, regexp_replacement, and regexp_flags.
- Refer to "7.3 Data Types for Masking" for information on the data types for which masking can be performed.

Note

- When column data type is character(*n*) or char(*n*) and if the string length after change exceeds n, the extra characters will be truncated and only characters up to the nth character will be displayed.
- When column data type is character varying(*n*) or varchar(*n*) and if the string length after change exceeds the length before the change, the extra characters will be truncated and only characters up to the length before change will be displayed.

7.2 Usage Method

Preparation

The following preparation is required to use this feature.

1. Set the postgresql.conf file parameters.

   Prepend "pgx_datamasking" to the shared_preload_libraries parameter.

2. Restart the instance.

3. Execute CREATE EXTENSION for the database that will use this feature.

   The target database is described as "postgres" here.

   Use the psql command to connect to the "postgres" database.

   #### Example

   ```
   postgres=# CREATE EXTENSION pgx_datamasking;
   CREATE EXTENSION
   ```

   #### Note

   You must always prepend "pgx_datamasking" to the "shared_preload_libraries" parameter.

   #### Information

   - Specify "false" for pgx_datamasking.enable to not use this feature. Data will not be masked even if a masking policy is configured. This feature becomes available again once "true" is specified for pgx_datamasking.enable. This setting can be made

by specifying a SET statement or specifying a parameter in the postgresql.conf file.
Example

```
postgres=# SET pgx_datamasking.enable=false;
```

- Hereafter, also perform this preparatory task for the "template1" database, so that this feature can be used by default when creating a new database.

Usage

To perform masking, a masking policy needs to be configured. The masking policy can be created, changed, confirmed, enabled, disabled or deleted during operation.
The procedures to perform these tasks are explained below with examples.

1. Creating a masking policy
2. Changing a masking policy
3. Confirming a masking policy
4. Enabling and disabling a masking policy
5. Deleting a masking policy

Note

Only database superusers can configure masking policies.

7.2.1 Creating a Masking Policy

An example of the operation on the server is shown below.

1. Create a masking policy
   Execute the pgx_create_confidential_policy system management function to create a masking policy.
   The following values are configured in this example.
   - Masking target: Numeric type c1
   - Masking type: FULL
   - Masking condition: '1=1'

```
postgres=# select pgx_create_confidential_policy(table_name := 't1', policy_name := 'p1',
expression := '1=1', column_name := 'c1', function_type := 'FULL');
 pgx_create_confidential_policy
--------------------------------
 t
(1 row)
```

2. Confirm the displayed data
   Confirm that the masking target data (column c1) has been correctly changed.

```
postgres=# select * from t1;
 c1 |      c2
----+--------------
  0 | 012-3456-7890
  0 | 012-3456-7891
  0 | 012-3456-7892
(3 row)
```

See

- Refer to "B.3.2 pgx_create_confidential_policy" for information on the pgx_create_confidential_policy system management function.

Note

- Only one masking policy can be created per table.
- All users can view the masking policy created, so do not grant the login privilege of the database where this feature is set to the users who refer to the changed data. Masking policies are defined in the "pgx_confidential_columns", "pgx_confidential_policies" and "pgx_confidential_values" tables.

7.2.2 Changing a Masking Policy

1. An example of the operation on the server is shown below.
2. Change a masking policy
   Execute the pgx_alter_confidential_policy system management function to change a masking policy.
   The following values are changed in this example.
   - Content of change: Add a masking target
   - Masking target: Character type c2
   - Masking type: PARTIAL
   - Masking condition: 'VVVFVVVVFVVVV, VVV-VVVV-VVVV, *, 4, 11'

```
postgres=# select pgx_alter_confidential_policy(table_name := 't1', policy_name := 'p1',
action := 'ADD_COLUMN', column_name := 'c2', function_type := 'PARTIAL', function_parameters :=
'VVVFVVVVFVVVV, VVV-VVVV-VVVV, *, 4, 11');
 pgx_alter_confidential_policy
-------------------------------
 t
(1 row)
```

3. Confirm the displayed data
   Confirm that the masking target data has been correctly changed.

```
postgres=# select * from t1;
 c1 |      c2
----+--------------
  0 | 012-****-****
  0 | 012-****-****
  0 | 012-****-****
(3 row)
```

See

- Refer to "B.3.1 pgx_alter_confidential_policy" for information on the pgx_alter_confidential_policy system management function.

7.2.3 Confirming a Masking Policy

An example of the operation on the server is shown below.

1. Confirm information about a masking target where a masking policy is set
   Refer to the pgx_confidential_columns table to confirm the masking target where the masking policy is set.

```
postgres=# select * from pgx_confidential_columns;
 schema_name | table_name | policy_name | column_name | function_type |
function_parameters           | regexp_pattern | regexp_replacement | regexp_flags |
column_description
-------------+------------+-------------+-------------+---------------
+---------------------------------------+----------------+--------------------+-------------
+--------------------
 public      | t1         | p1          | c1          | FULL
|                                       |                |                    |             |
```

```
 public      | t1         | p1          | c2          | PARTIAL       | VVVFVVVVFVVVV, VVV-VVVV-
VVVV, *, 4, 11 |                |                    |             |
(2 row)
```

2. Confirm information about the masking policy content
   Refer to pgx_confidential_policies to confirm the masking policy content.

```
postgres=# select * from pgx_confidential_policies;
 schema_name | table_name | policy_name | expression | enable | policy_description
-------------+------------+-------------+------------+--------+--------------------
 public      | t1         | p1          | 1=1        | t      |
(1 row)
```

See

- Refer to "E.1 pgx_confidential_columns" for information on the pgx_confidential_columns table.
- Refer to "E.2 pgx_confidential_policies" for information on the pgx_confidential_policies table.

7.2.4 Enabling and Disabling a Masking Policy

An example of the operation on the server is shown below.

1. Disable a masking policy
   Execute the pgx_enable_confidential_policy system management function to disable a masking policy.

```
postgres=# select pgx_enable_confidential_policy(table_name := 't1', policy_name := 'p1',
enable := 'f');
 pgx_enable_confidential_policy
--------------------------------
 t
(1 row)
```

2. Confirm the displayed data
   Confirm that the original data is displayed by disabling the masking policy.

```
postgres=# select * from t1;
 c1 |      c2
----+---------------
  1 | 012-3456-7890
  2 | 012-3456-7891
  3 | 012-3456-7892
(3 row)
```

3. Enable a masking policy
   Execute the pgx_enable_confidential_policy system management function to enable a masking policy.

```
postgres=# select pgx_enable_confidential_policy(table_name := 't1', policy_name := 'p1',
enable := 't');
 pgx_enable_confidential_policy
--------------------------------
 t
(1 row)
```

4. Confirm the displayed data
   Confirm that the masking target data has been correctly changed.

```
postgres=# select * from t1;
 c1 |      c2
----+---------------
  0 | 012-****-****
  0 | 012-****-****
```

```
  0 | 012-****-****
(3 row)
```

See

- Refer to "B.3.4 pgx_enable_confidential_policy" for information on the pgx_enable_confidential_policy system management function.

7.2.5 Deleting a Masking Policy

An example of the operation on the server is shown below.

1. Delete a masking policy
   Execute the pgx_drop_confidential_policy system management function to delete a masking policy.

```
postgres=# select pgx_drop_confidential_policy(table_name := 't1', policy_name := 'p1');
 pgx_drop_confidential_policy
------------------------------
 t
(1 row)
```

2. Confirm the displayed data
   Confirm that the original data is displayed by deleting the masking policy.

```
postgres=# select * from t1;
 c1 |      c2
----+--------------
  1 | 012-3456-7890
  2 | 012-3456-7891
  3 | 012-3456-7892
(3 row)
```

See

- Refer to "B.3.3 pgx_drop_confidential_policy" for information on the gx_drop_confidential_policy function.

7.3 Data Types for Masking

The data types for which data masking can be performed are shown below.

Category	Data type	Masking type		
		Full masking	Partial masking	Regular expression masking
Numeric type	smallint	Y	Y	N
	integer	Y	Y	N
	bigint	Y	Y	N
	decimal	Y	Y	N
	numeric	Y	Y	N
	float	Y	Y	N
	real	Y	Y	N
	double precision	Y	Y	N

Category	Data type	Masking type		
		Full masking	Partial masking	Regular expression masking
Character type	character varying(*n*)	Y	Y	Y
	varchar(*n*)	Y	Y	Y
	character(*n*)	Y	Y	Y
	char(*n*)	Y	Y	Y
Date/timestamp type	date	Y	Y	N
	timestamp	Y	Y	N

Note

Even if the data type can be masking, if the data is a special value (NaN, Infinity, -Infinity), it is not.

7.4 Security Notes

- The logical replication is available, which allows non-backed up clusters to subscribe to databases where data masking policies are enabled. Logical replication allows publisher and subscriber databases to have their own or the same data masking policies.

  In this scenario, the user must disable data masking on the publisher database whenever a subscription is created. This ensures that subscribers are able to obtain the original data (initial copy) instead of the masked version. Then, it is the user's responsibility to set masking policies to each subscribed database.

- Take strong caution in publishing data masking's confidential tables (pgx_confidential_policies, pgx_confidential_columns, etc.) unless the user is publishing all tables of the database and wants to apply the same data masking's policies on the subscribed database for all of them.

  Otherwise, as these confidential tables contain the masking policies for all tables of the database, confidential policies of unpublished tables may be unintentionally published. Additionally, it is not possible to apply different data masking policies on the subscriber database.

Chapter 8 Periodic Operations

This chapter describes the operations that must be performed periodically when running daily database jobs.

8.1 Configuring and Monitoring the Log

FUJITSU Enterprise Postgres enables you to output database errors and warnings to a log file.

This information is useful for identifying if errors have occurred and the causes of those errors.

By default, this information is output to the system log. It is recommended that you configure FUJITSU Enterprise Postgres to collect logs from its log files (for example, log_destination) before operating FUJITSU Enterprise Postgres.

Periodically monitor the log files to check if any errors have occurred.

See

- Refer to "Error Reporting and Logging" under "Server Administration" in the PostgreSQL Documentation for information on logs.
- Refer to "Configuring Parameters" in the Installation and Setup Guide for Server for information on log settings when operating with WebAdmin.

8.2 Monitoring Disk Usage and Securing Free Space

When a database is used for an extended period, free space on the disk is continuously consumed and in some cases the disk space runs out. When this happens, database jobs may stop and no longer run.

You should, therefore, periodically monitor the usage of disk space, and delete obsolete files located in the disk.

Monitor the disk usage of the disk where the following directories are located:

- Data storage destination directory
- Transaction log storage destination (if the transaction log is stored in a different directory from the data storage destination directory)
- Backup data storage destination directory
- Tablespace storage destination directory

8.2.1 Monitoring Disk Usage

To check the disk usage, use the following operating system commands:

- df command

You can even use SQL statements to check tables and indexes individually.

Refer to "Determining Disk Usage" under "Server Administration" in the PostgreSQL Documentation for information on this method.

Information

If you are using WebAdmin for operations, a warning is displayed when disk usage reaches 80%

8.2.2 Securing Free Disk Space

Secure free disk space by using the following operating system commands to delete unnecessary files, other than the database, from the same disk unit.

- rm command

You can also secure disk space by performing the following tasks periodically:

- To secure space on the data storage destination disk:

  Execute the REINDEX statement. Refer to "8.5 Reorganizing Indexes" for details.

- To secure space on the backup data storage destination disk:

  Execute backup using WebAdmin or the pgx_dmpall command.

8.3 Automatically Closing Connections

If an application stops responding and abnormally terminates for any reason, the connection from the application may remain active on the database server. If this situation continues for an extended period, other applications attempting to connect to the database server may encounter an error, or an error indicating that the tables are unavailable may occur.

It is, therefore, recommended that idle connections be closed automatically at regular intervals.

Set the following parameters in the postgresql.conf file to indicate the time permitted to elapse before a connection is closed.

Parameter name	Setting	Description
tcp_keepalives_idle	Time until keepalive is sent (seconds) If 0, the default value of the system is used.	Sends keepalive to an idle connection at the specified interval in seconds It is recommended to specify 30 seconds.
tcp_keepalives_interval	keepalive send interval (seconds) If 0, the default value of the system is used.	Sends keepalive at the specified interval It is recommended to specify 10 seconds.
tcp_user_timeout	Time to wait for a response from the server (milliseconds) If 0, the default value of the system is used. If not set, the behavior is the same as if 0 were specified.	After establishing the connection, when sending from the client to the server, if the TCP resend process operates, specify the time until it is considered to be disconnected. If a value other than 0 is specified in this parameter, the time until automatic disconnection is determined by the waiting time specified in this parameter. The actual wait time is until the timing of the first keepalive retransmission after the time specified by this parameter has elapsed.

Note

If a value other than 0 is specified for the tcp_user_timeout parameter, the waiting time set by the tcp_keepalives_idle parameter and tcp_keepalives_interval parameter will be invalid and the waiting time specified by the tcp_user_timeout parameter will be used.

See

Refer to "Connection Settings" under "Server Administration" in the PostgreSQL Documentation for information on the parameters.

8.4 Monitoring the Connection State of an Application

FUJITSU Enterprise Postgres does not immediately delete the updated or deleted data. If the VACUUM determines there are no transactions that reference the database, FUJITSU Enterprise Postgres collects obsolete data.

However, obsolete data is not collected if there are connections that have remained active for an extended period or connections occupying resources. In this case the database may expand, causing performance degradation.

See

Refer to "Routine Vacuuming" under "Server Administration" in the PostgreSQL Documentation for information on the VACUUM command.

In such cases, you can minimize performance degradation of the database by monitoring problematic connections.

The following method is supported for monitoring connections that have been in the waiting status for an extended period:

- 8.4.1 Using the View (pg_stat_activity)

8.4.1 Using the View (pg_stat_activity)

Use the view (pg_stat_activity) to identify and monitor connections where the client has been in the waiting status for an extended period.

Example

The example below shows connections where the client has been in the waiting status for at least 60 minutes.

However, when considering continued compatibility of applications, do not reference system catalogs directly in the following SQL statements.

```
postgres=# select * from pg_stat_activity where backend_type = 'client backend' and state='idle in
transaction' and current_timestamp > cast(query_start + interval '60 minutes' as timestamp);
-[ RECORD 1 ]----+------------------------------
datid            | 13003
datname          | db01
pid              | 4638
leader_pid       |
usesysid         | 10
usename          | fsep
application_name | apl01
client_addr      | 192.33.44.15
client_hostname  |
client_port      | 27500
backend_start    | 2022-02-24 09:09:21.730641+09
xact_start       | 2022-02-24 09:09:23.858727+09
query_start      | 2022-02-24 09:09:23.858727+09
state_change     | 2022-02-24 09:09:23.858834+09
wait_event_type  | Client
wait_event       | ClientRead
state            | idle in transaction
backend_xid      |
backend_xmin     |
query_id         |
query            | begin;
backend_type     | client backend
```

See

- Refer to "Notes on Application Compatibility" in the Application Development Guide for information on maintaining application compatibility.
- Refer to "The Statistics Collector" under "Server Administration" in the PostgreSQL Documentation for information on pg_stat_activity.

8.5 Reorganizing Indexes

Normally, a database defines indexes in tables, but if data is frequently updated, indexes can no longer use free space in the disk efficiently. This situation can also cause a gradual decline in database access performance.

To rearrange used space on the disk and prevent the database access performance from declining, it is recommended that you periodically execute the REINDEX command to reorganize indexes.

Check the disk usage of the data storage destination using the method described in "8.2 Monitoring Disk Usage and Securing Free Space".

Note

Because the REINDEX command retrieves the exclusive lock for an index being processed and locks writing of tables that are the source of the index, other processes that access these may stop while waiting to be locked.

Therefore, it is necessary to consider measures such as executing the command after the task is completed.

See

Refer to "Routine Reindexing" under "Server Administration" in the PostgreSQL Documentation for information on reorganizing indexes by periodically executing the REINDEX command.

Point

Typically, reorganize indexes once a month at a suitable time such as when conducting database maintenance. Use SQL statements to check index usage. If this usage is increasing on a daily basis, adjust the frequency of recreating the index as compared to the free disk space.

The following example shows the SQL statements and the output.

However, when considering continued compatibility of applications, do not reference system catalogs and functions directly in the following SQL statements. Refer to "Notes on Application Compatibility" in the Application Development Guide for details.

[SQL statements]

```
SELECT
  nspname AS schema_name,
  relname AS index_name,
  round(100 * pg_relation_size(indexrelid) / pg_relation_size(indrelid)) / 100 AS index_ratio,
  pg_size_pretty(pg_relation_size(indexrelid)) AS index_size,
  pg_size_pretty(pg_relation_size(indrelid)) AS table_size
FROM pg_index I
  LEFT JOIN pg_class C ON (C.oid = I.indexrelid)
  LEFT JOIN pg_namespace N ON (N.oid = C.relnamespace)
WHERE
  C.relkind = 'i' AND
  pg_relation_size(indrelid) > 0
ORDER BY pg_relation_size(indexrelid) DESC, index_ratio DESC;
```

[Output]

```
 schema_name |            index_name            | index_ratio | index_size | table_size
-------------+----------------------------------+-------------+------------+------------
 public      | pgbench_accounts_pkey            |        0.16 | 2208 KB    | 13 MB
 pg_catalog  | pg_depend_depender_index         |         0.6 | 224 KB     | 368 KB
 pg_catalog  | pg_depend_reference_index        |        0.58 | 216 KB     | 368 KB
...
```

See

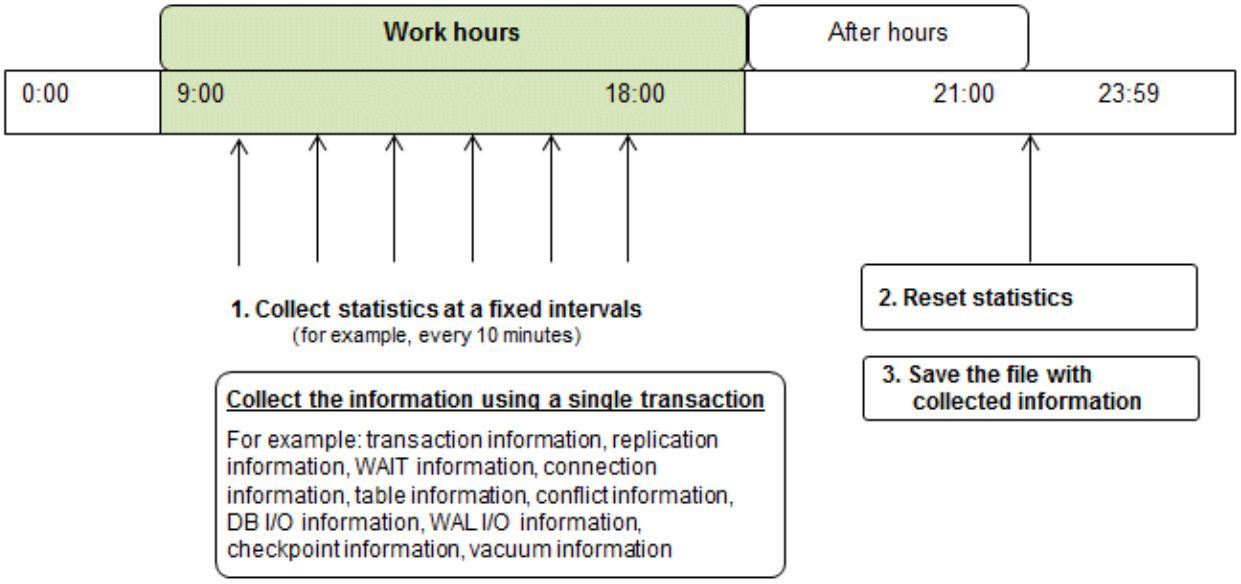
Refer to "Notes on Application Compatibility" in the Application Development Guide for information on maintaining application compatibility.

8.6 Monitoring Database Activity

FUJITSU Enterprise Postgres enables you to collect information related to database activity. By monitoring this information, you can check changes in the database status.

This information includes wait information for resources such as internal locks, and is useful for detecting performance bottlenecks. Furthermore, you should collect this information in case you need to request Fujitsu technical support for an investigation.

Figure 8.1 Overview of information collection



1. Collect statistics at fixed intervals during work hours.

   Accumulate the collected information into a file.

   Wherever possible, collect data from the various statistics views using a single transaction, because it enables you to take a snapshot of system performance at a given moment.

   Refer to "8.6.1 Information that can be Collected" for information on the system views that can be collected.

2. Reset statistics after work hours, that is, after jobs have finished.

   Refer to "8.6.3 Information Reset" for information on how to reset statistics.

3. Save the file with collected information.

   Keep the file with collected information for at least two days, in order to check daily changes in performance and to ensure that the information is not deleted until you have sent a query to Fujitsu technical support.

Where jobs run 24 hours a day, reset statistics and save the file with collected information when the workload is low, for example, at night.

Note

Statistics cumulatively add the daily database value, so if you do not reset them, the values will exceed the upper limit, and therefore will not provide accurate information.

The subsections below explain the following:

- Information that can be collected
- Collection configuration
- Information reset

8.6.1 Information that can be Collected

Information that can be collected is categorized into the following types:

- Information common to PostgreSQL
- Information added by FUJITSU Enterprise Postgres

Information common to PostgreSQL

Refer to "Monitoring Database Activity" under "Server Administration" in the PostgreSQL Documentation for information on information common to PostgreSQL.

Information added by FUJITSU Enterprise Postgres

You can collect the following information added by FUJITSU Enterprise Postgres.

Table 8.1 Information added by FUJITSU Enterprise Postgres

View name	Description
pgx_stat_lwlock	Displays statistic related to lightweight lock, with each type of content displayed on a separate line. This information helps to detect bottlenecks. Refer to "C.2 pgx_stat_lwlock" for details.
pgx_stat_latch	Displays statistics related latches, with each type of wait information within FUJITSU Enterprise Postgres displayed on a separate line. This information helps to detect bottlenecks. Refer to "C.3 pgx_stat_latch" for details.
pgx_stat_walwriter	Displays statistics related to WAL writing, in a single line. Refer to "C.4 pgx_stat_walwriter" for details.
pgx_stat_sql	Displays statistics related to SQL statement executions, with each type of SQL statement displayed on a separate line. Refer to "C.5 pgx_stat_sql" for details.
pgx_stat_gmc	Displays statistics related to Global Meta Cache hit ration and used memory size. Refer to “C.6 pgx_stat_gmc” for detail. Also refer to Chapter 13 Global Meta Cache" for information on the Global Meta Cache.

8.6.2 Collection Configuration

The procedure for configuring collection depends on the information content.

- Information common to PostgreSQL
- Information added by FUJITSU Enterprise Postgres

Information common to PostgreSQL

See

Refer to "The Statistics Collector" in "Monitoring Database Activity" under "Server Administration" in the PostgreSQL Documentation for information on information common to PostgreSQL.

Information added by FUJITSU Enterprise Postgres

Information added by FUJITSU Enterprise Postgres is collected by default.

To enable or disable information collection, change the configuration parameters in postgresql.conf. The following table lists the views for which you can enable or disable information collection, and the configuration parameters.

View name	Parameter
pgx_stat_lwlock pgx_stat_latch	track_waits (*1)
pgx_stat_sql	track_sql
pgx_stat_gmc	track_gmc

Remarks: You cannot change the collection status for pgx_stat_walwriter.

*1: When executing the SQL statement with EXPLAIN ANALYZE, processing time may increase because of this information collection. It is recommended to set this parameter to "off" when executing EXPLAIN ANALYZE to check the processing time.

Refer to "Appendix A Parameters" for information on the parameters.

8.6.3 Information Reset

This section describes how to reset information.

Information added by FUJITSU Enterprise Postgres

You can reset information added by FUJITSU Enterprise Postgres by using the pg_stat_reset_shared function in the same way as for information common to PostgreSQL.

Configure the following parameters in the pg_stat_reset_shared function:

Function	Type of return value	Description
pg_stat_reset_shared(text)	void	Reset some cluster-wide statistics counters to zero, depending on the argument (requires superuser privileges). Calling pg_stat_reset_shared('lwlock') will zero all counters shown in pgx_stat_lwlock. Similarly, in the following cases, all values of the pertinent statistics counter are reset: - If pg_stat_reset_shared('latch') is called: All values displayed in pgx_stat_latch - If pg_stat_reset_shared('walwriter') is called: All values displayed in pgx_stat_walwriter - If pg_stat_reset_shared('sql') is called: All values displayed in pgx_stat_sql - If pg_stat_reset_shared('gmc') is called:

Function	Type of return value	Description
		All values except size column in pgx_stat_gmc

See

Refer to "Statistics Functions" in "Monitoring Database Activity" under "Server Administration" in the PostgreSQL Documentation for information on other parameters of the pg_stat_reset_shared function.

Chapter 9 Streaming Replication Using WebAdmin

This chapter describes how to create a streaming replication cluster using WebAdmin.

Streaming replication allows the creation of one or more standby instances, which connect to the master instances and replicate the data using WAL records. The standby instance can be used for read-only operations.

WebAdmin can be used to create a streaming replication cluster. WebAdmin allows the creation of a cluster in the following configurations:

- Master-Standby Configuration: This configuration creates a master and standby instance together.
- Standby Only Configuration: This configuration creates a standby instance from an already existing instance.

Point

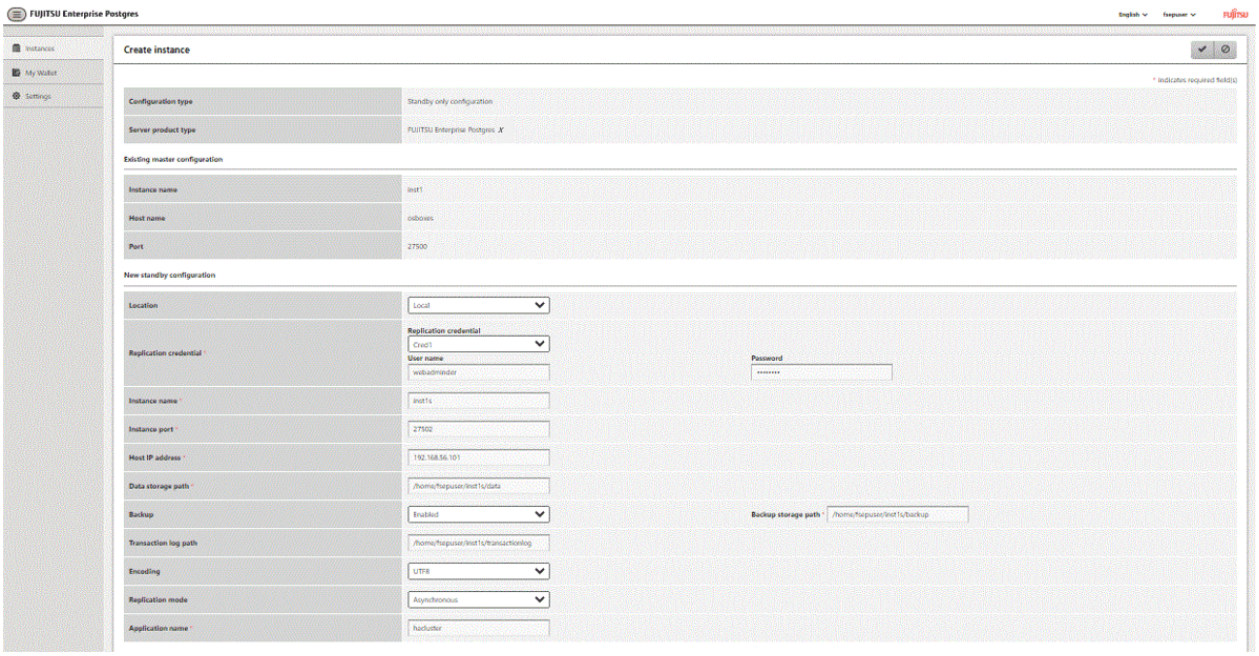
- A standby instance can be created from a standalone instance, a master instance, or even from another standby instance.
- If a streaming replication cluster is created using WebAdmin, the network with the host name (or IP address) specified in [Host name] will be used across sessions of WebAdmin, and also used as the log transfer network.
- To use a network other than the job network as the log transfer network, specify the host name other than the job network one in [Host name].

9.1 Creating a Standby Instance

Follow the procedure below to create a standby instance.

1. In the [Instances] tab, select the instance from which a standby instance is to be created.
2. Click .
3. Enter the information for the standby instance to be created. In the example below, a standby instance is created from instance "inst1".

   The instance name, host address and port of the selected instance are already displayed for easy reference.



   Enter the following items:

   - [Location]: Whether to create the instance in the server that the current user is logged in to, or in a remote server. The default is "Local", which will create the instance in the server machine where WebAdmin is currently running.

- [Replication credential]: The user name and password required for the standby instance to connect to the master instance. The user name and password can be entered or selected from the Wallet. Refer to "Appendix H WebAdmin Wallet" for information on creating wallet entries.
- [Instance name]: Name of the standby database instance to create.

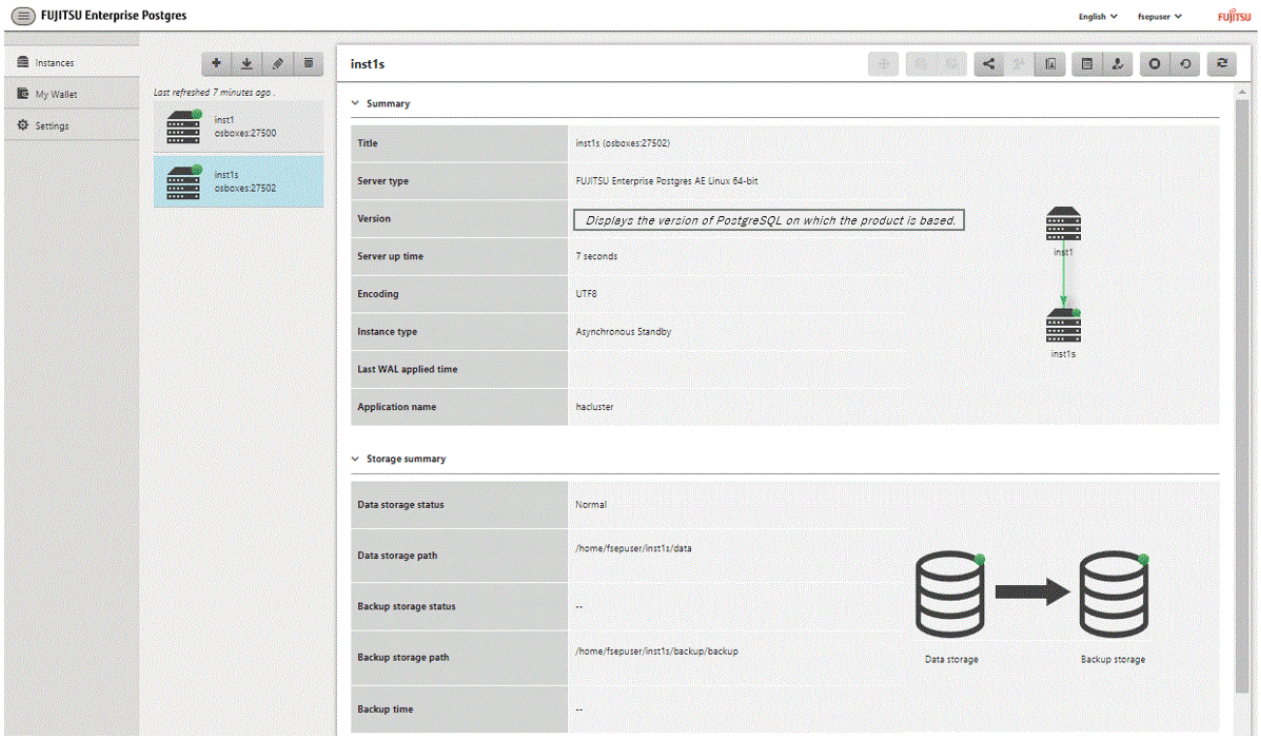
  The name must meet the conditions below:

  - Maximum of 16 characters
  - The first character must be an ASCII alphabetic character
  - The other characters must be ASCII alphanumeric characters
- [Instance port]: Port number of the standby database instance.
- [Host IP address]: The IP address of the server machine where the standby instance is to be created. This information is needed to configure the standby instance to be connected to the master.
- [Data storage path]: Directory where the database data will be stored
- [Backup storage path]: Directory where the database backup will be stored
- [Transaction log path]: Directory where the transaction log will be stored
- [Encoding]: Database encoding system
- [Replication mode]: Replication mode of the standby instance to be created ("Asynchronous" or "Synchronous")
- [Application name]: The reference name of the standby instance used to identify it to the master instance.

  The name must meet the conditions below:

  - Maximum of 16 characters
  - The first character must be an ASCII alphabetic character
  - The other characters must be ASCII alphanumeric characters

4. Click ✔ to create the standby instance.
5. Once the standby instance is created successfully, select standby instance in the [Instances] tab. The following page will be displayed:



Note

- Backups are not possible for standby instances in WebAdmin. As a result, and are disabled and no value is shown for [Backup storage status] and [Backup time].
- If using WebAdmin to manage Mirroring Controller, the message below may be output to the server log or system log in the standby instance. No action is required, as the instance is running normally.

```
ERROR:  pgx_rcvall failed (16491)
ERROR:  pgx_rcvall: backup of the database has not yet been performed, or an incorrect backup
storage directory was specified
```

- Replication credential (user name and password) should not contain hazardous characters. Refer to "Appendix I WebAdmin Disallow User Inputs Containing Hazardous Characters".

9.2 Promoting a Standby Instance

Streaming replication between a master and standby instance can be discontinued using WebAdmin.

Follow the procedure below to promote a standby instance to a standalone instance, thereby discontinuing the streaming replication.

1. In the [Instances] tab, select the standby instance that needs to be promoted.
2. Click .
3. Click [Yes] from the confirmation dialog box.

The standby instance will be promoted and will become a standalone instance, which is not part of a streaming replication cluster.

Once the standby instance is promoted to become a standalone instance, the backup storage status will be "Error". This is because no backups are available when the instance is newly promoted to a standalone instance. The status will be reset if a new backup is performed by clicking [Solution] or .

9.3 Converting an Asynchronous Replication to Synchronous

Streaming replication between a master and standby instance can be configured to be in Asynchronous or Synchronous mode. This mode can be changed even after the standby instance was successfully created.

Follow the procedure below to convert an Asynchronous standby instance to Synchronous.

1. In the [Instances] tab, select the master instance of the relevant cluster.
2. Click .
3. In the [Streaming replication] section, edit the value for [Synchronous standby names].
   - Add the "Application name" of the standby instance you want to be in Synchronous mode.
4. Click .
5. Select the master instance and click .
6. Select the standby instance. [Instance type] will now show the updated status.

Note

- Converting an Asynchronous standby instance to Synchronous can cause the master instance to queue the incoming transactions until the standby instance is ready. For this reason, it is recommended that this operation be performed during a scheduled maintenance period.
- When adding a synchronous standby instance, FUJITSU Enterprise Postgres will only keep the first entry in [Synchronous standby names] in synchronous state.

- To learn more about the differences between synchronous and asynchronous standby modes and their behavior, refer to "Streaming Replication" in "High Availability, Load Balancing, and Replication" in the PostgreSQL Documentation.

9.4 Converting a Synchronous Replication to Asynchronous

Streaming replication between a master and standby instance can be configured to be in Asynchronous or Synchronous Mode. This mode can be changed even after the standby instance was successfully created.

Follow the procedure below to convert a Synchronous standby instance to Asynchronous.

1. In the [Instances] tab, select the master instance of the relevant cluster.
2. Click  .
3. In the [Streaming replication] section, edit the value for [Synchronous standby names].
   - Remove the "Application name" of the standby instance you want to be in Asynchronous mode.
4. Click  .
5. Select the master instance and click  .
6. Select the standby instance. [Instance type] will now show the updated status.

Note

To learn more about the differences between synchronous and asynchronous standby modes and their behavior, refer to "Streaming Replication" in "High Availability, Load Balancing, and Replication" in the PostgreSQL Documentation.

9.5 Joining a Replication Cluster

WebAdmin facilitates the joining of an old master of the cluster as a standby node.

1. In the [Instances] tab, select the remote instance (from where the new cluster node will stream WAL entries), and then click  .
2. Configure the node to accept streaming requests from the new node.
3. In the [Instances] tab, select the new standby instance (which needs to be connected to the cluster), and then click  .
4. Set [Replication host name] to the remote instance.
5. Enter [Replication credential].

   Specify the user name and password required for the standby instance to connect to the remote instance. The user name and password can be entered or selected from the Wallet. Refer to "Appendix H WebAdmin Wallet" for information on creating wallet entries. Replication credential (user name and password) should not contain hazardous characters. Refer to "Appendix I WebAdmin Disallow User Inputs Containing Hazardous Characters".
6. Enter [Host IP address].

   Specify the IP address of the node where the standby instance was created.
7. Click  to open the [Join replication cluster] dialog box.

   For FUJITSU Enterprise Postgres 13 and earlier instances, select [Restart later] or [Restart now], and then click [Yes] to set up the standby instance.
   For FUJITSU Enterprise Postgres 14, click to set up the standby instance.
8. Upon successful completion, the confirmation dialog box will be displayed.
9. Click [Close] to return to the instance details window.

The instance will become a standby instance, and will be part of the streaming replication cluster. The replication diagram will display the relationship between the standby instance and the remote instance. The user can change the replication relationship of the remote instance from asynchronous to synchronous (and vice versa) using the [Configuration] window.

Chapter 10 Installing and Operating the In-memory Feature

The in-memory feature enables fast aggregation using Vertical Clustered Index (VCI) and memory-resident feature.

VCI has a data structure suitable for aggregation, and features parallel scan and disk compression, which enable faster aggregation through reduced disk I/O.

The memory-resident feature reduces disk I/O that occurs during aggregation. It consists of the preload feature that reads VCI data to memory in advance, and the stable buffer feature that suppresses VCI data eviction from memory. The stable buffer feature secures the proportion specified by parameter in the shared memory for VCI.

This chapter describes how to install and operate the in-memory feature.

10.1 Installing Vertical Clustered Index (VCI)

This section describes the installation of VCI.

1. Evaluating whether to Install VCI
2. Estimating Resources
3. Setting up

10.1.1 Evaluating whether to Install VCI

VCI uses available resources within the server to increase scan performance.

It speeds up processing in many situations, and can be more effective in the following situations:

- Single table processing
- Processing that handles many rows in the table
- Processing that handles some columns in the table
- Processing that performs very heavy aggregation such as simultaneous sum and average aggregation

VCI will not be used in the following cases, so it is necessary to determine its effectiveness in advance:

- The data type of the target table or column contains VCI restrictions.
- The SQL statement does not meet the VCI operating conditions
- VCI is determined to be slower based on cost estimation

Note

If performing operations that use VCI, the full_page_writes parameter setting in postgresql.conf must be enabled (on). For this reason, if this parameter is disabled (off), operations that use VCI return an error. In addition, to perform operations for tables that do not create a VCI when the full_page_writes parameter setting is temporarily disabled (off), do not create a VCI or perform operations to tables that created a VCI during that time.

See

- Refer to "10.1.4 Data that can Use VCI" for information on VCI restrictions.
- Refer to "Scan Using a Vertical Clustered Index (VCI)" - "Operating Conditions" in the Application Development Guide for information on VCI operating conditions.

10.1.2 Estimating Resources

Estimate resources before setting up VCI.

Select the aggregation that you want to speed up and identify the required column data. The additional resources below are required according to the number of columns.

- Memory

  Secure additional capacity required for the disk space for the column for which VCI is to be created.

- Disk

  Secure additional disks based on the disk space required for the column for which VCI is to be created, as VCI stores column data as well as existing table data on the disk. It is recommended to provide a separate disk in addition to the existing one, and specify it as the tablespace to avoid impact on any other jobs caused by I/O.

Information

The operations on VCI can continue even if the memory configured for VCI is insufficient by using VCI data on the disk.

See

Refer to "Estimating Memory Requirements" and "Estimating Database Disk Space Requirements" in the Installation and Setup Guide for Server for information on how to estimate required memory and disk space.

10.1.3 Setting up

This section describes how to set up VCI.

Setup flow

1. Setting Parameters
2. Installing the Extensions
3. Creating VCI
4. Confirming that VCI has been Created

10.1.3.1 Setting Parameters

Edit postgresql.conf to set the required parameters for VCI. After that, start or restart the instance.

The following table lists the parameters that need or are recommended to be configured in advance:

Parameter name	Setting value	Description	Required
shared_preload_libraries	Literal 'vci, pg_prewarm'	VCI and shared library to be preloaded at server start.	Y
session_preload_libraries	Literal 'vci, pg_prewarm'	VCI and shared library to be preloaded at connection start.	Y
reserve_buffer_ratio	Percentage of shared memory to be used for stable buffer table	Proportion of shared memory to be used for a stable buffer table.	N
vci.control_max_workers	Number of background workers that manage VCI	Number of background workers that manage VCI. Add this value to max_worker_processes.	N
vci.max_parallel_degree	Maximum number of background workers used for parallel scan	Maximum number of background workers used for parallel scan. Add this value to max_worker_processes.	N

Example

```
shared_preload_libraries = 'vci, pg_prewarm'
session_preload_libraries = 'vci, pg_prewarm'
reserve_buffer_ratio = 20
vci.control_max_workers = 8
vci.max_parallel_degree = 4
max_worker_processes = 18 # Example: If the initial value was 6, 6 + 8 + 4 = 18
```

Note

An error occurs if you use VCI to start instances when procfs is not mounted. Ensure that procfs is mounted before starting instances.

See

- Refer to "Appendix A Parameters" for information on all parameters for VCI. Refer also to default value for each parameter and details such as specification range in the same chapter. Refer to "Server Configuration" under "Server Administration" in the PostgreSQL documentation for information on shared_preload_libraries, session_preload_libraries, and max_worker_processes.

10.1.3.2 Installing the Extensions

Execute CREATE EXTENSION to install the VCI and pg_prewarm extensions. Both extensions need to be installed for each database.

- Installing VCI

```
db01=# CREATE EXTENSION vci;
```

- Installing pg_prewarm

```
db01=# CREATE EXTENSION pg_prewarm;
```

Note

- Only superusers can install VCI extensions.
- VCI extensions can only be installed in public schema.
- Some operations cannot be performed for VCI extensions. Refer to "10.2.1 Commands that cannot be Used for VCI" for details.

10.1.3.3 Creating a VCI

Execute the CREATE INDEX statement with the "USING vci" clause to create a VCI for the desired columns and the "WITH (stable_buffer=true)" clause to enable the stable buffer feature.

To use a separate disk for the VCI, specify the TABLESPACE clause.

```
db01=# CREATE INDEX idx_vci ON table01 USING vci (col01, col02) WITH (stable_buffer=true);
```

Note

- Some table types cannot be specified on the ON clause of CREATE INDEX. Refer to "10.1.4.1 Relation Types" for details.
- Some data types cannot be specified on the column specification of CREATE INDEX. Refer to "10.1.4.2 Data Types" for details.
- Some operations cannot be performed for VCI. Refer to "10.2.1 Commands that cannot be Used for VCI" for details.

- The same column cannot be specified more than once on the column specification of CREATE INDEX.
- VCI cannot be created for table columns that belong to the template database.
- CREATE INDEX creates multiple views named vci_*10digitRelOid_5digitRelAttr_1charRelType* alongside VCI itself. These are called VCI internal relations. Do not update or delete them as they are used for VCI aggregation.
- All data for the specified column will be replaced in columnar format when VCI is created, so executing CREATE INDEX on an existing table with data inserted takes more time compared with a general index (B-tree). Jobs can continue while CREATE INDEX is running.
- When CREATE INDEX USING VCI is invoked on a partitioned table, the default behavior is to recurse to all partitions to ensure they all have matching indexes. Each partition is first checked to determine whether an equivalent index already exists, and if so, that index will become attached as a partition index to the index being created, which will become its parent index. If no matching index exists, a new index will be created and automatically attached; the name of the new index in each partition will be determined as if no index name had been specified in the command. If the ONLY option is specified, no recursion is done, and the index is marked invalid. (ALTER INDEX ... ATTACH PARTITION marks the index valid, once all partitions acquire matching indexes.) Note, however, that any partition that is created in the future using CREATE TABLE ... PARTITION OF will automatically have a matching index, regardless of whether ONLY is specified.
- Parallel index build is not supported on VCI indexes.

10.1.3.4 Confirming that the VCI has been Created

Execute the SELECT statement to reference the pg_indexes catalog, and confirm that the VCI was created for the target columns.

Example

```
db01=# SELECT indexdef FROM pg_indexes WHERE indexdef LIKE '%vci%';
                          indexdef
-----------------------------------------------------
CREATE INDEX idx_vci ON table01 USING vci (col01, col02)
(1 row)
```

10.1.4 Data that can Use VCI

This section describes on which relation types and for which data types VCIs can be created.

10.1.4.1 Relation Types

VCIs cannot be created on some relation types.

The ON clause of CREATE INDEX described in "10.1.3.3 Creating a VCI" cannot specify relations on which VCIs cannot be created.

- Relations on which VCIs can be created
  - Normal tables
  - UNLOGGED TABLEs
- Relations on which VCIs cannot be created
  - Materialized views
  - Temporary tables
  - Views
  - Temporary views
  - Foreign tables

10.1.4.2 Data Types

VCIs cannot be created for some data types.

The column specification of CREATE INDEX described in "10.1.3.3 Creating a VCI" cannot specify a column with data type on which VCIs cannot be created.

Category	Data type	Supported by VCI?
Numeric	smallint	Y
	integer	Y
	bigint	Y
	decimal	Y
	numeric	Y
	real	Y
	double precision	Y
	serial	Y
	bigserial	Y
Monetary	money	Y
Character	varchar(*n*)	Y
	char(*n*)	Y
	nchar	Y
	nvarchar(*n*)	Y
	text	Y
Binary	bytea	Y
Date/time	timestamp	Y
	timestamp with time zone	Y
	date	Y
	time	Y
	time with time zone	Y
	interval	Y
Boolean	boolean	Y
Geometric	point	N
	line	N
	lseg	N
	box	N
	path	N
	polygon	N
	circle	N
Network address	cidr	N
	inet	N
	macaddr	N
	macaddr8	N

Category	Data type	Supported by VCI?
Bit string	bit(*n*)	Y
	bit varying(*n*)	Y
Text search	tsvector	N
	tsquery	N
UUID	uuid	Y
XML	xml	N
JSON	json	N
	jsonb	N
Range	int4range	N
	int8range	N
	numrange	N
	tsrange	N
	tstzrange	N
	daterange	N
Object identifier	oid	N
	regproc	N
	regprocedure	N
	regoper	N
	regoperator	N
	regclass	N
	regtype	N
	regconfig	N
	regdictionary	N
pg_lsn type	pg_lsn	N
Array type	-	N
User-defined type (Basic type, enumerated type, composite type, and range type)	-	N

10.2 Operating VCI

This section describes how to operate VCI.

10.2.1 Commands that cannot be Used for VCI

Some operations cannot be performed for VCI extensions and VCI itself.

This section describes SQL commands that cannot be executed for the VCI extensions and VCI itself, and client application commands.

SQL commands

- Operations that cannot be performed for the VCI extension

Command	Subcommand	Description
ALTER EXTENSION	UPDATE	The VCI extension cannot be specified. This operation is not required for VCI.
	SET SCHEMA	
	ADD	
	DROP	
CREATE EXTENSION	SCHEMA	The subcommands on the left cannot be performed if the VCI extension is specified. This operation is not required for VCI.

- Operations that cannot be performed on relations containing a VCI

Command	Subcommand	Description
ALTER INDEX	SET	The subcommands on the left cannot be performed if a VCI is specified. If the operation is required, delete the VCI using DROP INDEX, and re-create it using CREATE INDEX after completing the operation.
	SET TABLESPACE	
	ALL IN TABLESPACE	
ALTER OPERATOR CLASS	RENAME TO	The subcommands on the left cannot be performed if a VCI is specified. This operation is not supported in VCI.
	OWNER TO	
	SET SCHEMA	
ALTER OPERATOR FAMILY	ADD	
	DROP	
	RENAME TO	
	OWNER TO	
	SET SCHEMA	
ALTER TABLE	ALL IN TABLESPACE *name* [OWNED BY *roleName*] SET TABLESPACE *newTablespace*	A tablespace that contains a VCI cannot be specified. If the operation is required, delete the VCI using DROP INDEX, and re-create it using CREATE INDEX after completing the operation.
	DROP [COLUMN] [IF EXISTS] *colName* [RESTRICT | CASCADE]	A column that contains a VCI cannot be specified. If the operation is required, delete the VCI using DROP INDEX, and re-create it using CREATE INDEX after completing the operation.
	ALTER [COLUMN] *colName* [SET DATA] TYPE *dataType* [COLLATE *collation*] [USING *expr*]	
	CLUSTER ON *indexName*	A VCI cannot be specified. This operation is not supported in VCI.
	REPLICA IDENTITY {DEFAULT | USING INDEX *indexName* | FULL | NOTHING}	
CLUSTER	-	A table that contains a VCI and VCI cannot be specified. If the operation is required, delete the VCI using DROP INDEX, and re-create it using CREATE INDEX after completing the operation.
CREATE INDEX	UNIQUE	The subcommands on the left cannot be performed if a VCI is specified. This operation is not supported in VCI.
	CONCURRENTLY	

Command	Subcommand	Description
	[ASC | DESC]	
	[NULLS { FIRST | LAST }]	
	WITH	
	WHERE	
	INCLUDE	
CREATE OPERATOR CLASS	-	A VCI cannot be specified. This operation is not supported in VCI.
CREATE OPERATOR FAMILY	-	
CREATE TABLE	EXCLUDE	
DROP INDEX	CONCURRENTLY	The subcommands on the left cannot be performed if a VCI is specified. This operation is not supported in VCI.
REINDEX	-	A VCI cannot be specified. This command is not required as VCI uses daemon's automatic maintenance to prevent disk space from increasing.

Client application command

- Operations that cannot be performed on relations containing a VCI

Command	Description
clusterdb	Clustering cannot be performed for tables that contain a VCI.
reindexdb	VCIs cannot be specified on the --index option.

10.2.2 Data Preload Feature

The first aggregation using VCI immediately after an instance is started may take time, because the VCI data has not been loaded to buffer.

Therefore, use the preload feature to load the VCI data to buffer in advance when performing VCI aggregation after an instance is started.

When using the preload feature, execute the function pgx_prewarm_vci to each VCI created with CREATE INDEX.

```
db01=# SELECT pgx_prewarm_vci('idx_vci');
```

See

Refer to "B.4 VCI Data Load Control Function" for information on pgx_prewarm_vci.

Chapter 11 Parallel Query

FUJITSU Enterprise Postgres enhances parallel queries, by taking into consideration the aspects below:

- CPU load calculation
- Increase of workers during runtime
- Statistics view displays the action state

11.1 CPU Load Calculation

There may be a case when the user tries to execute a parallel query but there is not enough CPU available.

Adding dynamic workers at this stage will provide no benefits - instead, it may add overhead due to context switching.

FUJITSU Enterprise Postgres takes into consideration the current CPU load when deciding on the number of workers for parallel query.

11.2 Increase of Workers during Runtime

This FUJITSU Enterprise Postgres enhancement allows systems to allocate additional workers during query execution (if there are workers available at the time). This improves query performance, which could otherwise starve of CPU if there were fewer or no workers when the query started.

Note

The ability to increase workers during runtime is available only with parallel query.

11.3 Statistics View Displays the Action State

You can check the action state by using the existing statistics collector. Monitoring the statistics enables you to check the action state of parallel processing through, for example, changes in the system load.

The following table describes the column added to the statistics views:

pg_stat_all_tables

Column	Data type	Description
parallel_query	bigint	Number of parallel query initialized in the table.

The parallel query column has also been added to the following views:

- pg_stat_sys_tables
- pg_stat_user_tables
- pg_stat_xact_all_tables
- pg_stat_xact_sys_tables
- pg_stat_xact_user_tables

See

Refer to "The Statistics Collector" in "Server Administration" in the PostgreSQL Documentation for information on the statistics collector and views.

Values will be set for the pgx_stat_sql view in FUJITSU Enterprise Postgres if parallel query is run.

See

Refer to "C.5 pgx_stat_sql" for information on pgx_stat_sql view.

Chapter 12 High-Speed Data Load

High-speed data load uses the pgx_loader command to load data from files at high speed into FUJITSU Enterprise Postgres.

Note

- This feature is not available in single-user mode. This is because in single-user mode instances run in a single process, and it cannot start parallel workers.

12.1 Installing High-Speed Data Load

This section describes how to install high-speed data load.

Installation flow

1. Deciding whether to Install
2. Estimating Resources
3. Setup

12.1.1 Deciding whether to Install

The feature achieves high speed data load by executing the COPY FROM command in parallel. If the database system is unable to use sufficient resources due to the feature using more resources than the COPY FROM command of PostgreSQL, load performance may be inferior to that of the COPY FROM command of PostgreSQL. Therefore, determine if the feature will be effective by considering the factors below before deciding to install.

Database server memory

If the value of shared_buffers in postgresql.conf is small, fewer data pages are cached to the shared memory of the database server. This will result in multiple parallel workers more often having to wait for write exclusive locks to the same data page. Moreover, the smaller the number of data pages, the more often the table expands. During table expansion, access to the table is exclusive (standby event name: extend), so write time increases. To cater for that, increase the value of shared_buffers.

See

The standby event name is stored in the wait_event column of the pg_stat_activity view. Refer to "wait_event Description" in "The Statistics Collector" in the PostgreSQL Documentation for details.

Frequency of checkpoints

If checkpoints are issued at short intervals, write performance is reduced. If the messages below are output to the server log during data writes, increase the values of max_wal_size and checkpoint_timeout in postgresql.conf to reduce the frequency of checkpoints.

Example

```
LOG:  checkpoints are occurring too frequently (19 seconds apart)
HINT:  Consider increasing the configuration parameter "max_wal_size".
```

12.1.2 Estimating Resources

Estimate the memory requirements for high-speed data load.

Up to 128 parallel workers to perform data load can be specified for this feature. The additional resources below are required depending on the number of parallel workers.

- Dynamic shared memory created during data load

  The feature creates shared memory and shared memory message queues during data load. These are used to send external data from the back end to the parallel workers, and for error notifications.

Note

If the value of shared_buffers in postgresql.conf is small, the system will often have to wait for write exclusive locks to the same data page (as described in "Database server memory" in "12.1.1 Deciding whether to Install"). Since input data cannot be loaded from the shared memory message queues during such waits, they will often be full. In these cases, it will not be possible to write to the shared memory message queues, resulting in degraded data load performance.

See

Refer to "High-Speed Data Load Memory Requirements" in the Installation and Setup Guide for Server for information on the formula for estimating memory requirements.

12.1.3 Setup

This section describes how to set up high-speed data load.

Setup flow

1. Setting Parameters
2. Installing the Extension

12.1.3.1 Setting Parameters

Set the parameters required for high-speed data load in postgresql.conf. After that, start or restart the instance.

The table below lists the postgresql.conf parameters that must be changed, and the values that must be added to their current values. After editing postgresql.conf, start or restart the instance.

Parameter	Setting	Required
max_prepared_transactions	Add the number of transactions that can be prepared by parallel workers during data load to the parameter's current value. The resulting value must be equal to or greater than the maximum number of parallel workers used with this feature.	Mandatory
max_worker_processes	Number of parallel workers to perform data load.	Mandatory
max_parallel_workers	Add the maximum number of parallel workers to be used in a parallel query by this feature to the parameter's current value. The resulting value must be equal to or greater than the number of parallel workers used with this feature.	Mandatory

Example

The example below shows how to configure 2 instances of high-speed data load being executed simultaneously using a degree of parallelism of 4.

```
max_prepared_transactions = 13  #Example if the initial value was 5: 5 + 2 x 4 = 13
max_worker_processes = 16        #Example if the initial value was 8: 8 + 2 x 4 = 16
max_parallel_workers = 12        #Example if the initial value was 4: 4 + 2 x 4 = 12
```

Note

As shown in the example above, set the value of max_prepared_transactions, max_worker_processes and max_parallel_workers multiplied by the number of instances of this feature executed simultaneously.

The table below lists the postgresql.conf parameters that must also be checked.

Parameter	Setting	Required
dynamic_shared_memory_type	Implementation of dynamic shared memory to be used by the instance. The default value is recommended.	Mandatory

See

Refer to "Resource Consumption" in the PostgreSQL Documentation for information on the parameters.

12.1.3.2 Installing the Extension

Execute CREATE EXTENSION to install the high-speed data load extension. The extension needs to be installed on each database.

Example

The example below installs the extension on the "postgres" database.

```
postgres=# CREATE EXTENSION pgx_loader;
CREATE EXTENSION
```

Note

- Only superusers can install the high-speed data load extension.
- The high-speed data load extension can only be installed on the public schema.

12.2 Using High-Speed Data Load

This section describes how to use high-speed data load.

12.2.1 Loading Data

To load data from a file into a FUJITSU Enterprise Postgres table, execute the pgx_loader command in load mode.

Example

The example below loads the file /path/to/data.csv (2000 records) into table tbl using a degree of parallelism of 3.

```
$ pgx_loader load -j 3 -c "COPY tbl FROM '/path/to/data.csv' WITH CSV"
LOAD 2000
```

Point

If an external file contains data that violates the format or constraints, the data load may fail partway through, resulting in delays for routine tasks such as nightly batch processing. Therefore, it is recommended to remove the invalid data before executing the data load.

Note

The data inserted using this feature is dumped as a COPY command by the pg_dump command and the pg_dumpall command.

See

- Refer to "pgx_loader" in the Reference for information on the command.
- Refer to "COPY" in the PostgreSQL Documentation for information on the deployment destination and access privileges for external files.

12.2.2 Checking Progress

If you are performing a data load with a large external file as input, you can verify that the process is continuing by getting progress information during the load. Progress information can be obtained from the pgx_stat_progress_loader view. This view displays the sum of the progress information of the back-end process and the number of parallel worker processes. Search the pgx_stat_progress_loader view, for example, with a SELECT statement, to locate the appropriate row. After running the pgx_loader command, look in the pg_stat_activity view and locate a row in the pgx_stat_progress_loader view with the PID obtained.

Example

1. See the pg_stat_activity view. (9311 for back-end processes, 9312, 9313, 9314 for worker processes)

```
postgres=# select pid, application_name, backend_type from pg_stat_activity
pid  | application_name |         backend_type
-----+------------------+------------------------------
6216 |                  | autovacuum launcher
6218 |                  | logical replication launcher
6271 | psql             | client backend
9311 | pgx_loader       | client backend
9312 |                  | parallel loader for PID 9311
9313 |                  | parallel loader for PID 9311
9314 |                  | parallel loader for PID 9311
6214 |                  | background writer
6213 |                  | checkpointer
6215 |                  | walwriter
```

2. Check the information in the pgx_stat_progress_loader view.

```
postgres=# SELECT * FROM pgx_stat_progress_loader
pid  | datid | datname | relid | command  | type | bytes_processed | bytes_total |
tuples_processed | tuples_excluded
-----+-------+---------+-------+----------+------+-----------------+-------------
+------------------+----------------
9311 |  222  | testdb  | 333   |COPY FROM | FILE |        192000   |    450000   |        189000
|           3000
```

Refer to "C.7 pgx_stat_progress_loader" for information on the pgx_stat_progress_loader view.

Note

When you run the pgx_loader command, the PostgreSQL pg_stat_progress_copy view prints the progress of the back-end process and the number of parallel worker processes on each line. The backend process progress information tuples_processed, tuples_excluded is 0. Also, bytes_processed and bytes_total for worker processes are 0.

```
postgres=# SELECT * FROM pg_stat_progress_copy
pid  | datid | datname | relid | command  | type | bytes_processed | bytes_total | tuples_processed |
tuples_excluded
-----+-------+---------+-------+----------+------+-----------------+-------------+------------------
+----------------
9311 |  222  | testdb  | 333   |COPY FROM | FILE |          192000  |    450000   |              0
|              0
9312 |  222  | testdb  | 333   |COPY FROM | FILE |              0   |         0   |          63000
|           1000
9313 |  222  | testdb  | 333   |COPY FROM | FILE |              0   |         0   |          63000
|           1000
9314 |  222  | testdb  | 333   |COPY FROM | FILE |              0   |         0   |          63000
|           1000
```

Refer to "pg_stat_progress_copy View" in the PostgreSQL Documentation for information on the pg_stat_progress_copy view.

12.2.3 Recovering from a Data Load that Ended Abnormally

If a system interruption such as a server failure occurs while high-speed data load is being performed, transactions prepared using this feature may be changed to the in-doubt state. At that point, resources occupied by the transaction will be locked, and access to the relevant resources from other transactions will be blocked, rendering them unusable.

In such cases, check transactions that are in an in-doubt state, and resolve them.

Checking for in-doubt transactions

This section describes how to check for in-doubt transactions.

1. Refer to the pgx_loader_state table in the pgx_loader schema.

   Retrieve the global transaction identifier (gid column) of in-doubt transactions. In-doubt transactions will contain "rollback" in the column "state".

   #### Example

   The example below retrieves the global transaction identifier (gid) of in-doubt transactions performed by the database role myrole and that used table tbl. The retrieved global transaction identifiers pgx_loader:9589 and pgx_loader:9590 identify in-doubt transactions.

   ```
   postgres=# SELECT gid, state FROM pgx_loader.pgx_loader_state WHERE
   postgres-# role_oid IN (SELECT oid FROM pg_roles WHERE rolname = 'myrole') AND
   postgres-# relation_oid IN (SELECT relid FROM pg_stat_all_tables WHERE
   postgres-# relname = 'tbl');
          gid       | state
   -----------------+-------------
    pgx_loader:9590 | rollback
    pgx_loader:9591 | commit
    pgx_loader:9589 | rollback
   (3 rows)
   ```

2. Refer to the pg_prepared_xacts system view.

   Check if the in-doubt transactions retrieved above exist.

Example

The example below checks if in-doubt transactions with the global transaction identifiers pgx_loader:9589 and pgx_loader:9590 exist.

```
postgres=# SELECT gid FROM pg_prepared_xacts WHERE gid IN ('pgx_loader:9589','pgx_loader:9590');
       gid
------------------
 pgx_loader:9590
 pgx_loader:9589
(2 rows)
```

See

Refer to "F.1 pgx_loader_state" for information on the pgx_loader_state table.

Resolving in-doubt transactions

Execute the pgx_loader command in recovery mode to resolve in-doubt transactions.

After executing the pgx_loader command in recovery mode, perform the procedure described in "Checking for in-doubt transactions" to check if the in-doubt transactions have been resolved.

Example

The example below completes the in-doubt transactions prepared for table tbl.

```
$ pgx_loader recovery -t tbl
```

Point

The recovery mode of the pgx_loader command only resolves transactions prepared by high-speed data load. For transactions prepared by an application using distributed transactions other than this feature, follow the procedure described in "17.13 Actions in Response to Error in a Distributed Transaction".

12.3 Removing High-Speed Data Load

This section describes how to remove high-speed data load.

12.3.1 Removing the Extension

Execute DROP EXTENSION to remove the high-speed data load extension. The extension needs to be removed on each database.

Example

The example below removes the extension on the "postgres" database.

```
postgres=# DROP EXTENSION pgx_loader;
DROP EXTENSION
```

Note

- The information required for operation of high-speed data load is stored in the pgx_loader_state table of the pgx_loader schema. Do not remove the high-speed data load extension if the pgx_loader_state table is not empty.
- Only superusers can remove the high-speed data load extension.
- The high-speed data load extension can only be removed on the public schema.

Chapter 13 Global Meta Cache

The Global Meta Cache (GMC) feature loads a meta cache into shared memory using the pgx_global_metacache parameter. This reduces the amount of memory required throughout the system.

13.1 Usage

Describes how to use the Global Meta Cache feature.

13.1.1 Deciding Whether to Enable the Global Meta Cache Feature

Global Meta Cache is a mechanism for sharing meta caches between processes, so it works well on systems with a high number of resources accessed and SQL connections. The number of resources is primarily the number of tables accessed by a process, the number of indexes, or the total number of all columns in all tables accessed.

In particular, consider using Global Meta Cache if the total size of the meta cache for each process exceeds the amount of installed memory, or takes up a large portion of that memory, thereby squeezing memory allocations to the database cache or the Operating system file cache. Using Global Meta Cache may increase the time it takes to execute a single SQL to reference a meta cache on shared memory, but you can expect a greater benefit from being able to allocate more memory, such as for the database cache.

If performance degradation using Global Meta Cache is not acceptable, you may want to limit the number of tables accessed by a process.

13.1.2 Estimating Memory for Global Meta Cache

To enable the Global Meta Cache feature, the pgx_global_metacache parameter must specify an upper limit on the size of the shared memory (Hereinafter, the GMC area) dedicated to Global Meta Cahche. Ideally, this upper limit should be the size estimated in “Appendix A Parameters”. Values lower than this can still work, but refer to "13.1.3 How the GMC Memory Area Is Used" on using the GMC area to understand the disadvantages.

13.1.3 How the GMC Memory Area Is Used

At startup, the memory for the GMC area is not used much, but the GMC area grows as new meta caches are placed in the GMC area. If it does, it discards any meta caches that the system determines are not heavily used and places a new one in the GMC area.

Therefore, the GMC area will work even if it is smaller than the estimate, but the meta cache will be regenerated if the discarded meta cache needs to be reused. Note that if this happens frequently, it will degrade overall performance.

With this in mind, it may not be a problem if, for example, the tables to be accessed are different depending on the time zone, and the degradation of the time zone immediately after the change is acceptable.

In any case, be sure to test and tune the system thoroughly before running it.

13.1.4 Enabling the Global Meta Cache Feature

To Enable the Global Meta Cache feature edit the postgresql.conf file and set the pgx_global_metacahe parameter. Restarting the instance after editing the postgresql.conf file is required. Refer to "Appendix A Parameters" for information on the parameters.

Parameter Name	Description
pgx_global_metacache	Specify the maximum amount of memory for the GMC area on shared memory. When it’s set to 0 (default value), the Global Meta Cache feature is disabled. When enabled, the minimum value allowed is 10MB.

When the cache is created, if the total amount of meta caches on shared memory exceeds the value specified by pgx_global_metacache, the inactive, unreferenced meta caches are removed from the GMC area. Note that if all GMC are in use and the cache cannot be created in the GMC area, the cache is temporarily created in the local memory of the backend process.

Example

Here is an example postgresql.conf configuration:

```
pgx_global_metacache = 800 MB
```

Wait Events

The Global Meta Cache feature may cause wait events. Wait events are identified in the wait_event column of the pg_stat_activity view. GMC specific wait events are described below.

[GMC Feature Wait Events]

Wait Event Type	Wait Event Name	Description
LWLock	GlobalCatcache	Waiting to find, add, and remove meta caches in the GMC area.
IPC	GMCSweep	Waiting to select a meta cache that can be deleted when GMC space is low. If the GMC is fully referencing and there is no deletable meta cache, it is waiting for the reference to be removed and a deletable meta cache to be selected.

Note

If GMCSweep is happened frequently, increase the pgx_global_metacache setting.

See

Refer to "Viewing Statistics" in the PostgreSQL Documentation for information on the pg_stat_activity view.

13.1.5 Estimating Resources

Refer to "Global Meta Cache Memory Requirements" in the Installation and Setup Guide for Server for formulas to estimate the amount of memory used by the Global Meta Cache feature.

13.2 Statistics

Describes the statistics for the Global Meta Cache feature.

13.2.1 System View

You can check the cache hit ratio and size of the GMC area in the system view pgx_stat_gmc. Refer to "C.6 pgx_stat_gmc" for information on the columns.

If the cache hit ratio is low and the current memory usage is close to pgx_global_metacache, increase the pgx_global_metacache setting because performance may be degraded.

Refer to "8.6 Monitoring Database Activity" in the Operations Guide for information on the statistics.

Chapter 14 Local Meta Cache Limit

Local Meta Cache Limit feature limits the size of a Local Meta Cache by removing it if it has not been accessed for a long time.

14.1 Usage

Describes how to use the Local Meta Cache Limit feature.

14.1.1 Deciding Whether to Enable the Local Meta Cache Limit Feature

Refer to "Appendix A Parameters", after estimating the total amount of memory to be used as the catalog cache and relation cache, when the total amount of memory exceeds the amount of installed memory or occupies a large amount of installed memory, consider using this feature.

This feature adds the action of discarding the meta cache that has been held permanently. If you attempt to refer to a destroyed meta cache again, the meta cache is recreated, so using this feature will result in poor performance compared to not using it.

Therefore, read the following to understand how to discard a meta cache.

- 14.1.3 Cache Removal when Local Meta Cache Limit is Enabled
- 14.1.4 Performance Impact and Parameter Tuning of the Local Meta Cache Limit Feature
- Parameters for the Local Meta Cache Limit feature

How to set the upper limit with these considerations is described in detail in the estimation formula in "Appendix A Parameters".

14.1.2 How to Set Parameters for the Local Meta Cache Limit Feature

To enable the Local Meta Cache Limit feature, set the pgx_catalog_cache_max_size and pgx_relation_cache_max_size parameters.

Parameter Name	Description
pgx_catalog_cache_max_size	Specify the maximum amount of memory that the backend process should use as the catalog cache. You can enable catalog cache removal by setting it to 8 KB or more. When it is set to 0 (default value), the catalog cache removal is disabled.
pgx_relation_cache_max_size	Specify the maximum amount of memory that the backend process should use as the relation cache. You can enable relation cache removal by setting it to 8 KB or more. When it is set to 0 (default value), the relation cache removal is disabled.

Example

Here is an example postgresql.conf configuration:

```
pgx_catalog_cache_max_size = 1MB
pgx_relation_cache_max_size = 1MB
```

14.1.3 Cache Removal when Local Meta Cache Limit is Enabled

When this feature is enabled, the caching strategy is to keep the cache as long as possible within the specified upper limit. If holding a new cache exceeds the limit, consider locality of reference and remove the cache from the one with the longest unreferenced time.

However, because the cache used by active transactions cannot be removed, if a transaction uses a large number of caches, the cache may be held above the limit. In this case, remove the all caches at the end of the transaction. This is necessary to free up memory.

In PostgreSQL, in order to acquire memory at high speed, a memory block of a certain size is acquired from the OS, and a small memory is cut out from the block and used. The memory for the metacache is cut out in the same way. Therefore, it is possible to return the memory block to the OS by destroying all the meta caches scattered throughout the memory block. When this happens, the next SQL execution will

be slowed down due to the re-creation of the meta cache. Therefore, upper limit of feature should be set to a value larger than the size of the meta cache used by at least one transaction.

When the size of the meta cache exceeds the upper limit, the following message is output:

```
WARNING: could not reduce Cat/RelCacheMemoryContext size to AA kilobytes, reduced to BB kilobytes
HINT: consider increasing the configuration parameter pgx_catalog/relation_cache_max_size
```

(***AA***: Upper limit, ***BB***: Amount of memory actually used)

CatCacheMemoryContext and RelCacheMemoryContext are memory areas for storing the catalog cache and relation cache, respectively. If this message is output, consider increasing the upper limit.

If the memory consumption by the backend process exceeds the allowable value by increasing the upper limit, reconsider the SQL to be executed, such as reducing the number of tables accessed in one transaction, or add memory adjust to the amount of memory used.

14.1.4 Performance Impact and Parameter Tuning of the Local Meta Cache Limit Feature

By observing how much meta cache regeneration is taking place, you can determine if the low upper limit is the cause of the failure to achieve the desired performance.

From the message below, calculate the cache hit ratio as follows:

```
Cache hit ratio = Number of cache hits ÷ Number of times the cache was searched
```

If the cache hit ratio is 80% or higher, this feature will not be the main factor that impedes performance. If not, raise the upper limit and see if performance can reach the goal. In doing so, first try to shift the focus of allocation to the relations cache. This is because when executing SQL, the relation cache generated based on the catalog cache is mainly referenced, so it is advantageous to leave a large amount of relation cache.

```
Catalog cache:catalog cache hit stats: search XX, hits YY
Relation cache:relation cache hit stats: search XX, hits YY
```

(***XX***: Number of times the cache was searched, ***YY***: Number of cache hits)

This message is printed when the transaction ends. However, if you output the message frequently, the performance will be degraded by itself, so you can adjust the output interval with the following parameters.

Parameter Name	Description
pgx_cache_hit_log_interval	When the transaction ends, if the time set in this parameter has elapsed since the previous message was output, the message is output. If set to 0, a message will be output each time the transaction ends. Setting -1 disables the output. The default value is 10min. Even if pgx_catalog_cache_max_size and pgx_relation_cache_max_size are disabled, the message output of the corresponding cache will be invalid. Immediately after connecting to the server, a small transaction occurs before the request from the user application, such as for user authentication. Since it is meaningless to know the hit ratio for these, a message is output at the end of the transaction that started after the time set in this parameter has elapsed after connecting to the server. For the same reason, setting a small value such as 0 may result in a message being printed at the end of such a small transaction. You can check which transaction the message corresponds to from the information output at the beginning. This information depends on the setting of the parameter log_line_prefix.

Example

Here is an example postgresql.conf configuration:

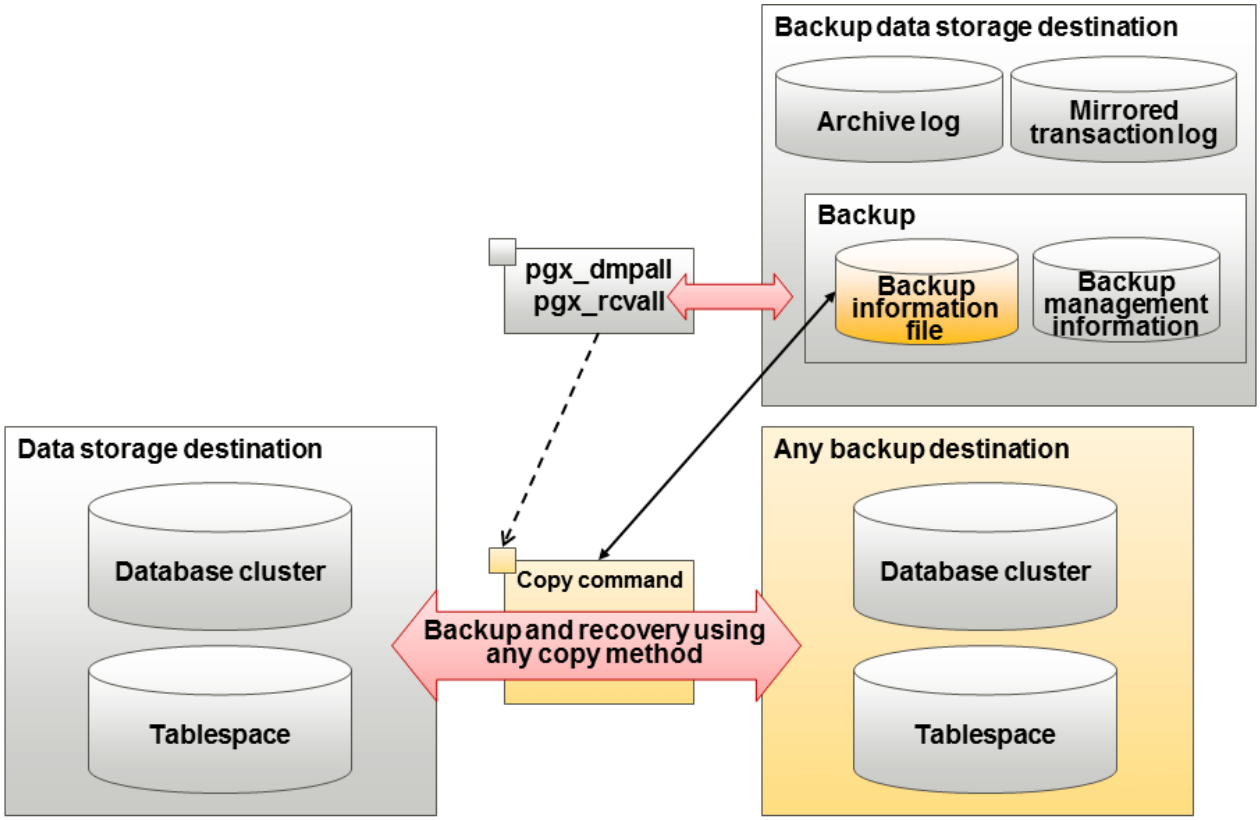
```
pgx_cache_hit_log_interval= 30min
```

Chapter 15 Backup/Recovery Using the Copy Command

By using a copy command created by the user, the pgx_dmpall command and the pgx_rcvall command can perform backup to any destination and can perform recovery from any destination using any copy method.

Copy commands must be created in advance as executable scripts for the user to implement the copy process on database clusters and tablespaces, and are called when executing the pgx_dmpall and pgx_rcvall commands.

This appendix describes backup/recovery using the copy command.



Point

It is also possible to back up only some tablespaces using the copy command. However, database resources not backed up using the copy command are still backed up to the backup data storage destination.

Note

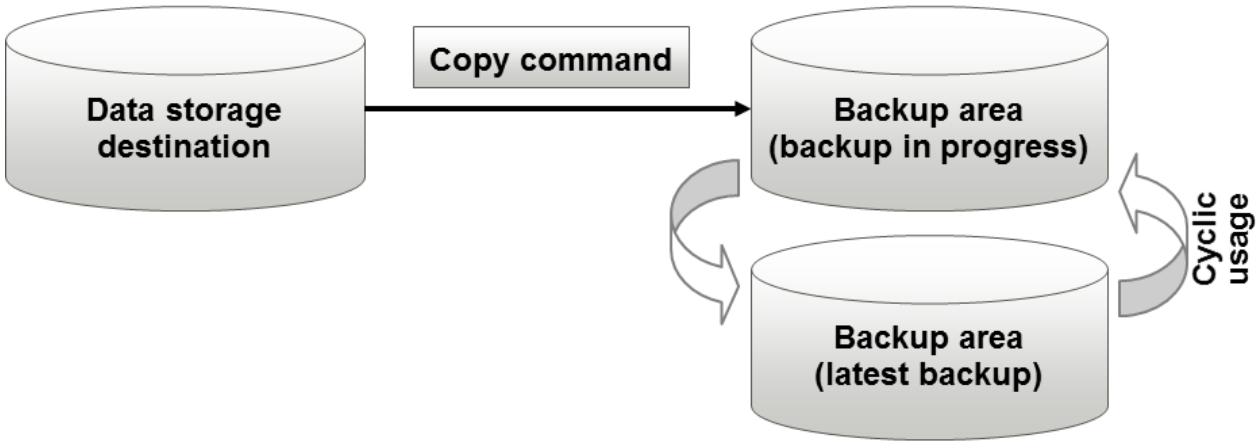
Both the backup data storage destination and the optional backup destination are necessary for recovery - if they are located in secondary media, combined management of these is necessary.

15.1 Configuration of the Copy Command

This section describes the configuration of the copy command for backup and recovery.

Cyclic usage of the backup area

Prepare two backup areas for the copy command in case an issue affects the data storage destination during backup. The copy command performs backup while cyclically using these backup areas.

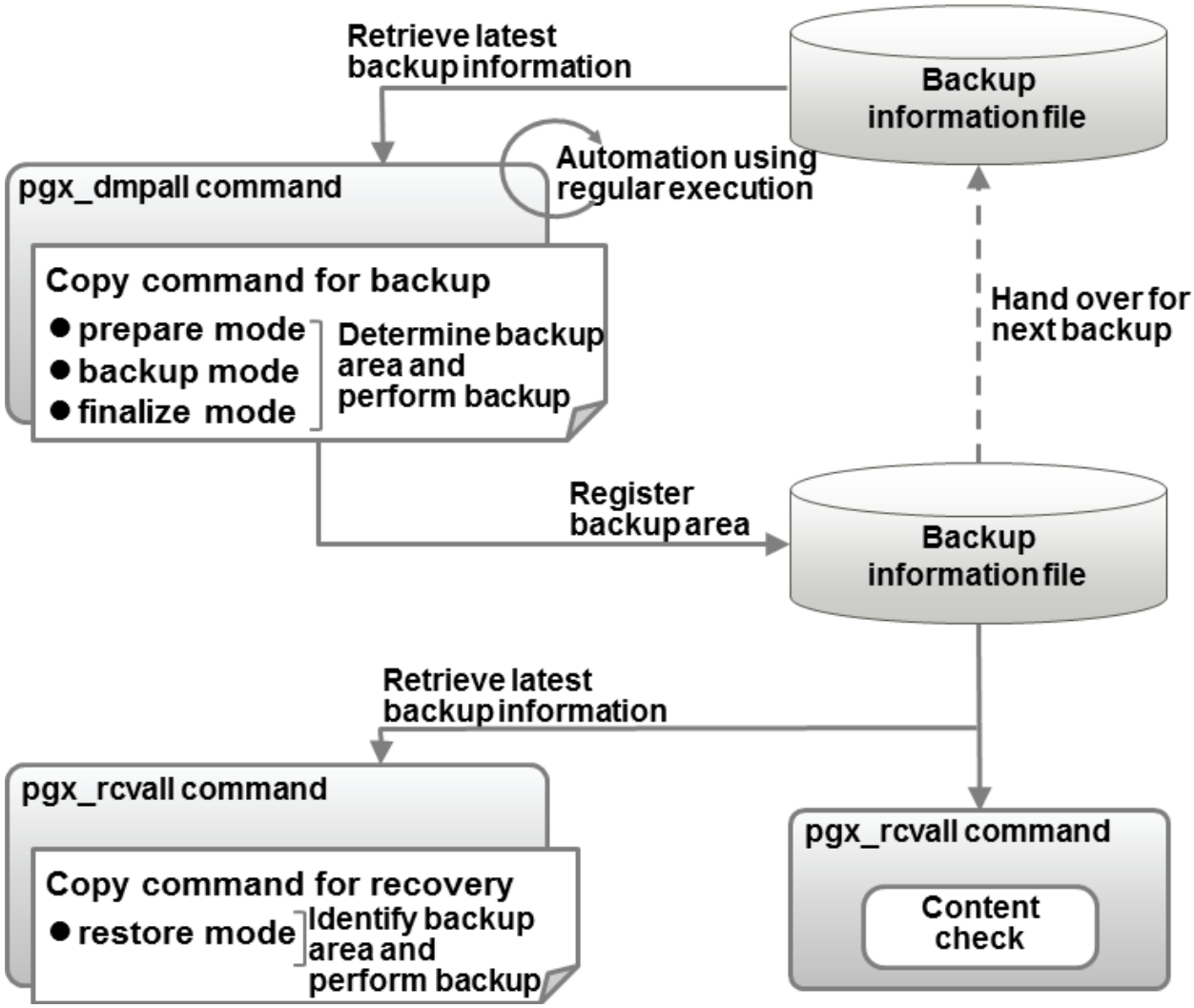


Note

The backup data storage destination cannot be used as these backup areas used by the copy command.

Backup using the backup information file

The copy command must determine the backup destination on each backup, as it is necessary to cycle through the backup areas. Backup can be automated by using the backup information file, which contains information about the backup destination.



Information

The backup information file is prepared in the backup data storage destination by the pgx_dmpall command, and contains information that can be read or updated by the copy command. This file is managed by associating it with the latest backup successfully completed by the pgx_dmpall command, so the latest backup information relating to the copy command registered by the user can be retrieved. Additionally, the content of the backup information file can be displayed using the pgx_rcvall command.

Configuration of the copy command for backup

The pgx_dmpall command calls the copy command for backup after execution for the three modes below. It is therefore necessary for the copy command for backup to implement the required processing for each of the modes.

- prepare mode

  Determines which of the two backup areas will be used for the current backup.

  The backup area to be used for the current backup is determined by reading the information relating to the latest backup destination where the backup information file was written to during the previous backup.

- backup mode

  Performs backup on the backup area determined by prepare mode, using any copy method.

- finalize mode

  Writes information relating to the destination of the current backup to the backup information file.

  This enables the prepare mode to check the destination of the previous backup during the next backup.

Note

The user can use any method to hand over backup information between modes within the copy command, such as creating temporary files.

Configuration of the copy command for recovery

The pgx_rcvall command calls the copy command for recovery for the mode below. It is therefore necessary for the copy command for recovery to implement the required processing for the mode.

- restore mode

  Any copy method can be used to implement restore from the backup destination retrieved using the copy command for backup.

Point

By referring to the mode assigned to the copy command as an argument, backup and recovery can be implemented using a single copy command.

Example

Using a bash script

```
case $1 in
    prepare)
        processingRequiredForPrepareMode
        ;;
    backup)
        processingRequiredForBackupMode
        ;;
    finalize)
         processingRequiredForFinalizeMode
```

```
        ;;
    restore)
         processingRequiredForRestoreMode
        ;;
esac
```

Point

A sample batch file that backs up the database cluster and tablespace directory to a specific directory is supplied to demonstrate how to write a copy command.

The sample is stored in the directory below:

```
/installDir/share/copy_command.archive.sh.sample
```

15.2 Backup Using the Copy Command

To perform backup using the copy command, in addition to performing the standard backup procedure, it is also necessary to create a copy command, and then execute the pgx_dmpall command specifying it. This section describes the procedure specific to using the copy command.

Preparing for backup

You must prepare for backup before actually starting the backup process.

Perform the following procedure:

1. Determine the database resources to be backed up

   Determine the database resources to be backed up using the copy command. The copy command can back up the following resources:

   - Database cluster
   - Tablespace

   To back up only some tablespaces, create a file listing them. This file is not necessary to back up all tablespaces.

   Example

   To back up only tablespaces tblspc1 and tblspc2

   ```
   tblspc1
   tblspc2
   ```

2. Prepare a backup area

   Prepare a backup area to save the database resources to be backed up, as determined in step 1.

3. Create the copy command

   Create the copy commands for backup and recovery. Refer to "15.4 Copy Command Interface" for details.

Performing backup

Execute the pgx_dmpall command with the -Y option specifying the full path of the copy command for backup created in step 3 of preparation for backup.

The example below backs up only some tablespaces, but not the database cluster, using the copy command.

Example

```
$ pgx_dmpall -D /database/inst1 -Y '/database/command/backup.sh'
  --exclude-copy-cluster -P '/database/command/tablespace_list.txt'
```

Point

- To exclude up the database cluster from backup using the copy command, specify the --exclude-copy-cluster option.
- To back up only some tablespaces using the copy command, use the -P option specifying the full path of the file created in step 1 of preparation for backup.

See

- Refer to "pgx_dmpall" in the Reference for information on the command.

Checking backup status

Use the pgx_rcvall command to check the backup status.

Execute the pgx_rcvall command with the -l option specified to output backup data information. If backup was performed using the copy command, the resources backed up using the copy command will also be output.

Example

```
$ pgx_rcvall -l -D /database/inst1
Date                Status   Dir                                Resources backed up by the copy command
2022-03-01 13:30:40 COMPLETE /backup/inst1/2022-03-01_13-30-40 pg_data,dbspace,indexspace
```

15.3 Recovery Using the Copy Command

To perform recovery using the copy command, in addition to performing the standard recovery procedure, it is also necessary to create a copy command, and then execute the pgx_rcvall command specifying it. This section describes the procedure specific to using the copy command.

Determining the backup area of the latest backup

Check the backup information file to determine the backup area used for the latest backup, and confirm that it is in a recoverable state.

Execute the pgx_rcvall command with the --view-results-of-copying option to output the content of the backup information file.

Example

```
$ pgx_rcvall -D /database/inst1 --view-results-of-copying
```

Perform recovery

Execute the pgx_rcvall command with the -Y option specifying the full path of the copy command for recovery created in step 3 of the preparation for backup described in "15.2 Backup Using the Copy Command".

The example below recover only some tablespaces, but not the database cluster, using the copy command.

Example

```
$ pgx_rcvall -D /database/inst1 -B /backup/inst1 -Y '/database/command/recovery.sh'
```

Point

If the latest backup was performed using the copy command, the pgx_rcvall command automatically recognizes which database resources were backed up using the copy command, or whether resources were backed up to the backup data storage destination. Therefore, recovery can be performed by simply executing the pgx_rcvall command specifying the copy command for recovery.

See

Refer to "pgx_rcvall" in the Reference for information on the command.

15.4 Copy Command Interface

The following types of copy command are available:

- Copy command for backup
- Copy command for recovery

This appendix describes the interface of each copy command.

15.4.1 Copy Command for Backup

Feature

User command called from the pgx_dmpall command.

Format

The syntax for calling the copy command from the pgx_dmpall command is described below.

If the operation mode is "prepare"

```
copyCommandName prepare 'pathOfBackupInfoFile' 'pathOfBackupTargetListFile'
```

If the operation mode is "backup"

```
copyCommandName backup
```

If the operation mode is "finalize"

```
copyCommandName finalize 'pathOfBackupInfoFile'
```

Argument

- Operation mode

Mode	Description
prepare	Implements the preparation process for backing up using the copy command. Called before the PostgreSQL online backup mode is started.
backup	Implements the backup process. Called during the PostgreSQL online backup mode.

Mode	Description
finalize	Implements the backup completion process. Called after the PostgreSQL online backup mode is completed.

- Full path of the backup information file

  Full path of the backup information file of the latest backup, enclosed in single quotation marks. If a backup has not been performed, specify '-'.

- Full path of the backup target list file

  Full path of the file containing the resources to be backed up using the copy command, enclosed in single quotation marks. One of the following is described in each resource name.

Resource	Description
Database cluster	pg_data
Tablespace	Tablespace name

Example

To back up the database cluster and the tablespaces dbspace and indexspace using the copy command, the file should contain the following:

```
pg_data
dbspace
indexspace
```

Information

The encoding of resource names output to the backup target list file by the pgx_dmpall command is the encoding used when this command connects to the database with auto specified for the client_encoding parameter, and is dependent on the locale at the time of command execution.

The number of arguments vary depending on operation mode. The argument of each operation mode is as follows.

Operation mode	First argument	Second argument	Third argument
prepare	Operation mode	Backup information file path name	Backup target list file path name
backup		None	None
finalize		Backup information file path name	

Additionally, the access permissions for the backup information file and backup target list file are different depending on the operation mode. The access permissions of each operation mode are as follows.

Operation mode	Backup information file	Backup target list file
prepare	Can be viewed by the instance administrator only	Can be viewed by the instance administrator only
backup	-	-
finalize	Can be viewed and updated by the instance administrator only	-

Return value

Return value	Description
0	Normal end The pgx_dmpall command continues processing.
Other than 0	Abnormal end The pgx_dmpall command terminates in error.

Description

- The copy command operates with the privileges of the operating system user who executed the pgx_dmpall command. Therefore, grant copy command execution privileges to users who will execute the pgx_dmpall command. Additionally, have the copy command change users as necessary.
- To write to the backup information file, use a method such as redirection from the copy command.
- Because the copy command is called for each mode, implement all processing for each one.
- To copy multiple resources simultaneously, have the copy command copy them in parallel.

Note

- The backup information file and backup target list file cannot be deleted. Additionally, the privileges cannot be changed.
- Standard output and standard error output of the copy command are output to the terminal where the pgx_dmpall command was executed.
- If the copy command becomes unresponsive, the pgx_dmpall command will also become unresponsive. If the copy command is deemed to be unresponsive by the operating system, use an operating system command to forcibly stop it.
- Output the copy command execution trace and the result to a temporary file, so that if it terminates in error, the cause can be investigated at a later time.
- For prepare mode only, it is possible to use the PostgreSQL client application to access the database using the copy command. For all other modes, do not execute FUJITSU Enterprise Postgres commands or PostgreSQL applications.
- Enable the fsync parameter in postgresql.conf, because data on the shared memory buffer needs to have been already written to disk when backup starts.

15.4.2 Copy Command for Recovery

Feature

User command called from the pgx_rcvall command.

Format

The syntax for calling the copy command from the pgx_rcvall command is described below.

```
copyCommandName restore 'pathOfBackupInfoFile' 'pathOfBackupTargetListFile'
```

Argument

- Operation mode

Mode	Description
restore	Performs restore.

- Full path of the backup information file

  Full path of the backup information file, enclosed in single quotation marks.

- Full path of the backup target list file

  Full path of the file containing the resources to be restored using the copy command, enclosed in single quotation marks.

The access permissions for the backup information file and backup target list file are as below.

Backup information file	Backup target list file
Can be viewed by the instance administrator only	Can be viewed by the instance administrator only

Return value

Return value	Description
0	Normal end The pgx_rcvall command continues processing.
Other than 0	Abnormal end The pgx_rcvall command terminates in error.

Description

- The copy command operates with the privileges of the operating system user who executed the pgx_rcvall command. Therefore, grant copy command execution privileges to users who will execute the pgx_rcvall command. Additionally, have the copy command change users as necessary.
- The copy command is called once only in restore mode.
- To copy multiple resources simultaneously, have the copy command copy them in parallel.

Note

- The backup information file and backup target list file cannot be deleted. Additionally, the privileges cannot be changed.
- Standard output and standard error output of the copy command are output to the terminal where the pgx_rcvall command was executed.
- If the copy command becomes unresponsive, the pgx_rcvall command will also become unresponsive. If the status of the copy command is deemed to be unresponsive by the operating system, use an operating system command to forcibly stop it.
- Output the copy command execution trace and the result to a temporary file, so that if it terminates in error, the cause can be investigated at a later time.
- Do not execute FUJITSU Enterprise Postgres commands or PostgreSQL applications in the copy command.
- There may be files and directories not required for recovery using the archive log included in the backup, such as postmaster.pid, pg_wal/*subdirectory* and pg_replslot in the database cluster. If such unnecessary files and directories exist, have the copy command delete them after the restore.

Chapter 16 WAL Compression for Streaming Replication

WAL compression for streaming replication feature is a feature of FUJITSU Enterprise Postgres that compresses the WAL sent during streaming replication.

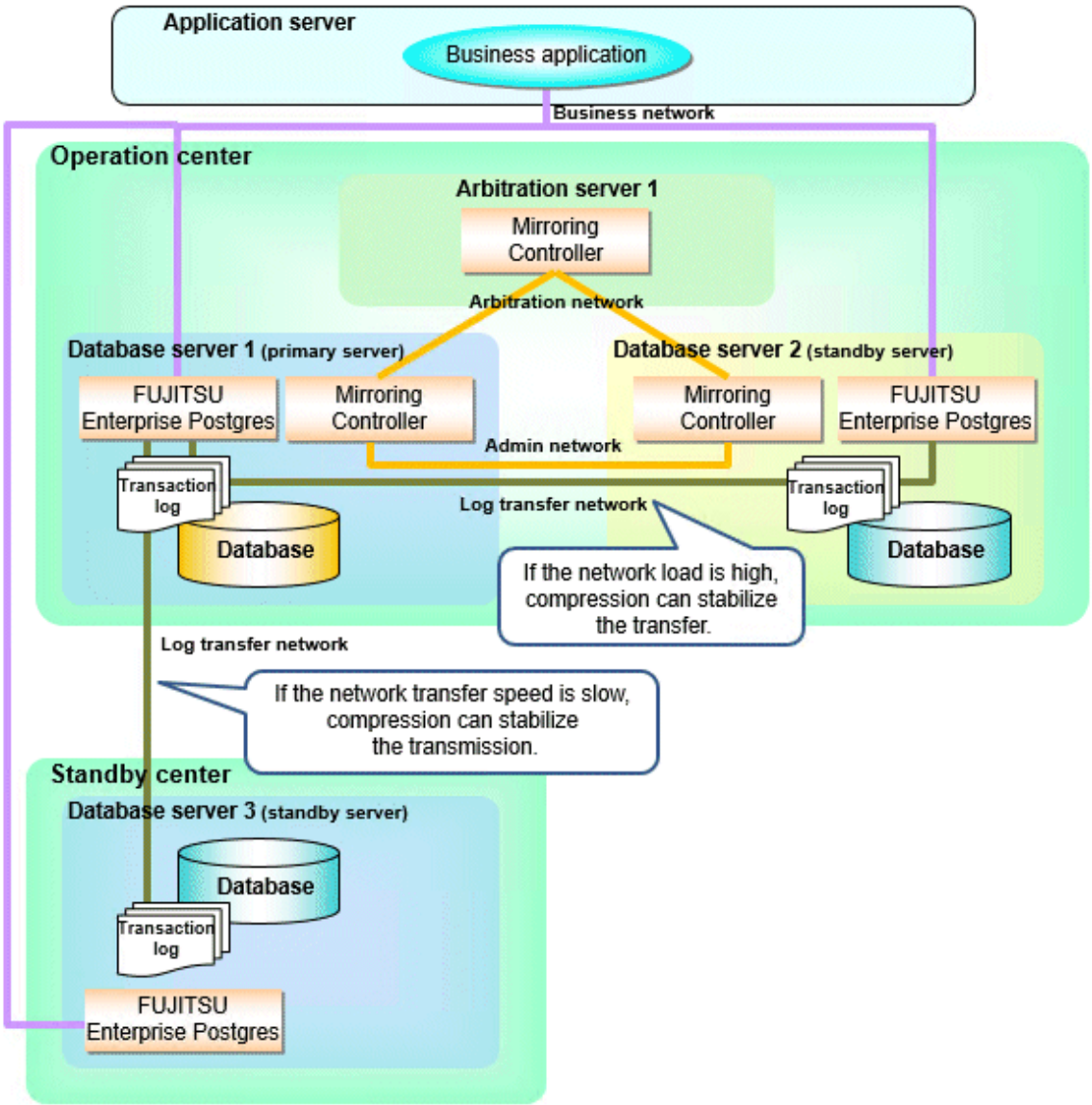
16.1 Usage

Describes how to use WAL compression for streaming replication feature.

16.1.1 Deciding Whether to Enable the WAL Compression for Streaming Replication Feature

This feature compress WAL of streaming replication by zlib library. This reduce the load on the network. so it prevents the occurrence of streaming replication delay due to network bottlenecks. This is especially effective in environments where the network transfer speed is slow, such as when transferring data to a disaster prevention environment.

The compression/decompression process works by enabling the feature. so the throughput may decrease when the network is fast and the load is low. Therefore, it is necessary to judge the effectiveness in advance.



Note

This feature does not support logical replication.

See

zEnterprise Data Compression (zEDC) is available for zlib compression. Refer to "Appendix L Utilize zEnterprise Data Compression (zEDC) " for more information.

16.1.2 Enabling WAL Compression for Streaming Replication Fetature

To enable the WAL compression for streaming replication feature, set the streaming_wal_compression parameter.

Parameter Name	Description
streaming_wal_compression	Specifies that you want to send a compressed WAL by streaming replication. -1: Compress at zlib's default compression level 0: Uncompressed 1-9: Compress at specified compression level, 9 is high compression Default is uncompressed.

Example

Here is an example postgresql.conf configuration:

```
streaming_wal_compression = 1
```

Note

Using zEDC for compression / decompression speeds up compression / decompression.

Because compression is performed on the primary server, if you want to compress using zEDC, you set zEDC on primary server.

Because decompression is performed on the standby server, if you want to decompress using zEDC, you set zEDC on standby server.

Refer to the IBM documentation for information on configuring the zEDC.

Chapter 17 Actions when an Error Occurs

This chapter describes the actions to take when an error occurs in the database or an application, while FUJITSU Enterprise Postgres is operating.

Depending on the type of error, it may be necessary to recover the database cluster. The recovery process recovers the following resources:

- Data storage destination
- Transaction log storage destination (if the transaction log is stored in a separate disk from the data storage destination)
- Backup data storage destination

Note

Even if a disk is not defective, the same input-output error messages, as those generated when the disk is defective, may be output. The recovery actions differ for these error messages.

Check the status of the disk, and select one of the following actions:

- If the disk is defective

  Refer to "17.1 Recovering from Disk Failure (Hardware)", and take actions accordingly.

- If the disk is not defective

  Refer to "17.14 I/O Errors Other than Disk Failure", and take actions accordingly.

  A few examples of errors generated even if the disk is not defective include:

  - Network error with an external disk
  - Errors caused by power failure or mounting issues

Determining the cause of an error

If an error occurs, refer to the WebAdmin message and the server log, and determine the cause of the error.

See

Refer to "Configuring Parameters" in the Installation and Setup Guide for Server for information on server logs.

Approximate recovery time

The formulas for deriving the approximate recovery time of resources in each directory are given below.

If using the copy command with the pgx_rcvall command, the recovery time will depend on the implementation of the copy command.

- Data storage destination or transaction log storage destination

```
Recovery time = (usageByTheDataStorageDestination + usageByTheTransactionLogStorageDestination) /
diskWritePerformance x 1.5
```

  - *usageByTheDataStorageDestination*: Disk space used by the database cluster
  - *usageByTheTransactionLogStorageDestination*: Disk space used by the transaction log stored outside the database cluster
  - *diskWritePerformance*: Measured maximum data volume (bytes/second) that can be written per second in the system environment where the operation is performed
  - 1.5: Coefficient assuming the time excluding disk write, which is the most time-consuming step

- Backup data storage destination

```
Recovery time = usageByTheBackupDataStorageDestination / diskWritePerformance x 1.5 x
EffectOfCompression
```

  - *usageByTheBackupDataStorageDestination*: Disk space used by the backup data (If compressed, the amount of disk space when decompressed. If you do not know the decompression size, calculate it by the disk space of the database cluster.)
  - *diskWritePerformance*: Measured maximum data volume (bytes/second) that can be written per second in the system environment where the operation is performed
  - 1.5: Coefficient assuming the time excluding disk write, which is the most time-consuming step
  - *EffectOfCompression*: Specify 0.6 for compression or 1 for no compression

17.1 Recovering from Disk Failure (Hardware)

This section describes how to recover database clusters to a point immediately before failure, if a hardware failure occurs in the data storage disk or the backup data storage disk.

There are two methods of recovery:

- 17.1.1 Using WebAdmin
- 17.1.2 Using Server Command

Point

Back up the database cluster after recovering it. Backup deletes obsolete archive logs (transaction logs copied to the backup data storage destination), freeing up disk space and reducing the recovery time.

17.1.1 Using WebAdmin

Recover the database cluster by following the appropriate recovery procedure below for the disk where the failure occurred.

Note

Recovery operation cannot be performed on an instance that is part of a streaming replication cluster in standby mode.

If disk failure occurs on a standby instance, it may be necessary to delete and re-create the instance.

Recovery operation can be performed on an instance that is part of a streaming replication cluster in "Master" mode. If a recovery operation is performed on a master instance, it will break the replication cluster and streaming replication will stop between the master instance and all its standby instances. In such an event, the standby instances can be promoted to standalone instances or can be deleted and re-created.

If failure occurred in the data storage disk or the transaction log storage disk

Follow the procedure below to recover the data storage disk or the transaction log storage disk.

1. Stop applications

   Stop applications that are using the database.

2. Stop the instance

   Stop the instance. Refer to "2.1.1 Using WebAdmin" for information on how to stop an instance. WebAdmin automatically stops instances if recovery of the database cluster is performed without stopping the instance.

3. Recover the failed disk

   Replace the disk, and then recover the volume configuration information.

4. Create a tablespace directory

   If a tablespace was defined after backup, create a directory for it.

5. Recover the keystore, and enable automatic opening of the keystore

   Do the following if the data in the database has been encrypted:

   - Restore the keystore to its state at the time of the database backup.
   - Enable automatic opening of the keystore.

6. Recover the database cluster

   Log in to WebAdmin, and in the [Instances] tab, click [Solution] for the error message in the lower-right corner.

7. Run recovery

   In the [Restore Instance] dialog box, click [Yes].

   Instance restore is performed. An instance is automatically started when recovery is successful.

8. Resume applications

   Resume applications that are using the database.

Point

WebAdmin may be unable to detect disk errors, depending on how the error occurred.

If this happens, refer to "17.10.3 Other Errors" to perform recovery.

If failure occurred on the backup data storage disk

Follow the procedure below to recover the backup data storage disk.

1. Recover the failed disk

   Replace the disk, and then recover the volume configuration information.

2. Recover the backup data

   Log in to WebAdmin, and in the [Instances] tab, click [Solution] for the error message.

3. Run backup

   Perform backup to enable recovery of the backup data. In the [Backup] dialog box, click [Yes]. The backup is performed. An instance is automatically started when backup is performed.

Point

If you click [Recheck the status], the resources in the data storage destination and the backup data storage destination are reconfirmed. As a result, the following occurs:

- If an error is not detected

  The status of the data storage destination and the backup data storage destination returns to normal, and it is possible to perform operations as usual.

- If an error is detected

  An error message is displayed in the message list again. Click [Solution], and resolve the problem by following the resolution for the cause of the error displayed in the dialog box.

17.1.2 Using Server Command

Recover the database cluster by following the appropriate recovery procedure below for the disk where the failure occurred.

If failure occurred on the data storage disk or the transaction log storage directory

Follow the procedure below to recover the data storage disk or the transaction log storage directory.

1. Stop applications

   Stop applications that are using the database.

2. Stop the instance

   Stop the instance, refer to "2.1.2 Using Server Commands" for details.

   If the instance fails to stop, refer to "17.11 Actions in Response to Failure to Stop an Instance".

3. Recover the failed disk

   Replace the disk, and then recover the volume configuration information.

4. Create a storage destination directory

   - If failure occurred on the data storage disk
     Create a data storage destination directory. If a tablespace was defined, also create a directory for it.
   - If failure occurred on the translation log storage disk
     Create a transaction log storage destination directory.

   Example

   To create a data storage destination directory:

   ```
   $ mkdir /database/inst1
   $ chown fsepuser:fsepuser /database/inst1
   $ chmod 700 /database/inst1
   ```

   See

   Refer to "Preparing Directories to Deploy Resources" under "Setup" in the Installation and Setup Guide for Server for information on how to create a storage directory.

5. Recover the keystore, and enable automatic opening of the keystore

   When the data in the database has been encrypted, restore the keystore to its state at the time of the database backup. Configure automatic opening of the keystore as necessary.

6. Recover the database cluster

   Recover the database cluster using the backup data.

   Specify the following in the pgx_rcvall command:

   - Specify the data storage location in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.
   - Specify the backup data storage location in the -B option.

   Example

   ```
   > pgx_rcvall -D /database/inst1 -B /backup/inst1
   ```

   Note

   If recovery fails, remove the cause of the error in accordance with the displayed error message and then re-execute the pgx_rcvall command.

   If the message "pgx_rcvall: an error occurred during recovery" is displayed, then the log recorded when recovery was executed is output after this message. The cause of the error is output in around the last fifteen lines of the log, so remove the cause of the error in accordance with the message and then re-execute the pgx_rcvall command.

The following message displayed during recovery is output as part of normal operation of pgx_rcvall command (therefore the user does not need not be concerned).

```
FATAL:  the database system is starting up
```

7. Start the instance

   Start the instance.

   Refer to "2.1.2 Using Server Commands" for information on how to start an instance.

8. Resume applications

   Resume applications that are using the database.

If failure occurred on the backup data storage disk

The procedure for recovering the backup data storage disk is described below.

There are two methods of taking action:

- Performing recovery while the instance is active
- Stopping the instance before performing recovery

The following table shows the different steps to be performed depending on whether you stop the instance.

No	Step	Instance stopped	
		No	Yes
1	Confirm that transaction log mirroring has stopped	Y	N
2	Stop output of archive logs	Y	N
3	Stop applications	N	Y
4	Stop the instance	N	Y
5	Recover the failed disk	Y	Y
6	Create a backup data storage destination directory	Y	Y
7	Resume output of archive logs	Y	N
8	Resume transaction log mirroring	Y	N
9	Start the instance	N	Y
10	Run backup	Y	Y
11	Resume applications	N	Y

Y: Required
N: Not required

The procedure is as follows:

If an instance has not been stopped

1. Confirm that transaction log mirroring has stopped

   Use the following SQL function to confirm that transaction log mirroring has stopped.

```
 postgres=# SELECT pgx_is_wal_multiplexing_paused();
 pgx_is_wal_multiplexing_paused
--------------------
 t
(1 row)
```

   If transaction log mirroring has not stopped, then stop it using the following SQL function.

```
postgres=# SELECT pgx_pause_wal_multiplexing();
LOG:  multiplexing of transaction log files has been stopped
pgx_pause_wal_multiplexing
---------------------------

(1 row)
```

2. Stop output of archive logs

   Transaction logs may accumulate during replacement of backup storage disk, and if the data storage disk or the transaction log storage disk becomes full, there is a risk that operations may not be able to continue.

   To prevent this, use the following methods to stop output of archive logs.

   - Changing archive_command

     Specify a command that will surely complete normally, such as "echo skipped archiving WAL file %f" or "/bin/true", so that archive logs will be regarded as having been output.

     If you specify echo, a message is output to the server log, so it may be used as a reference when you conduct investigations.

   - Reload the configuration file

     Execute the pg_ctl reload command or the pg_reload_conf SQL function to reload the configuration file.

   If you simply want to stop output of errors without the risk that operations will not be able to continue, specify an empty string ('') in archive_command and reload the configuration file.

3. Recover the failed disk

   Replace the disk, and then recover the volume configuration information.

4. Create a backup data storage destination

   Create a backup data storage destination.

   Example

   ```
   $ mkdir /database/inst1
   $ chown fsepuser:fsepuser /database/inst1
   $ chmod 700 /database/inst1
   ```

   Refer to "3.2.2 Using Server Commands" for information on how to create a backup data storage destination.

5. Resume output of archive logs

   Return the archive_command setting to its original value, and reload the configuration file.

6. Resume transaction log mirroring

   Execute the pgx_resume_wal_multiplexing SQL function.

   Example

   ```
   SELECT pgx_resume_wal_multiplexing()
   ```

7. Run backup

   Use the pgx_dmpall command to back up the database cluster.

   Specify the following value in the pgx_dmpall command:

   - Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

   Example

```
> pgx_dmpall -D /database/inst1
```

If an instance has been stopped

1. Stop applications

   Stop applications that are using the database.

2. Stop the instance

   Stop the instance. Refer to "2.1.2 Using Server Commands" for details.

   If the instance fails to stop, refer to "17.11 Actions in Response to Failure to Stop an Instance".

3. Recover the failed disk

   Replace the disk, and then recover the volume configuration information.

4. Create a backup data storage destination

   Create a backup data storage destination.

   Example

   ```
   # mkdir /backup/inst1
   # chown fsepuser:fsepuser /backup/inst1
   # chmod 700 /backup/inst1
   ```

   Refer to "3.2.2 Using Server Commands" for details.

5. Start the instance

   Start the instance. Refer to "2.1.2 Using Server Commands" for information on how to start an instance.

6. Run backup

   Use the pgx_dmpall command to back up the database cluster.

   Specify the following value in the pgx_dmpall command:

   - Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

   Example

   ```
   > pgx_dmpall -D /database/inst1
   ```

7. Resume applications

   Resume applications that are using the database.

See

- Refer to "pgx_rcvall" and "pgx_dmpall" in the Reference for information on the pgx_rcvall command and pgx_dmpall command.
- Refer to "Write Ahead Log" under "Server Administration" in the PostgreSQL Documentation for information on archive_command.
- Refer to "B.1 WAL Mirroring Control Functions" for information on pgx_resume_wal_multiplexing.

17.2 Recovering from Data Corruption

If data in a disk is logically corrupted and the database does not operate properly, you can recover the database cluster to its state at the time of backup.

There are two methods of recovery:

- 17.2.1 Using WebAdmin
- 17.2.2 Using the pgx_rcvall Command

Note

- Back up the database cluster after recovering it. Backup deletes obsolete archive logs (transaction logs copied to the backup data storage destination), freeing up disk space and reducing the recovery time.
- If you recover data to a point in the past, a new time series (database update history) will start from that recovery point. When recovery is complete, the recovery point is the latest point in the new time series. When you subsequently recover data to the latest state, the database update is re-executed on the new time series.

17.2.1 Using WebAdmin

If using WebAdmin, recover the data to the point immediately prior to data corruption by using the backup data.

Refer to "17.1.1 Using WebAdmin" for details.

17.2.2 Using the pgx_rcvall Command

Recover the database cluster by specifying in the pgx_rcvall command the date and time of the backup you want to read from. Then re-execute the transaction as required to recover the data.

Follow the procedure below to recover the data storage disk.

1. Stop applications

   Stop applications that are using the database.

2. Stop the instance

   Stop the instance. Refer to "2.1.2 Using Server Commands" for information on how to stop an instance.

   If the instance fails to stop, refer to "17.11 Actions in Response to Failure to Stop an Instance".

3. Confirm the backup date and time

   Execute the pgx_rcvall command to confirm the backup data saved in the backup data storage destination, and determine a date and time prior to data corruption.

   Specify the following values in the pgx_rcvall command:

   - Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.
   - Specify the backup storage directory in the -B option.
   - The -l option displays the backup data information.

   Example

   ```
   > pgx_rcvall -D /database/inst1 -B /backup/inst1 -l
   Date                    Status          Dir
   2022-03-20 10:00:00     COMPLETE        /backup/inst1/2022-03-20_10-00-00
   ```

4. Recover the keystore, and enable automatic opening of the keystore

   When the data in the database has been encrypted, restore the keystore to its state at the time of the database backup. Configure automatic opening of the keystore as necessary.

5. Recover the database cluster

   Use the pgx_rcvall command to recover the database cluster.

   Specify the following values in the pgx_rcvall command:

   - Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.
   - Specify the backup storage directory in the -B option.

- Specify the recovery date and time in the -e option.

Example

In the following examples, "March 20, 2022 10:00:00" is specified as the recovery time.

```
> pgx_rcvall -D /database/inst1 -B /backup/inst1 -e '2022-03-20 10:00:00'
```

Note

If recovery fails, remove the cause of the error in accordance with the displayed error message and then re-execute the pgx_rcvall command.

If the message "pgx_rcvall: an error occurred during recovery" is displayed, then the log recorded when recovery was executed is output after this message. The cause of the error is output in around the last fifteen lines of the log, so remove the cause of the error in accordance with the message and then re-execute the pgx_rcvall command.

The following message displayed during recovery is output as part of normal operation of pgx_rcvall command (therefore the user does not need not be concerned).

```
FATAL: the database system is starting up
```

6. Start the instance

   Start the instance. Refer to "2.1.2 Using Server Commands" for information on how to start an instance.

   If necessary, re-execute transaction processing from the specified recovery time, and then resume database operations.

7. Resume applications

   Resume applications that are using the database.

See

Refer to "pgx_rcvall" in the Reference for information on the pgx_rcvall command.

17.3 Recovering from an Incorrect User Operation

This section describes how to recover database clusters when data has been corrupted due to erroneous user operations.

There are two methods of recovery:

- 17.3.1 Using WebAdmin
- 17.3.2 Using the pgx_rcvall Command

Note

- Back up the database cluster after recovering it. Backup deletes obsolete archive logs (transaction logs copied to the backup data storage destination), freeing up disk space and reducing the recovery time.
- If you recover data to a point in the past, a new time series (database update history) will start from that recovery point. When recovery is complete, the recovery point is the latest point in the new time series. When you subsequently recover data to the latest state, the database update is re-executed on the new time series.
- An effective restore point is one created on a time series for which you have made a backup. That is, if you recover data to a point in the past, you cannot use any restore points set after that recovery point. Therefore, once you manage to recover your target past data, make a backup.

17.3.1 Using WebAdmin

You can use WebAdmin to recover data to a backup point.

Note

Recovery operation cannot be performed on an instance that is part of a streaming replication cluster in standby mode.

If disk failure occurs on a standby instance, it may be necessary to delete and re-create the instance.

Recovery operation can be performed on an instance that is part of a streaming replication cluster in "Master" mode. If a recovery operation is performed on a master instance, it will break the replication cluster and streaming replication will stop between the master instance and all its standby instances. In such an event, the standby instances can be promoted to standalone instances or can be deleted and re-created.

Follow the procedure below to recover the data in the data storage disk.

1. Stop applications

   Stop applications that are using the database.

2. Stop the instance

   Stop the instance. Refer to "2.1.1 Using WebAdmin" for information on how to stop an instance.

3. Recover the keystore, and enable automatic opening of the keystore

   Do the following if the data in the database has been encrypted:

   - Restore the keystore to its state at the time of the database backup.
   - Enable automatic opening of the keystore.

4. Recover the database cluster

   Log in to WebAdmin, and in the [Instances] tab, select the instance to be recovered and click  .

5. Recover to the backup point

   In the [Restore Instance] dialog box, click [Yes].

   Recovery is performed. An instance is automatically started when recovery is successful.

6. Resume database operations

   If necessary, re-execute transaction processing from the backup point to when an erroneous operation was performed, and then resume database operations.

17.3.2 Using the pgx_rcvall Command

The pgx_rcvall command recovers database clusters to the restore point created with the server command. Refer to "Setting a restore point" in "3.2.2 Using Server Commands" for information on how to create a restore point.

Follow the procedure below to recover the data in the data storage disk.

1. Stop applications

   Stop applications that are using the database.

2. Stop the instance

   Stop the instance. Refer to "2.1.2 Using Server Commands" for information on how to stop an instance.

   If the instance fails to stop, refer to "17.11 Actions in Response to Failure to Stop an Instance".

3. Confirm the restore point

   Execute the pgx_rcvall command to confirm the backup data saved in the backup data storage destination, and use a restore point recorded in an arbitrary file, as explained in "3.2.2 Using Server Commands", to determine a restore point prior to the erroneous operation.

Specify the following values in the pgx_rcvall command:

- Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.
- Specify the backup data storage destination in the -B option.
- The -l option displays the backup data information.

Example

```
> pgx_rcvall -D /database/inst1 -B /backup/inst1 -l
Date                    Status          Dir
2022-03-01 10:00:00     COMPLETE        /backup/inst1/2022-03-01_10-00-00
```

4. Recover the keystore, and enable automatic opening of the keystore

   When the data in the database has been encrypted, restore the keystore to its state at the time of the database backup. Configure automatic opening of the keystore as necessary.

5. Recover the database cluster

   Use the pgx_rcvall command to recover the database cluster.

   Specify the following values in the pgx_rcvall command:

   - Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.
   - Specify the backup data storage destination in the -B option.
   - The -n option recovers the data to the specified restore point.

   Example

   The following example executes the pgx_rcvall command with the restore point "batch_20220303_1".

```
> pgx_rcvall -D /database/inst1 -B /backup/inst1 -n batch_20220303_1
```

Note

If recovery fails, remove the cause of the error in accordance with the displayed error message and then re-execute the pgx_rcvall command.

If the message "pgx_rcvall: an error occurred during recovery" is displayed, then the log recorded when recovery was executed is output after this message. The cause of the error is output in around the last fifteen lines of the log, so remove the cause of the error in accordance with the message and then re-execute the pgx_rcvall command.

The following message displayed during recovery is output as part of normal operation of pgx_rcvall (therefore the user does not need not be concerned).

```
FATAL:  the database system is starting up
```

6. Start the instance

   Start the instance.

   Refer to "2.1.2 Using Server Commands" for information on how to start an instance.

7. Restart operation of the database

   If necessary, re-execute transaction processing from the specified recovery time to the point when an erroneous operation was performed, and then resume database operations.

See

Refer to "pgx_rcvall" in the Reference for information on the pgx_rcvall command.

17.4 Actions in Response to an Application Error

If there is a connection from a client that has been in the waiting state for an extended period, you can minimize performance degradation of the database by closing the problematic connection.

The following methods are available for identifying a connection to be closed:

- view(pg_stat_activity) (refer to "17.4.1 When using the view (pg_stat_activity)")
- ps command (refer to "17.4.2 Using the ps Command")

Use the system management function (pg_terminate_backend) to disconnect connections.

17.4.1 When using the view (pg_stat_activity)

When using the view (pg_stat_activity), follow the procedure below to close a connection.

1. Use psql command to connect to the postgres database.

```
> psql postgres
psql (14.0)
Type "help" for help.
```

2. Close connections from clients that have been in the waiting state for an extended period.

   Use pg_terminate_backend() to close connections that have been trying to connect for an extended period.

   However, when considering continued compatibility of applications, do not reference or use system catalogs and functions directly in SQL statements. Refer to " Notes on Application Compatibility" in the Application Development Guide for details.

   Example

   The following example closes connections where the client has been in the waiting state for at least 60 minutes.

```
select pid,usename,application_name,client_addr,pg_terminate_backend(pid) from pg_stat_activity
where backend_type = 'client backend' and state='idle in transaction' and current_timestamp >
cast(query_start + interval '60 minutes' as timestamp);
-[ RECORD 1 ]--------+--------------
pid                  | 4684
username             | fsepuser
application_name     | apl1
client_addr          | 192.11.11.1
pg_terminate_backend | t
```

See

- Refer to "System Administration Functions" under "The SQL Language" in the PostgreSQL Documentation for information on pg_terminate_backend.
- Refer to "Notes on Application Compatibility" in the Application Development Guide for information on how to maintain application compatibility.

17.4.2 Using the ps Command

Follow the procedure below to close a connection using a standard Unix tool (ps command).

1. Execute the ps command.
   Note that "<*x*>" indicates the product version.

```
> ps axwfo user,pid,ppid,tty,command | grep postgres
fsepuser 19174 18027 pts/1                \_ grep postgres
fsepuser 20517     1 ?      /opt/fsepv<x>server64/bin/postgres -D /disk01/data
```

```
fsepuser 20518 20517 ?        \_ postgres: logger
fsepuser 20520 20517 ?        \_ postgres: checkpointer
fsepuser 20521 20517 ?        \_ postgres: background writer
fsepuser 20522 20517 ?        \_ postgres: walwriter
fsepuser 20523 20517 ?        \_ postgres: autovacuum launcher
fsepuser 20524 20517 ?        \_ postgres: archiver
fsepuser 20525 20517 ?        \_ postgres: stats collector
fsepuser 18673 20517 ?        \_ postgres: fsepuser postgres 192.168.100.1(49448) idle
fsepuser 16643 20517 ?        \_ postgres: fsepuser db01 192.168.100.11(49449) UPDATE waiting
fsepuser 16644 20517 ?        \_ postgres: fsepuser db01 192.168.100.12(49450) idle in transaction
```

Process ID 16643 may be a connection that was established a considerable time ago by the UPDATE statement, or a connection that has occupied resources (waiting).

2. Close connections from clients that have been in the waiting state for an extended period.

   Use pg_terminate_backend() to close the connection with the process ID identified in step 1 above.

   The example below disconnects the process with ID 16643.

   However, when considering continued compatibility of applications, do not reference or use system catalogs and functions directly in SQL statements.

```
postgres=# SELECT pg_terminate_backend (16643);
 pg_terminate_backend
----------------------
t
(1 row)
```

See

- Refer to "System Administration Functions" under "The SQL Language" in the PostgreSQL Documentation for information on pg_terminate_backend.
- Refer to "Notes on Application Compatibility" in the Application Development Guide for information on how to maintain application compatibility.

17.5 Actions in Response to an Access Error

If access is denied, grant privileges allowing the instance administrator to operate the following directories, and then re-execute the operation. Also, refer to the event log and the server log, and confirm that the file system has not been mounted as read-only due to a disk error. If the file system has been mounted as read-only, mount it properly and then re-execute the operation.

- Data storage destination
- Tablespace storage destination
- Transaction log storage destination
- Backup data storage destination

See

Refer to "Preparing Directories to Deploy Resources" under "Setup" in the Installation and Setup Guide for Server for information on the privileges required for the directory.

17.6 Actions in Response to Insufficient Space on the Data Storage Destination

If the data storage destination runs out of space, check if the disk contains any unnecessary files and delete them so that operations can continue.

If deleting unnecessary files does not solve the problem, you must migrate data to a disk with larger capacity.

There are two methods of migrating data:

- 17.6.1 Using a Tablespace
- 17.6.2 Replacing the Disk with a Larger Capacity Disk

17.6.1 Using a Tablespace

FUJITSU Enterprise Postgres enables you to use a tablespace to change the storage destination of database objects, such as tables and indexes, to a different disk.

The procedure is as follows:

1. Create a tablespace

   Use the CREATE TABLESPACE command to create a new tablespace in the prepared disk.

2. Modify the tablespace

   Use the ALTER TABLE command to modify tables for the newly defined tablespace.

See

Refer to "SQL Commands" under "Reference" in the PostgreSQL Documentation for information on the CREATE TABLESPACE command and ALTER TABLE command.

17.6.2 Replacing the Disk with a Larger Capacity Disk

Before replacing the disk with a larger capacity disk, migrate resources at the data storage destination using the backup and recovery features.

There are two methods of performing backup and recovery:

- 17.6.2.1 Using WebAdmin
- 17.6.2.2 Using Server Commands

The following sections describe procedures that use each of these methods to replace the disk and migrate resources at the data storage destination.

Note

- Before replacing the disk, stop applications and instances that are using the database.
- It is recommended that you back up the database cluster following recovery. Backup deletes obsolete archive logs (transaction logs copied to the backup data storage destination), freeing up disk space and reducing the recovery time.

17.6.2.1 Using WebAdmin

Follow the procedure below to replace the disk and migrate resources at the data storage destination by using WebAdmin.

1. Back up files

   If the disk at the data storage destination contains any required files, back up the files. It is not necessary to back up the data storage destination.

2. Stop applications

   Stop applications that are using the database.

3. Back up the database cluster

   Back up the latest resources at the data storage destination. Refer to "3.2.1 Using WebAdmin" for details.

4. Stop the instance

   Stop the instance. Refer to "2.1.1 Using WebAdmin" for information on how to stop an instance.

5. Replace with a larger capacity disk

   Replace the disk. Then, recover the volume configuration information.

6. Recover the database cluster

   Log in to WebAdmin, and perform recovery operations. Refer to steps 4 ("Create a tablespace directory ") to 7 ("Run recovery") under "If failure occurred in the data storage disk or the transaction log storage disk" in "17.1.1 Using WebAdmin" for information on the procedure. An instance is automatically started when recovery is successful.

7. Resume applications

   Resume applications that are using the database.

8. Restore the files

   Restore the files backed up in step 1.

17.6.2.2 Using Server Commands

Follow the procedure below to replace the disk and migrate resources at the data storage destination by using server commands.

1. Back up files

   If the disk at the data storage destination contains any required files, back up the files. It is not necessary to back up the data storage destination.

2. Stop applications

   Stop applications that are using the database.

3. Back up the database cluster

   Back up the latest resources at the data storage destination. Refer to "3.2.2 Using Server Commands" for details.

4. Stop the instance

   After backup is complete, stop the instance. Refer to "2.1.2 Using Server Commands" for information on how to stop an instance.

   If the instance fails to stop, refer to "17.11 Actions in Response to Failure to Stop an Instance".

5. Replace with a larger capacity disk

   Replace the disk. Then, recover the volume configuration information.

6. Create a data storage destination

   Create a data storage destination. If a tablespace was defined, also create a directory for it.

   Example

   ```
   $ mkdir /database/inst1
   $ chown fsepuser:fsepuser /database/inst1
   $ chmod 700 /database/inst1
   ```

7. Recover the keystore, and enable automatic opening of the keystore

   When the data in the database has been encrypted, restore the keystore to its state at the time of the database backup. Configure automatic opening of the keystore as necessary.

8. Recover the database cluster

   Use the pgx_rcvall command to recover the database cluster.

   - Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.
   - Specify the backup storage directory in the -B option.

   Example

```
> pgx_rcvall -D /database/inst1 -B /backup/inst1
```

   Note

   If recovery fails, remove the cause of the error in accordance with the displayed error message and then re-execute the pgx_rcvall command.

   If the message "pgx_rcvall: an error occurred during recovery" is displayed, then the log recorded when recovery was executed is output after this message. The cause of the error is output in around the last fifteen lines of the log, so remove the cause of the error in accordance with the message and then re-execute the pgx_rcvall command.

   The following message displayed during recovery is output as part of normal operation of pgx_rcvall (therefore the user does not need not be concerned).

```
FATAL:  the database system is starting up
```

   See

   Refer to "pgx_rcvall" in the Reference for information on the pgx_rcvall command.

9. Start the instance

   Start the instance.

   Refer to "2.1.2 Using Server Commands" for information on how to start an instance.

10. Resume applications

    Resume applications that are using the database.

11. Restore files

    Restore the files backed up in step 1.

17.7 Actions in Response to Insufficient Space on the Backup Data Storage Destination

If space runs out on the backup data storage destination, check if the disk contains any unnecessary files and delete them, and then make a backup as required.

If deleting unnecessary files does not solve the problem, take the following action:

- 17.7.1 Temporarily Saving Backup Data
- 17.7.2 Replacing the Disk with a Larger Capacity Disk

17.7.1 Temporarily Saving Backup Data

This method involves temporarily moving backup data to a different directory, saving it there, and securing disk space on the backup data storage destination so that a backup can be made normally.

Use this method if you need time to prepare a larger capacity disk.

If space runs out on the backup data storage destination, archive logs can no longer be stored in the backup data storage destination. As a result, transaction logs continue to accumulate in the data storage destination or the transaction log storage destination.

If action is not taken soon, the transaction log storage destination will become full, and operations may not be able to continue.

To prevent this, secure space in the backup data storage destination, so that archive logs can be stored.

There are two methods of taking action:

- 17.7.1.1 Using WebAdmin
- 17.7.1.2 Using Server Commands

17.7.1.1 Using WebAdmin

Follow the procedure below to recover the backup data storage disk.

1. Temporarily save backup data

   Move backup data to a different directory and temporarily save it, and secure space in the backup data storage destination directory.

   The reason for saving the backup data is so that the data in the data storage destination can be recovered even if it is corrupted before you perform recovery. If there is no disk at the save destination and you consider that there is no risk of corruption at the data storage destination, delete the backup data.

   The following example saves backup data from the backup data storage destination directory (/backup/inst1) under /mnt/usb/backup.

   Example

   ```
   > mkdir /mnt/usb/backup/
   > mv /backup/inst1/* /mnt/usb/backup/
   ```

2. Back up the database cluster

   Back up the latest resources at the data storage destination. Refer to "3.2.1 Using WebAdmin" for details.

3. Delete temporarily saved backup data

   If backup completes normally, the temporarily saved backup data becomes unnecessary and is deleted.

   The following example deletes backup data that was temporarily saved in /mnt/usb.

   Example

   ```
   > rm -rf /mnt/usb/backup
   ```

17.7.1.2 Using Server Commands

The following describes the procedure for recovering the backup storage disk.

There are two methods of taking action:

- Performing recovery while the instance is active
- Stopping the instance before performing recovery

The following table shows the different steps to be performed depending on whether you stop the instance.

No	Step	Instance stopped	
		No	Yes
1	Stop transaction log mirroring	Y	N
2	Stop output of archive logs	Y	N
3	Stop applications	N	Y
4	Stop the instance	N	Y
5	Temporarily save backup data	Y	Y

No	Step	Instance stopped	
		No	Yes
6	Resume output of archive logs	Y	N
7	Resume transaction log mirroring	Y	N
8	Start an instance	N	Y
9	Run backup	Y	Y
10	Resume applications	N	Y
11	Delete temporarily saved backup data	Y	Y

Y: Required
N: Not required

The procedure is as follows:

Performing recovery while the instance is active

1. Stop transaction log mirroring

   Stop transaction log mirroring.

   ```
   postgres=# SELECT pgx_pause_wal_multiplexing();
   LOG:  multiplexing of transaction log files has been stopped
   pgx_pause_wal_multiplexing
   ---------------------------

   (1 row)
   ```

2. Stop output of archive logs

   Transaction logs may accumulate during replacement of backup storage disk, and if the data storage disk or the transaction log storage disk becomes full, there is a risk that operations may not be able to continue.

   To prevent this, use the following methods to stop output of archive logs.

   - Changing the archive_command parameter

     Specify a command that will surely complete normally, such as "echo skipped archiving WAL file %f" or "/bin/true", so that archive logs will be regarded as having been output.

     If you specify echo, a message is output to the server log, so it may be used as a reference when you conduct investigations.

   - Reloading the configuration file

     Run the pg_ctl reload command or the pg_reload_conf SQL function.

   If you simply want to stop output of errors without the risk that operations will not be able to continue, specify an empty string ('') in archive_command and reload the configuration file.

3. Temporarily save backup data

   Move backup data to a different directory and temporarily save it, and secure space in the backup data storage destination directory.

   The reason for saving the backup data is so that the data in the data storage destination can be recovered even if it is corrupted before you perform the next step. If there is no disk at the save destination and you consider that there is no risk of corruption at the data storage destination, delete the backup data.

   The following example saves backup data from the backup data storage destination directory (/backup/inst1) under /mnt/usb/backup.

   Example

   ```
   > mkdir /mnt/usb/backup/
   > mv /backup/inst1/* /mnt/usb/backup/
   ```

4. Resume output of archive logs

   Return the archive_command setting to its original value, and reload the configuration file.

5. Resume transaction log mirroring

   Execute the pgx_resume_wal_multiplexing SQL function.

   Example

   ```
   SELECT pgx_resume_wal_multiplexing()
   ```

6. Run backup

   Use the pgx_dmpall command to back up the database cluster.

   Specify the following option in the pgx_dmpall command:

   - Specify the directory of the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

     Example

     ```
     > pgx_dmpall -D /database/inst1
     ```

7. Delete temporarily saved backup data

   If backup completes normally, the temporarily saved backup data becomes unnecessary and is deleted.

   The following example deletes backup data that was temporarily saved in /mnt/usb.

   Example

   ```
   > rm -rf /mnt/usb/backup
   ```

If an instance has been stopped

1. Stop applications

   Stop applications that are using the database.

2. Stop the instance

   Stop the instance. Refer to "2.1.2 Using Server Commands" for details.

   If the instance fails to stop, refer to "17.11 Actions in Response to Failure to Stop an Instance".

3. Temporarily save backup data

   Move backup data to a different directory and temporarily save it, and secure space in the backup data storage destination directory.

   The reason for saving the backup data is so that the data in the data storage destination can be recovered even if it is corrupted before you perform recovery. If there is no disk at the save destination and you consider that there is no risk of corruption at the data storage destination, delete the backup data.

   The following example saves backup data from the backup data storage destination directory (/backup/inst1) under /mnt/usb/backup.

   Example

   ```
   > mkdir /mnt/usb/backup/
   > mv /backup/inst1/* /mnt/usb/backup/
   ```

4. Start the instance

   Start the instance. Refer to "2.1.2 Using Server Commands" for information on how to start an instance.

5. Run backup

   Use the pgx_dmpall command to back up the database cluster.

   Specify the following value in the pgx_dmpall command:

- Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

  Example

  ```
  > pgx_dmpall -D /database/inst1
  ```

6. Resume applications

   Resume applications that are using the database.

7. Delete temporarily saved backup data

   If backup completes normally, the temporarily saved backup data becomes unnecessary and is deleted.

   The following example deletes backup data that was temporarily saved in /mnt/usb.

   Example

   ```
   > rm -rf /mnt/usb/backup
   ```

See

- Refer to "pgx_rcvall" and "pgx_dmpall" in the Reference for information on the pgx_rcvall command and pgx_dmpall command.
- Refer to "Write Ahead Log" under "Server Administration" in the PostgreSQL Documentation for information on archive_command.
- Refer to "B.1 WAL Mirroring Control Functions" for information on the pgx_is_wal_multiplexing_paused and pgx_resume_wal_multiplexing.

17.7.2 Replacing the Disk with a Larger Capacity Disk

This method involves replacing the disk at the backup data storage destination with a larger capacity disk, so that it does not run out of free space again. After replacing the disk, back up data to obtain a proper backup.

There are two methods of performing backup:

- 17.7.2.1 Using WebAdmin
- 17.7.2.2 Using Server Commands

Note

Before replacing the disk, stop applications that are using the database.

17.7.2.1 Using WebAdmin

Follow the procedure below to recover the backup storage disk.

1. Back up files

   If the disk at the backup data storage destination contains any required files, back up the files. It is not necessary to back up the backup data storage destination.

2. Temporarily save backup data

   Save the backup data to a different directory.

   The reason for saving the backup data is so that the data in the data storage destination can be recovered even if it is corrupted before you perform the next step. If there is no disk at the save destination and you consider that there is no risk of corruption at the data storage destination, delete the backup data.

   The following example saves backup data from the backup data storage destination directory (/backup/inst1) under /mnt/usb/backup.

Example

```
> mkdir /mnt/usb/backup/
> mv /backup/inst1/* /mnt/usb/backup/
```

3. Replace with a larger capacity disk

   Replace the disk. Then, recover the volume configuration information.

4. Run backup

   Log in to WebAdmin, and perform recovery operations. Refer to steps 2 ("Recover the backup data") and 3 ("Run backup") under "If failure occurred on the backup storage disk" in "17.1.1 Using WebAdmin".

5. Restore files

   Restore the files backed up in step 1.

6. Delete temporarily saved backup data

   If backup completes normally, the temporarily saved backup data becomes unnecessary and is deleted.

   The following example deletes backup data that was temporarily saved in /mnt/usb.

   Example

```
> rm -rf /mnt/usb/backup
```

17.7.2.2 Using Server Commands

The procedure for recovering the backup data storage disk is described below.

There are two methods of taking action:

- Performing recovery while the instance is active
- Stopping the instance before performing recovery

The following table shows the different steps to be performed depending on whether you stop the instance.

No	Step	Instance stopped	
		No	Yes
1	Back up files	Y	Y
2	Temporarily save backup data	Y	Y
3	Confirm that transaction log mirroring has stopped	Y	N
4	Stop output of archive logs	Y	N
5	Stop applications	N	Y
6	Stop the instance	N	Y
7	Replace with a larger capacity disk	Y	Y
8	Create a backup storage directory	Y	Y
9	Resume output of archive logs	Y	N
10	Resume transaction log mirroring	Y	N
11	Start the instance	N	Y
12	Run backup	Y	Y
13	Resume applications	N	Y
14	Restore files	Y	Y
15	Delete temporarily saved backup data	Y	Y

Y: Required
N: Not required

The procedure is as follows:

If an instance has not been stopped

1. Back up files

   If the disk at the backup data storage destination contains any required files, back up the files. It is not necessary to back up the backup data storage destination.

2. Temporarily save backup data

   Save the backup data to a different directory.

   The reason for saving the backup data is so that the data in the data storage destination can be recovered even if it is corrupted before you perform the next step. If there is no disk at the save destination and you consider that there is no risk of corruption at the data storage destination, delete the backup data.

   The following example saves backup data from the backup data storage destination directory (/backup/inst1) under /mnt/usb/backup.

   Example

   ```
   > mkdir /mnt/usb/backup/
   > mv /backup/inst1/* /mnt/usb/backup/
   ```

3. Confirm that transaction log mirroring has stopped

   Use the following SQL function to confirm that transaction log mirroring has stopped.

   ```
    postgres=# SELECT pgx_is_wal_multiplexing_paused();
    pgx_is_wal_multiplexing_paused
   -------------------
    t
   (1 row)
   ```

   If transaction log mirroring has not stopped, then stop it using the following SQL function.

   ```
   postgres=# SELECT pgx_pause_wal_multiplexing();
   LOG:  multiplexing of transaction log files has been stopped
   pgx_pause_wal_multiplexing
   ---------------------------

   (1 row)
   ```

4. Stop output of archive logs

   Transaction logs may accumulate during replacement of backup storage disk, and if the data storage destination disk or the transaction log storage destination disk becomes full, there is a risk that operations may not be able to continue.

   To prevent this, use the following methods to stop output of archive logs.

   - Changing the archive_command parameter

     Specify a command that will surely complete normally, such as "echo skipped archiving WAL file %f" or "/bin/true", so that archive logs will be regarded as having been output.

     If you specify echo, a message is output to the server log, so it may be used as a reference when you conduct investigations.

   - Reloading the configuration file

     Run the pg_ctl reload command or the pg_reload_conf SQL function.

   If you simply want to stop output of errors without the risk that operations will not be able to continue, specify an empty string ('') in archive_command and reload the configuration file.

5. Replace with a larger capacity disk

   Replace the disk. Then, recover the volume configuration information.

6. Create a backup data storage destination

   Create a backup data storage destination.

   Example

   ```
   # mkdir /backup/inst1
   # chown fsepuser:fsepuser /backup/inst1
   # chmod 700 /backup/inst1
   ```

   Refer to "3.2.2 Using Server Commands" for details.

7. Resume output of archive logs

   Return the archive_command setting to its original value, and reload the configuration file.

8. Resume transaction log mirroring

   Execute the pgx_resume_wal_multiplexing SQL function.

   Example

   ```
   SELECT pgx_resume_wal_multiplexing()
   ```

9. Run backup

   Use the pgx_dmpall command to back up the database cluster.

   Specify the following value in the pgx_dmpall command:

   - Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

   Example

   ```
   > pgx_dmpall -D /database/inst1
   ```

10. Restore files

    Restore the files backed up in step 1.

11. Delete temporarily saved backup data

    If backup completes normally, the temporarily saved backup data becomes unnecessary and is deleted.

    The following example deletes backup data that was temporarily saved in /mnt/usb.

    Example

    ```
    > rm -rf /mnt/usb/backup
    ```

If an instance has been stopped

1. Back up files

   If the disk at the backup data storage destination contains any required files, back up the files. It is not necessary to back up the backup data storage destination.

2. Temporarily save backup data

   Save the backup data to a different directory.

   The reason for saving the backup data is so that the data in the data storage destination can be recovered even if it is corrupted before you perform the next step. If there is no disk at the save destination and you consider that there is no risk of corruption at the data storage destination, delete the backup data.

The following example saves backup data from the backup data storage destination directory (/backup/inst1) under /mnt/usb/backup.

Example

```
> mkdir /mnt/usb/backup/
> mv /backup/inst1/* /mnt/usb/backup/
```

3. Stop applications

   Stop applications that are using the database.

4. Stop the instance

   Stop the instance. Refer to "2.1.2 Using Server Commands" for information on how to stop an instance.

   If the instance fails to stop, refer to "17.11 Actions in Response to Failure to Stop an Instance".

5. Replace with a larger capacity disk

   Replace the disk. Then, recover the volume configuration information.

6. Create a backup data storage destination

   Create a backup data storage destination.

   Example

   ```
   # mkdir /backup/inst1
   # chown fsepuser:fsepuser /backup/inst1
   # chmod 700 /backup/inst1
   ```

   Refer to "3.2.2 Using Server Commands" for details.

7. Start the instance

   Start the instance. Refer to "2.1.2 Using Server Commands" for information on how to start an instance.

8. Run backup

   Use the pgx_dmpall command to back up the database cluster.

   Specify the following value in the pgx_dmpall command:

   - Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

   Example

   ```
   > pgx_dmpall -D /database/inst1
   ```

9. Resume applications

   Resume applications that are using the database.

10. Restore files

    Restore the files backed up in step 1.

11. Delete temporarily saved backup data

    If backup completes normally, the temporarily saved backup data becomes unnecessary and is deleted.

    The following example deletes backup data that was temporarily saved in /mnt/usb.

    Example

    ```
    > rm -rf /mnt/usb/backup
    ```

See

- Refer to "pgx_rcvall" and "pgx_dmpall" in the Reference for information on the pgx_rcvall command and pgx_dmpall command.
- Refer to "Write Ahead Log" under "Server Administration" in the PostgreSQL Documentation for information on archive_command.
- Refer to "B.1 WAL Mirroring Control Functions" for information on the pgx_is_wal_multiplexing_paused and pgx_resume_wal_multiplexing.

17.8 Actions in Response to Insufficient Space on the Transaction Log Storage Destination

If the transaction log storage destination runs out of space, check if the disk contains any unnecessary files and delete them so that operations can continue.

If deleting unnecessary files does not solve the problem, you must migrate data to a disk with larger capacity.

17.8.1 Replacing the Disk with a Larger Capacity Disk

Before replacing the disk with a larger capacity disk, migrate resources at the transaction log storage destination using the backup and recovery features.

There are two methods of performing backup and recovery:

- 17.8.1.1 Using WebAdmin
- 17.8.1.2 Using Server Commands

The following sections describe procedures that use each of these methods to replace the disk and migrate resources at the transaction log storage destination.

Note

- Before replacing the disk, stop applications that are using the database.
- It is recommended that you back up the database cluster following recovery. Backup deletes obsolete archive logs (transaction logs copied to the backup data storage destination), freeing up disk space and reducing the recovery time.

17.8.1.1 Using WebAdmin

Follow the procedure below to replace the disk and migrate resources at the transaction log storage destination by using WebAdmin.

1. Back up files

   If the disk at the transaction log storage destination contains any required files, back up the files. It is not necessary to back up the transaction log storage destination.

2. Back up the database cluster

   Back up the latest data storage destination resources and transaction log storage destination resources (refer to "3.2.1 Using WebAdmin" for details).

3. Stop applications

   Stop applications that are using the database.

4. Stop the instance

   Stop the instance. Refer to "2.1.1 Using WebAdmin" for information on how to stop an instance. WebAdmin automatically stops instances if recovery of the database cluster is performed without stopping the instance.

5. Replace with a larger capacity disk

   Replace the disk. Then, recover the volume configuration information.

6. Create a tablespace directory

   If a tablespace was defined after backing up, create a directory for it.

7. Recover the keystore, and enable automatic opening of the keystore

   Do the following if the data in the database has been encrypted:

   - Restore the keystore to its state at the time of the database backup.
   - Enable automatic opening of the keystore.

8. Recover the database cluster

   Log in to WebAdmin, and perform recovery operations. Refer to steps 4 ("Create a tablespace directory ") to 7 ("Run Recovery") under " If failure occurred in the data storage disk or the transaction log storage disk " in "17.1.1 Using WebAdmin" for information on the procedure. An instance is automatically started when recovery is successful.

9. Resume applications

   Resume applications that are using the database.

10. Restore files

    Restore the files backed up in step 1.

17.8.1.2 Using Server Commands

Follow the procedure below to replace the disk and migrate resources at the transaction log storage destination by using server commands.

1. Back up files

   If the disk at the transaction log storage destination contains any required files, back up the files. It is not necessary to back up the transaction log storage destination.

2. Back up the database cluster

   Use server commands to back up the latest data storage destination resources and transaction log storage destination resources. Refer to "3.2.2 Using Server Commands" for information on how to perform backup.

3. Stop applications

   Stop applications that are using the database.

4. Stop the instance

   After backup is complete, stop the instance. Refer to "2.1.2 Using Server Commands" for information on how to stop an instance.

   If the instance fails to stop, refer to "17.11 Actions in Response to Failure to Stop an Instance".

5. Replace with a larger capacity disk

   Replace the disk. Then, recover the volume configuration information.

6. Create a transaction log storage destination

   Create a transaction log storage destination. If a tablespace was defined, also create a directory for it.

   Example

   ```
   # mkdir /tranlog/inst1
   # chown fsepuser:fsepuser /tranlog/inst1
   # chmod 700 /tranlog/inst1
   ```

7. Recover the keystore, and enable automatic opening of the keystore

   When the data in the database has been encrypted, restore the keystore to its state at the time of the database backup. Configure automatic opening of the keystore as necessary.

8. Recover the database cluster

   Use the pgx_rcvall command to recover the database cluster.

- Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.
- Specify the backup storage directory in the -B option.

Example

```
> pgx_rcvall -D /database/inst1 -B /backup/inst1
```

Note

If recovery fails, remove the cause of the error in accordance with the displayed error message and then re-execute the pgx_rcvall command.

If the message "pgx_rcvall: an error occurred during recovery" is displayed, then the log recorded when recovery was executed is output after this message. The cause of the error is output in around the last fifteen lines of the log, so remove the cause of the error in accordance with the message and then re-execute the pgx_rcvall command.

The following message displayed during recovery is output as part of normal operation of pgx_rcvall command (therefore the user does not need not be concerned).

```
FATAL:  the database system is starting up
```

See

Refer to "pgx_rcvall" in the Reference for information on the pgx_rcvall command.

9. Start the instance

   Start the instance.

   Refer to "2.1.2 Using Server Commands" for information on how to start an instance.

10. Resume applications

    Resume applications that are using the database.

11. Restore files

    Restore the files backed up in step 1.

17.9 Errors in More Than One Storage Disk

If an error occurs in the storage destination disks or resources are corrupted, determine the cause of the error from system logs and server logs and remove the cause.

If errors occur in either of the following combinations, you cannot recover the database.

Recreate the instance, and rebuild the runtime environment.

Data storage disk	Transaction log storage disk	Backup data storage disk
Error	-	Error
-	Error	Error

See

Refer to "Setup" in the Installation and Setup Guide for Server for information on how to create an instance and build the runtime environment.

17.10 Actions in Response to Instance Startup Failure

If an instance fails to start, refer to the system log and the server log, and determine the cause of the failure.

If using WebAdmin, remove the cause of the error. Then, click [Solution] and [Recheck the status] and confirm that the instance is in the normal state.

The following sections describe common causes of errors and the actions to take.

17.10.1 Errors in the Configuration File

If you have directly edited the configuration file using a text editor or changed the settings using WebAdmin, refer to the system log and the server log, confirm that no messages relating to the files below have been output.

- postgresql.conf
- pg_hba.conf

See

Refer to the following for information on the parameters in the configuration file:

- "Configuring Parameters" in the Installation and Setup Guide for Server
- "Appendix A Parameters"
- "Server Configuration" and "Client Authentication" under "Server Administration" in the PostgreSQL Documentation

17.10.2 Errors Caused by Power Failure or Mounting Issues

If mounting is cancelled after restarting the server, for example, because the disk device for each storage destination disk was not turned on, or because automatic mounting has not been set, then starting an instance will fail.

Refer to "17.14.2 Errors Caused by Power Failure or Mounting Issues", and take actions accordingly.

17.10.3 Other Errors

This section describes the recovery procedure to be used if you cannot take any action or the instance cannot start even after you have referred to the system log and the server log.

There are two methods of recovery:

- 17.10.3.1 Using WebAdmin
- 17.10.3.2 Using Server Commands

Note that recovery will not be possible if there is an error at the backup data storage destination. If the problem cannot be resolved, contact Fujitsu technical support.

17.10.3.1 Using WebAdmin

Follow the procedure below to perform recovery.

1. Delete the data storage destination directory and the transaction log storage destination directory

   Back up the data storage destination directory and the transaction log storage destination directory before deleting them.

2. Reconfirm the status

   Log in to WebAdmin, and in the [Instances] tab, click [Solution] for the error message.

   Click [Recheck the status] to reconfirm the storage destination resources.

3. Run recovery

   Restore the database cluster after WebAdmin detects an error.

Refer to "17.2.1 Using WebAdmin" for details.

17.10.3.2 Using Server Commands

Follow the procedure below to recover the database.

1. Delete the data storage destination directory and the transaction log storage destination directory

   Save the data storage destination directory and the transaction log storage destination directory, and then delete them.

2. Execute recovery

   Use the pgx_rcvall command to recover the database cluster.

   Refer to "17.2.2 Using the pgx_rcvall Command" for details.

17.11 Actions in Response to Failure to Stop an Instance

If an instance fails to stop, refer to the system log and the server log, and determine the cause of the failure.

If the instance cannot stop despite taking action, perform the following operation to stop the instance.

There are two methods of recovery:

- 17.11.1 Using WebAdmin
- 17.11.2 Using Server Commands

17.11.1 Using WebAdmin

In the [Instances] tab, click  and select the Fast stop mode or the Immediate stop mode to stop the instance. Forcibly terminate the server process from WebAdmin if the instance cannot be stopped.

Refer to "2.1.1 Using WebAdmin" for information on the stop modes.

17.11.2 Using Server Commands

There are three methods:

- Stopping the Instance Using the Fast Mode

  If backup is in progress, then terminate it, roll back all executing transactions, forcibly close client connections, and then stop the instance.

- Stopping the Instance Using the Immediate Mode

  Forcibly terminate the instance immediately. A crash recovery is run when the instance is restarted.

- Forcibly Stopping the Server Process

  Reliably stops the server process when the other methods are unsuccessful.

17.11.2.1 Stopping the Instance Using the Fast Mode

Specify "-m fast" in the pg_ctl command to stop the instance.

If the instance fails to stop when you use this method, stop the instance as described in "17.11.2.2 Stopping the Instance Using the Immediate Mode" or "17.11.2.3 Forcibly Stopping the Server Process".

Example

```
> pg_ctl stop -D /database/inst1 -m fast
```

17.11.2.2 Stopping the Instance Using the Immediate Mode

Specify "-m immediate " in the pg_ctl command to stop the instance.

If the instance fails to stop when you use this method, stop the instance as described in "17.11.2.3 Forcibly Stopping the Server Process".

Example

```
> pg_ctl stop -D /database/inst1 -m immediate
```

17.11.2.3 Forcibly Stopping the Server Process

If both the Fast mode and the Immediate mode fail to stop the instance, use the kill command or the kill parameter of the pg_ctl command to forcibly stop the server process.

The procedure is as follows:

1. Execute the ps command
   Note that "<*x*>" indicates the product version.

   ```
   > ps axwfo user,pid,ppid,tty,command | grep postgres
   fsepuser 19174 18027 pts/1                \_ grep postgres
   fsepuser 20517     1 ?        /opt/fsepv<x>server64/bin/postgres -D /database/inst1
   fsepuser 20518 20517 ?         \_ postgres: logger
   fsepuser 20520 20517 ?         \_ postgres: checkpointer
   fsepuser 20521 20517 ?         \_ postgres: background writer
   fsepuser 20522 20517 ?         \_ postgres: walwriter
   fsepuser 20523 20517 ?         \_ postgres: autovacuum launcher
   fsepuser 20524 20517 ?         \_ postgres: archiver
   fsepuser 20525 20517 ?         \_ postgres: stats collector
   ```

   The process ID (20517) indicates the server process.

2. Forcibly stop the server process

   As instance manager, forcibly stop the server process.

   Using the pg_ctl command

   ```
   > pg_ctl kill SIGQUIT 20517
   ```

   Using the kill command

   ```
   > kill -s SIGQUIT 20517
   ```

17.12 Actions in Response to Failure to Create a Streaming Replication Standby Instance

When creating a streaming replication standby instance using WebAdmin, if the instance creation fails, refer to the system log and the server log, and determine the cause of the failure.

When an error occurs in the creation of the standby instance using WebAdmin, it is unlikely that the partially created standby instance can be resumed to complete the operation.

In such a scenario, fix the cause of the error, delete the partially created standby instance, and then create a new standby instance. This recommendation is based on the following assumptions:

- As the instance is yet to be created completely, there are no applications connecting to the database.
- The standby instance is in error state and is not running.
- There are no backups for the standby instance and as a result, it cannot be recovered.

See

Refer to "Deleting Instances" in the Installation and Setup Guide for details on how to delete an instance.

17.13 Actions in Response to Error in a Distributed Transaction

If a system failure (such as server failure) occurs in an application that uses distributed transactions, then transactions may be changed to the in-doubt state.

At that point, resources accessed by the transaction will be locked, and rendered unusable by other transactions.

The following describes how to check for in-doubt transactions, and how to resolve them.

How to check for in-doubt transactions

The following shows how to check for them:

If the server fails

1. An in-doubt transaction will have occurred if a message similar to the one below is output to the log when the server is restarted.

   Example

   ```
   LOG: Restoring prepared transaction 2103.
   ```

2. Refer to system view pg_prepared_xacts to obtain information about the prepared transaction.

   If the transaction identifier of the prepared transaction in the list (in the transaction column of pg_prepared_xacts) is the same as the identifier of the in-doubt transaction obtained from the log output when the server was restarted, then that row is the information about the in-doubt transaction.

   Example

   ```
   postgres=# select * from pg_prepared_xacts;
    transaction |   gid     |   prepared |  owner   | database
   -------------+-----------+------------+----------+----------
   2103 | 374cc221-f6dc-4b73-9d62-d4fec9b430cd | 2022-03-06 16:28:48.471+08 | postgres |
   postgres (1 row)
   ```

   Information about the in-doubt transaction is output to the row with the transaction ID 2103 in the transaction column.

If the client fails

If there are no clients connected and there is a prepared transaction in pg_prepared_xacts, then you can determine that the transaction is in the in-doubt state.

If at least one client is connected and there is a prepared transaction in pg_prepared_xacts, you cannot determine whether there is a transaction in the in-doubt state. In this case, use the following query to determine the in-doubt transaction from the acquired database name, user name, the time PREPARE TRANSACTION was executed, and the information about the table name accessed.

```
select gid,x.database,owner,prepared,l.relation::regclass as relation from pg_prepared_xacts x
left join pg_locks l on l.virtualtransaction = '-1/'||x.transaction and l.locktype='relation';
```

If it still cannot be determined from this information, wait a few moments and then check pg_prepared_xacts again.

If there is a transaction that has continued since the last time you checked, then it is likely that it is the one in the in-doubt state.

Point

As you can see from the explanations in this section, there is no one way to definitively determine in-doubt transactions.

Consider collecting other supplementary information (for example, logging on the client) or performing other operations (for example, allocating database users per job).

How to resolve in-doubt transactions

From the system view pg_prepared_xacts mentioned above, obtain the global transaction identifier (in the gid column of pg_prepared_xacts) for the in-doubt transaction, and issue either a ROLLBACK PREPARED statement or COMMIT PREPARED statement to resolve the in-doubt transaction.

Example

- Rolling back in-doubt transactions

```
postgres=# rollback prepared '374cc221-f6dc-4b73-9d62-d4fec9b430cd';
ROLLBACK PREPARED
```

- Committing in-doubt transactions

```
postgres=# commit prepared '374cc221-f6dc-4b73-9d62-d4fec9b430cd';
COMMIT PREPARED
```

17.14 I/O Errors Other than Disk Failure

Even if a disk is not defective, the same input-output error messages, as those generated when the disk is defective, may be output.

A few examples of such errors are given below. The appropriate action for each error is explained respectively.

- 17.14.1 Network Error with an External Disk
- 17.14.2 Errors Caused by Power Failure or Mounting Issues

17.14.1 Network Error with an External Disk

This is an error that occurs in the network path to/from an external disk.

Determine the cause of the error by checking the information in the system log and the server log, the disk access LED, network wiring, and network card status. Take appropriate action to remove the cause of the error, for example, replace problematic devices.

17.14.2 Errors Caused by Power Failure or Mounting Issues

These are errors that occur when the disk device is not turned on, automatic mounting of the disk was not set, or mounting was accidentally cancelled.

In this case, check the information in the system log and the server log, the disk access LED, and whether the disk is mounted correctly. If problems are detected, take appropriate action.

If mounting has been cancelled, it is possible that mounting was accidentally cancelled, or automatic mounting at the time of starting the operating system is not set. In this case, set the mounting to be performed automatically.

17.15 Anomaly Detection and Resolution

The following operations performed via the command line interface will result in an anomaly in WebAdmin:

- Changes to the port and backup_destination parameters in postgresql.conf
- Changes to Mirroring Controller configuration of cluster replication added via WebAdmin

This section describes when WebAdmin checks for such anomalies, and what takes place when an anomaly is detected.

17.15.1 Port Number and Backup Storage Path Anomalies

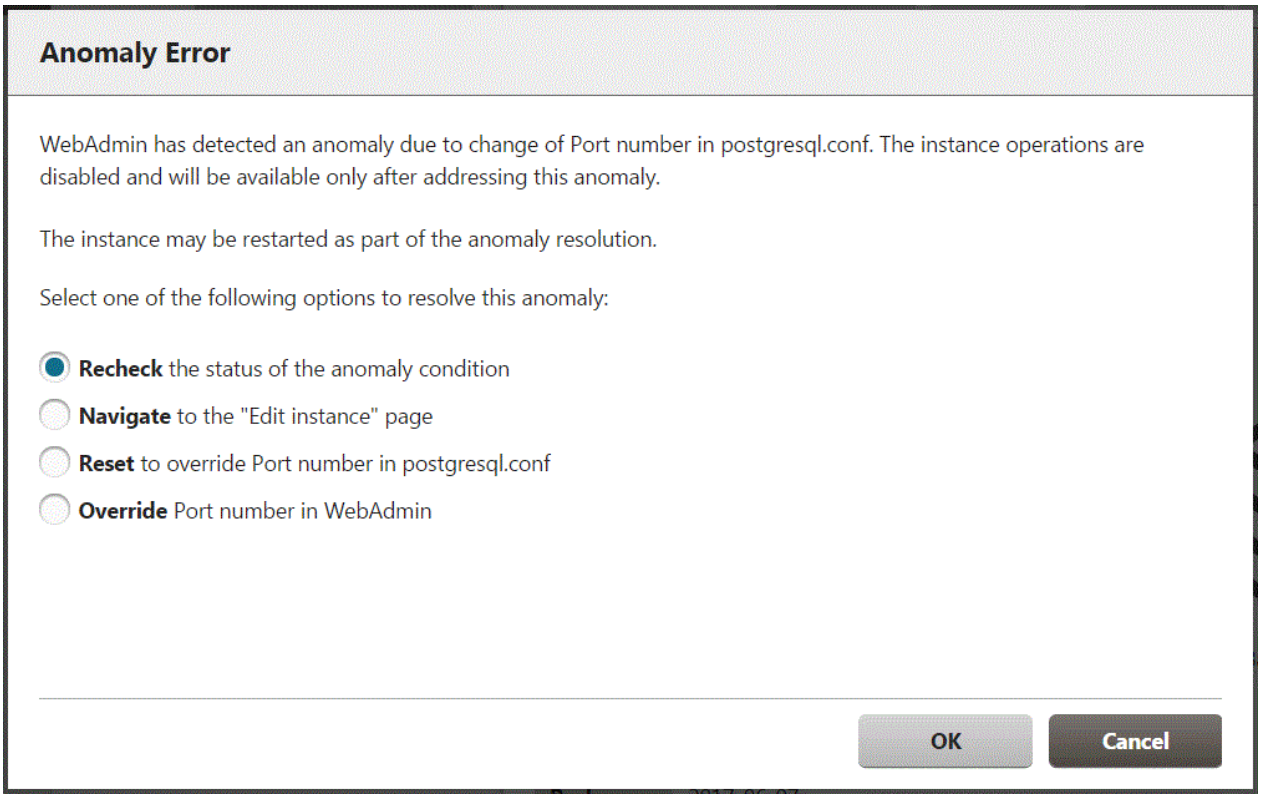
An anomaly occurs when the value of [Port number] and/or [Backup storage path] in WebAdmin is different from the value of its corresponding parameter in postgresql.conf - port and backup_destination, respectively.

WebAdmin checks for anomalies when an instance is selected for viewing or any instance operation is performed. Anomalies will be identified for the selected instance only.

The following occurs when an anomaly is detected in port number and/or backup storage path:

- All instance operation buttons are disabled, except for "Edit instance", "Refresh instance", and "Delete Mirroring Controller"
- A red error status indicator is displayed on the instance icon
- For an anomaly specific to backup storage path, a red error status indicator is displayed on the [Backup storage] disk icon, and [Backup storage status] is set to "Error"
- The message, "WebAdmin has detected an anomaly with...", is displayed in the [Message] section along with an associated [Solution] button

Click [Solution]. The [Anomaly Error] dialog box is displayed.



Select the required option, click [OK], and then resolve the anomaly error.

Refer to "Editing instance information" in the Installation and Setup Guide for Server for information on the [Edit instance] page.

Note

Critical errors encountered during anomaly resolution will be displayed, however, rollback of the instance to its previous state is not supported.

17.15.2 Mirroring Controller Anomalies

The following conditions will cause a Mirroring Controller anomaly:

- The Mirroring Controller management folder or configuration files have been deleted
- The permissions to the Mirroring Controller management folder or configuration files have been changed such that:
  - The instance administrator's access to Mirroring Controller configuration is denied
  - Users other than an instance administrator have access privileges to Mirroring Controller configuration files

WebAdmin checks for anomalies when Mirroring Controller status check is performed.

The following occurs when a Mirroring Controller anomaly is detected:

- All Mirroring Controller functionality is disabled for the replication cluster, except for "Delete Mirroring Controller"
- [Mirroring Controller status] is set to "Error"
- Either of the following messages is displayed in the [Message] section

  "Failed to access the Mirroring Controller management folder or configuration files '*path*'. Mirroring Controller functionality has been disabled. Consider deleting Mirroring Controller and adding it again."

  "Failed to find the Mirroring Controller management folder or configuration files '*path*'. Mirroring Controller functionality has been disabled. Consider deleting Mirroring Controller and adding it again."

Appendix A Parameters

This appendix describes the parameters to be set in the postgresql.conf file of FUJITSU Enterprise Postgres.

The postgresql.conf file is located in the data storage destination.

Information

The maximum value that can be expressed as a 4-byte signed integer changes according to the operating system. Follow the definition of the operating system in use.

- core_directory (string)

  This parameter specifies the directory where the corefile is to be output. If this parameter is omitted, the data storage destination is used by default. This parameter can only be set when specified on starting an instance. It cannot be changed dynamically, while an instance is active.

- core_contents (string)

  This parameter specifies the contents to be included in the corefile.

  - full: Outputs all contents of the server process memory to the corefile.
  - none: Does not output a corefile.
  - minimum: Outputs only non-shared memory server processes to the corefile. This reduces the size of the corefile. However, in some cases, this file may not contain sufficient information for examining the factor that caused the corefile to be output.

  If this parameter is omitted, "minimum" is used by default. This parameter can only be set when specified on starting an instance. It cannot be changed dynamically, while an instance is active.

- keystore_location (string)

  This parameter specifies the directory that stores the keystore file. Specify a different location from other database clusters. This parameter can only be set when specified on starting an instance. It cannot be changed dynamically, while an instance is active. Cannot be specified with the tde_kms.kms_conninfo_file parameter.

- tde_kms.kms_conninfo_file (string)

  When using the key management service as a key store, specifies the file that contains the connection information for the key management system. Cannot be specified with the keystore_location parameter.

  Create a connection information file for the key management system in the following format:

```
protocol    kms-name    address    port    auth-method    [auth-options]
```

  The fields have the following meanings:

  - protocol

    Specifies the protocol to connect to the key management system. In the current version, only "kmip" indicating the KMIP protocol can be specified.

  - kms-name

    The key management system name assigned to the key management system and specified when declaring the master encryption key or opening the keystore. The name of the key management system must be unique within this file. The key management system name must be a string of no more than 63 characters beginning with a-z, consisting of a-z, a number (0 -9), and an underscore. Upper and lower case letters are the same.

  - address

    Specifies the host name or IP address of the key management service.

  - port

    Specifies the port number on which the key management service listens for services.

- auth-method

  Specifies the authentication method for the key management service.

- auth-options

  The auth-method is followed by the authentication method options. You can specify multiple options in a name = value field.

Authentication method when using a key management service of type KMIP

cert

A certificate is used to authenticate the KMIP server and the client, FUJITSU Enterprise Postgres, to each other. The auth-options can be.

- sslcert

  Specifies the file name of the client certificate. The corresponding format is PEM format.

- sslkey

  Specifies the file name of the private key used for the client certificate. The corresponding format is PEM format. If you choose to encrypt the file with a passphrase, use a passphrase that is no more than 1023 bytes long.

- sslkeypassphrase-obf

  Specifies the file that contains the obfuscated passphrase for the private key file specified by sslkey. This option allows the keystore to be opened automatically when the server starts. The pgx _ keystore command creates obfuscated files. It can be omitted.

- sslrootcert

  Specifies the file name of the SSL Certificate Authority certificate. The corresponding format is PEM format. Used to verify the server certificate of the connection destination.

Example

```
kmip   mykmipsvr  mykmipsvr.example.com   5696   cert   sslcert=postgres.crt   sslkey=postgres.key
sslrootcert=root.crt
```

Note

cert authentication does not verify that the server you are connecting to is the same server you are trying to connect to. Any server using a server certificate that is signed with the certificate of the certificate authority specified in sslrootcert is considered the correct destination. To avoid problems with this behavior, consider using your own CA or self-signed certificate for the KMIP server.

- tde_z.IBM_CCA_CSU_DEFAULT_ADAPTER (string)

  This parameter specifies the value of the environment variable CSU_DEFAULT_ADAPTER for IBM Common Cryptographic Architecture (CCA) configuration. If this parameter is omitted, will follow the current CCA configuration. This parameter can only be set when specified on starting an instance. It cannot be changed dynamically, while an instance is active.

Information

Refer to IBM documentaion for the environment variable CSU_DEFAULT_ADAPTER.

- tde_z.IBM_CCA_CSU_DEFAULT_DOMAIN (string)

  This parameter specifies the value of the environment variable CSU_DEFAULT_DOMAIN for IBM Common Cryptographic Architecture (CCA) configuration. If this parameter is omitted, will follow the current CCA configuration. This parameter can only be set when specified on starting an instance. It cannot be changed dynamically, while an instance is active.

Information

Refer to IBM documentaion for the environment variable CSU_DEFAULT_DOMAIN.

- tde_z.SLOT_ID (string)

  Specifies the slot ID assigned to the instance of FUJITSU Enterprise Postgres. This parameter can only be set when specified on starting an instance. It cannot be changed dynamically, while an instance is active.

- tde_z.USER_PIN (string)

  User PIN to open a keystore. Specifies the user PIN set to the slot ID assigned to the instance of FUJITSU Enterprise Postgres. This parameter can only be set when specified on starting an instance. It cannot be changed dynamically, while an instance is active.

- tablespace_encryption_algorithm (string)

  This parameter specifies the encryption algorithm for tablespaces that will be created. Valid values are "AES128", "AES256", and "none". If you specify "none", encryption is not performed. The default value is "none". To perform encryption, it is recommended that you specify "AES256". Only superusers can change this setting.

- backup_destination (string)

  This parameter specifies the absolute path of the directory where pgx_dmpall will store the backup data. Specify a different location from other database clusters. This parameter can only be set when specified on starting an instance. It cannot be changed dynamically, while an instance is active.

  Place this directory on a different disk from the data directory to be backed up and the tablespace directory. Ensure that users do not store arbitrary files in this directory, because the contents of this directory are managed by the database system.

- search_path (string)

  When using the SUBSTR function compatible with Oracle databases, set "oracle" and "pg_catalog" in the search_path parameter. You must specify "oracle" before "pg_catalog".

Example

```
search_path = '"$user", public, oracle, pg_catalog'
```

Information

  - The search_path feature specifies the priority of the schema search path. The SUBSTR function in Oracle database is defined in the oracle schema.
  - Refer to "Statement Behavior" under "Server Administration" in the PostgreSQL Documentation for information on search_path.

- track_waits (string)

  This parameter enables collection of statistics for pgx_stat_lwlock and pgx_stat_latch.

  - on: Enables collection of statistics.
  - off: Disables collection of statistics.

  If this parameter is omitted, "on" is assumed.

  Only superusers can change this setting.

- track_sql (string)

  This parameter enables collection of statistics for pgx_stat_sql.

  - on: Enables collection of statistics.
  - off: Disables collection of statistics.

If this parameter is omitted, "on" is assumed.

Only superusers can change this setting.

- streaming_wal_compression (numerical value)

  This parameter specifies compression level to compress the WAL sent for streaming replication. It is specified on the standby server.

  -1: Compress at zlib's default compression level

  0: Uncompressed

  1-9: Compress at specified compression level, 9 is high compression

  If this parameter is omitted, 0 will be used.

Parameters for the in-memory feature

- reserve_buffer_ratio (numerical value)

  This parameter specifies the proportion of shared memory to be used for a stable buffer table.

  - Minimum value: 0
  - Maximum value: 80

  If this parameter is omitted, 0 will be used.

- vci.cost_threshold (numerical value)

  This parameter specifies the lowest cost that selects an execution plan that uses a VCI. If the cost of the best execution plan that does not use a VCI is lower than this value, that execution plan will be selected.

  - Minimum value: 0
  - Maximum value: Maximum value that can be expressed as a 4-byte signed integer

  If this parameter is omitted or a value outside this range is specified, 18000 will be used.

- vci.control_max_workers (numerical value)

  This parameter specifies the number of background workers that manage VCI. The number of workers for the entire instance is limited by max_worker_processes, so add the value specified here to max_worker_processes.

  - Minimum value: 1
  - Maximum value: 8388607

  If this parameter is omitted or a value outside this range is specified, 8 will be used.

- vci.enable (string)

  This parameter enables or disables VCI.

  - on: Enables VCI.
  - off: Disables VCI.

  If this parameter is omitted, "on" will be used.

- vci.log_query (string)

  This parameter enables or disables log output when VCI is not used due to insufficient memory specified by vci.max_local_ros.

  - on: Enables log output.
  - off: Disables log output.

  If this parameter is omitted, "off" will be used.

- vci.maintenance_work_mem (numerical value)

  This parameter specifies the maximum memory size used for maintenance of VCI (when executing CREATE INDEX, for example).

  - Minimum value: 1 MB

  - Maximum value: Maximum value that can be expressed as a 4-byte signed integer

  If this parameter is omitted or a value outside this range is specified, 256 MB will be used.

- vci.max_local_ros (numerical value)

  This parameter specifies the maximum memory size used for VCI scan.

  - Minimum value: 64 MB
  - Maximum value: Maximum value that can be expressed as a 4-byte signed integer

  If this parameter is omitted or a value outside this range is specified, 64 MB will be used.

- vci.max_parallel_degree (numerical value)

  This parameter specifies the maximum number of background workers used for parallel scan. The number of workers for the entire instance is limited by max_worker_processes, so add the value specified here to max_worker_processes.

  A value from -8388607 to 8388607 can be specified.

  - Integer (1 or greater): Parallel scan is performed using the specified degree of parallelism.
  - 0: Stops the parallel scan process.
  - Negative number: The specified value minus the maximum number of CPUs obtained from the environment is used as the degree of parallelism and parallel scan is performed.

  If this parameter is omitted or a value outside this range is specified, 0 will be used.

- vci.shared_work_mem (numerical value)

  This parameter specifies the maximum memory size used for VCI parallel scan.

  - Minimum value: 32 MB
  - Maximum value: Maximum value that can be expressed as a 4-byte signed integer

  If this parameter is omitted or a value outside this range is specified, 1 GB will be used.

Parameters for the Global Meta Cache feature

- pgx_global_metacache (numerical value)

  Specifies the memory size of the GMC area.

  Specify a value calculated by the formula below.

  A value lower than the calculated value will still work, but the meta cache may not be able to fit into the GMC area.

  In this case, the system will discard the meta cache it thinks it is no longer needed, but if it is needed again, the meta cache will need to be expanded and will not perform well.

  If the value is less than 10 MB and is set to a nonzero value that disables the feature, the database startup fails because the Global Meta Cache feature cannot operate.

  A setting of 0 disables the Global Meta Cache feature. The default is 0.

  Changing this setting requires restarting the database.

```
Size of GMC area
 = Max(10MB,
     (All user table x 0.4 KB
      + All user Indexes x 0.3 KB
      + All user columns x 0.8 KB) x 1.5 (*1) )

*1) Safety Factor (1.5)
This value takes into account the case where both GMC before and after the change temporarily exist
at the same time in shared memory when the table definition is changed or the row of the system
catalog is changed.
```

- track_gmc (string)

  This parameter enables collection of statistics for pgx_stat_gmc.

  - on: Enables collection of statistics.
  - off: Disables collection of statistics.

  If this parameter is omitted, "on" is used.

  Only superusers can change this setting.

Parameters for the Local Meta Cache Limit feature

- pgx_catalog_cache_max_size(numerical value)

  Specifies the maximum amount of memory that the backend process should use as the catalog cache.

  You can enable catalog cache deletion by setting it to 8 KB or more.

  A setting of 0 disables the catalog cache removal. The default is 0.

  If no units are specified, they are treated as KB.

  - Minimum value: 8KB
  - Maximum value: Maximum value that can be expressed as a 4-byte signed integer

  When calculating the parameter settings, the factors that determine the cache size are calculated as the number of tables, the number of indexes, and the number of columns. What is kept as a catalog cache or relation cache also includes objects such as databases, roles, or procedures, but these are small compared to the above factors and do not need to be factored into them. It also includes a calculation method for pgx_relacion_cache_max_size because the given memory is distributed between the catalog cache and the relation cache.

The calculation method here assumes that all backends have similar access and that the transaction also has access to a similar number of resources. If you have a small number of singular backends or transactions, consider excluding them as errors.

1. Determine how much memory a backend process can use. Decide by subtracting the memory size required by the entire system such as the database cache from the installed memory and dividing the rest by the number of connections.

2. For best performance, use the following formula to calculate the total memory size of the catalog cache when the backend holds the catalog cache for all resources accessed during its lifetime.
   The amount of memory varies depending on whether Global Meta Cache is enabled or disabled. Enabling Global Meta Cache reduces the amount of memory required because most of the cache is located on shared memory.

   ```
   When Global Meta Cache is enabled:
     (Number of tables to access + Number of indexes to access + Number of columns to access)
         × 0.1KB × 1.5 (*1)
   When Global Meta Cache is disabled:
     { Number of tables to access × 0.5KB(pg_class tuple size)
         + Number of indexes to access × 0.5KB(pg_index tuple size)
         + Number of columns to access × 1.0KB(pg_statistic tuple size)} × 1.5 (*1)

   *1) Safety Factor (1.5)
   The system catalog contains columns with variable-length types. For example, the tuple size in
   pg_class is a constant value multiplied by the number of tables, while relname in pg_class is
   variable length data.
   It is not practical to calculate every definition in detail, so we added 50% to the above
   formula.
   ```

3. In the same way as in 2., calculate the relation cache using the following formula.

   ```
   (1.4KB × Number of tables to access + 2.4KB × Number of indexes to access) × 1.5 (*1)
   ```

```
*1) Safety Factor (1.5)
The relation cache is structured to facilitate the use of table and index definitions, holds
pointers to various objects, and is sized to include them. It is variable length because the
type of object allocated by the table definition and its size change. Since it is not
realistic to calculate for all definitions, 50% is added.
```

4. If the value of 1. ≥ the value of 2. + the value of 3., the backend process can keep all caches to the extent allowed, so there is no need to limit the caches. If you want to cap for safety, set the value of 2. to pgx_catalog_cache_max_size and the value of 3. to pgx_relation_cache_max_size.
5. If the value of 1. < the value of 2. + the value of 3. then you need to limit the cache. However, this parameter does not limit the size of the cache used by a transaction. Therefore, take the following steps.
6. Calculate the catalog cache used by a transaction using the formula in 2.
7. Calculate the relation cache used by a transaction using the formula in 3.
8. If the value of 1. < the value of 6. + the value of 7., then the value of 1. needs to be increased. In other words, in some cases, it may be necessary to increase the installed memory or reduce the number of connections.
9. If the value of 1. ≥ the value of 6. + the value of 7., the condition of 1. can be satisfied by limiting the cache with this parameter. Divide the value of 1. by the ratio of 2. and 3. and set it as a parameter. Set the value distributed to 2. to pgx_catalog_cache_max_size and the value distributed to 3. to pgx_relation_cache_max_size.
10. The value calculated in 9. is a provisional value. If you cannot meet your target performance, first try to shift the focus of allocation to the relation cache. This is because when executing SQL, the relation cache generated based on the catalog cache is mainly referenced, so it is advantageous to leave a large amount of relation cache. If the performance is still not satisfied, adjust the parameters by referring to "14.1.4 Performance Impact and Parameter Tuning of the Local Meta Cache Limit Feature".

Note

Be careful when partitioning the table.

The cached definition changes depending on whether the parent table is specified in the SQL statement or the child table is specified. In particular, note that if you specify a parent table, the definitions of all child tables are cached. This is because when you specify a parent table in an SQL statement, you need to know the definitions of all the child tables in order to determine which child table will contain the desired data. Note that the column information of the parent table is not cached.

When specifying the parent table:

```
Number of tables to access = Number of parent tables to access + Number of defined child tables
Number of columns = Number of defined columns x number of defined child tables
```

When specifying the child table directly:

```
Number of tables to access = Number of child tables actually accessed
Number of columns = Number of defined columns x number of child tables actually accessed
```

Example)

Suppose the parent table T (1 index, 3 columns) is split from child tables T1 to T5 (1 index, 3 columns, respectively). If the parent table T is specified in SQL, when the child tables that contain the data to be queried are limited to T1 and T2, and when accessing the data using the indexes defined by T1 and T2, calculate as follows.

```
Number of tables = 1(parent table) + 5(child table) = 6
Number of indexes = 2 (index to access)
Number of columns = 3 (number of columns) x 5 (child table) = 15
```

If you specify child tables T1 and T2 in SQL and use the indexes defined on T1 and T2 when accessing data, the calculation is as follows.

```
Number of tables = 2(child table)
Number of indexes = 2 (index to access)
Number of columns = 3 (number of columns) x 2 (child table) = 6
```

- pgx_relation_cache_max_size(numerical value)

  Specifies the maximum amount of memory that the backend process should use as the relation cache.

  You can enable catalog cache deletion by setting it to 8 KB or more.

  A setting of 0 disables the relation cache removal. The default is 0.

  If no units are specified, they are treated as KB.

  - Minimum value: 8KB
  - Maximum value: Maximum value that can be expressed as a 4-byte signed integer

  For the calculation method for parameter setting, refer to the calculation method of pgx_catalog_cache_max_size.

- pgx_cache_hit_log_interval(numerical value)

  Specifies the time interval to output a message indicating the cache reference status for each backend process.

  When the transaction ends, if the time set in this parameter has elapsed since the previous message was output, the message is output.

  If set to 0, a message will be output each time the transaction ends.

  Setting -1 disables the output. The default value is 10min.

  If no units are specified, they are treated as ms.

  Even if pgx_catalog_cache_max_size and pgx_relation_cache_max_size are disabled, the message output of the corresponding cache will be invalid.

  Immediately after connecting to the server, a small transaction occurs before the request from the user application, such as for user authentication. Since it is meaningless to know the hit rate for these, a message will be output at the end of the transaction that started after the time set in this parameter has elapsed after connecting to the server.

  For the same reason, setting a small value such as 0 may result in a message being printed at the end of such a small transaction.

  You can check which transaction the message corresponds to from the information output at the beginning.

  This information depends on the setting of the parameter log_line_prefix.

  - Minimum value: 0
  - Maximum value: 2147483647ms

See

Refer to "Server Configuration" under "Server Administration" in the PostgreSQL Documentation for information on other postgresql.conf parameters.

Appendix B System Administration Functions

This appendix describes the system administration functions of FUJITSU Enterprise Postgres.

See

Refer to "System Administration Functions" under "The SQL Language" in the PostgreSQL Documentation for information on other system administration functions.

B.1 WAL Mirroring Control Functions

The following table lists the functions that can be used for backup and recovery based on WAL mirroring.

Table B.1 WAL mirroring control functions

Name	Return type	Description
pgx_pause_wal_multiplexing()	void	Stops WAL multiplexing
pgx_resume_wal_multiplexing()	void	Resumes WAL multiplexing
pgx_is_wal_multiplexing_paused()	boolean	Returns true if WAL multiplexing has stopped

If WAL multiplexing has not been configured, these functions return an error. Setting the backup_destination parameter in postgresql.conf configures WAL multiplexing.

Only superusers can execute these functions.

B.2 Transparent Data Encryption Control Functions

The following table lists the functions that can be used for transparent data encryption.

Table B.2 Transparent data encryption control functions

Name	Return type	Description
pgx_open_keystore(*user pin* | *passphrase*)	void	Opens the keystore
pgx_set_master_key(*user pin* | *passphrase*)	void	Sets the master encryption key
pgx_set_keystore_passphrase(*oldPassphrase*, *newPassphrase*)	void	Changes the keystore passphrase

B.2.1 pgx_open_keystore

pgx_open_keystore opens the keystore.

The pgx_open_keystore function uses the specified user pin or passphrase to open the keystore. When the keystore is opened, it enables access to the master encryption key. In this way, you can access the encrypted data and create encrypted tablespaces. If you are using a file-based key store, and the keystore is already open, this function returns an error.

Using the key management system as a keystore

pgx_open_keystore makes available (opens a keystore) a master encryption key on a key management system that has already been declared for use. The keystore cannot be opened unless it has been declared to use a master encryption key.

If the keystore is already open, use the credentials you entered to reconnect to the key management system.

Specify the authentication information for connecting to the key management system. Arguments must be specified in naming notation. The information you pass in the argument depends on the key management system you use.

Using the key management service of type KMIP

The following arguments are specified in naming notation.

- sslpassphrase text

  Specifies the passphrase of the client certificate private key file when connecting to the KMIP server. This can be omitted if no passphrase is set in the private key file.

If the key management system information file specifies an obfuscated credentials file, the file is recreated with the new credentials.

Example

To specify the passphrase mykmippassphrase for the client certificate private key file in naming notation:

```
SELECT pgx_open_keystore( sslpassphrase => 'mykmippassphrase' );
```

Only superusers can execute this function. Also, this function cannot be executed within a transaction block.

B.2.2 pgx_set_master_key

The pgx_set_master_key function generates a master encryption key and stores it in the file-based keystore. If the keystore does not exist, this function creates a keystore. If the keystore already exists, this function modifies the master encryption key. If the keystore has not been opened, this function opens it.

The user pin is a string of 4 to 8 bytes.

The passphrase is a string of 8 to 200 bytes.

Only superusers can execute this function. Also, this function cannot be executed within a transaction block. Processing is not affected by whether the keystore is open.

B.2.3 pgx_declare_external_master_key

pgx_declare_external_master_key declares the use of an encryption key that exists in the key management system as the master encryption key for transparent data encryption. If the master encryption key already exists, change the master encryption key. If the keystore is not open, it is opened.

The argument specifies information that identifies the master encryption key. Arguments must be specified in naming notation. The information you pass in the argument depends on the key management system you use.

This function can only be executed by superuser. Also, you cannot execute this function within a transaction block.

This function is available if you have installed the extension 'tde_kms'.

Using a key management system of type KMIP

The following arguments are specified in naming notation:

- kms_name text

  Specify the key management system name specified in the key management system connection information file. Required.

- key_id text

  Specify the key ID assigned to the encryption key in the KMIP server. Required.

- sslpassphrase text

  Specify the passphrase of the client certificate private key file when connecting to the KMIP server. This can be omitted if the private key file does not have a passphrase.

Example

```
SELECT pgx_declare_external_master_key( kms_name => 'mykmipsvr', key_id =>
'a0eebc99-9c0b-0000-0000-000000000000', sslpassphrase => 'mykmippassphrase' );
```

B.2.4 pgx_set_keystore_passphrase

The pgx_set_keystore_passphrase function changes the file-based keystore passphrase. Specify the current passphrase in *oldPassphrase*, and a new passphrase in *newPassphrase*.

The passphrase is a string of 8 to 200 bytes.

Only superusers can execute this function. Also, this function cannot be executed within a transaction block. Processing is not affected by whether the keystore is open.

B.3 Data Masking Control Functions

The table below lists the functions that can be used for data masking.

Table B.3 Data masking control functions

Name	Return type	Description
pgx_alter_confidential_policy	boolean	Changes masking policies
pgx_create_confidential_policy	boolean	Creates masking policies
pgx_drop_confidential_policy	boolean	Deletes masking policies
pgx_enable_confidential_policy	boolean	Enables or disables masking policies
pgx_update_confidential_values	boolean	Changes replacement characters when full masking is specified for masking type

B.3.1 pgx_alter_confidential_policy

Description

Changes masking policies

Format

The format varies depending on the content to be changed. The format is shown below.

- Common format

```
common_arg:
[schema_name    := 'schemaName',]
table_name    := 'tableName',
policy_name     := 'policyName'
```

- Add a masking target to a masking policy

```
pgx_alter_confidential_policy(
commonArg,
[action        := 'ADD_COLUMN', ]
column_name    := 'colName'
[, function_type    := 'FULL'] |
[, function_type    := 'PARTIAL', partialOpt] |
[, function_type    := 'REGEXP', regexpOpt]
)
```

```
partialOpt:
function_parameters    := 'maskingFmt'


regexpOpt:
regexp_pattern        := 'regexpPattern',
regexp_replacement    := 'regexpReplacementChar',
[, regexp_flags        := 'regexpFlags']
```

- Delete a masking target from a masking policy

```
pgx_alter_confidential_policy(
commonArg,
action        := 'DROP_COLUMN',
column_name    := 'colName'
)
```

- Change the masking condition

```
pgx_alter_confidential_policy(
commonArg,
action        := 'MODIFY_EXPRESSION',
expression    := 'expr'
)
```

- Change the content of a masking policy set for a masking target

```
pgx_alter_confidential_policy(
commonArg,
action        := 'MODIFY_COLUMN',
column_name    := 'colName'
[, function_type    := 'FULL'] |
[, function_type    := 'PARTIAL', partialOpt] |
[, function_type    := 'REGEXP', regexpOpt]
)


partialOpt:
function_parameters    := 'maskingFmt'


regexpOpt:
regexp_pattern        := 'regexpPattern',
regexp_replacement        := 'regexpReplacementChar',
[, regexp_flags        := 'regexpFlags']
```

- Change the masking policy description

```
pgx_alter_confidential_policy(
commonArg,
action        := 'SET_POLICY_DESCRIPTION',
policy_description    := 'policyDesc'
)
```

- Change the masking target description

```
pgx_alter_confidential_policy(
commonArg,
action        := 'SET_COLUMN_DESCRIPTION',
column_name    := 'colName',
column_description    := 'colDesc'
)
```

Argument

The argument varies depending on the content to be changed. Details are as follows.

- Common arguments

Masking type for which an argument can be specified	Argument	Data type	Description	Default value
All	schema_name	varchar(63)	Schema name of table for which a masking policy is applied	'public'
	table_name	varchar(63)	Name of table for which a masking policy is applied	Mandatory
	policy_name	varchar(63)	Masking policy name	Mandatory

- Add a masking target to a masking policy

Masking type for which an argument can be specified	Argument	Data type	Description	Default value
All	action	varchar(63)	'ADD_COLUMN'	'ADD_COLUMN'
	column_name	varchar(63)	Masking target name	Mandatory
	function_type	varchar(63)	Masking type - 'FULL': Full masking - 'PARTIAL': Partial masking - 'REGEXP': Regular expression masking	'FULL'
Partial masking	function_parameters	varchar(1024)	Masking format for partial masking	Mandatory
Regular expression masking	regexp_pattern	varchar(1024)	Search pattern for regular expression masking	Mandatory
	regexp_replacement	varchar(1024)	Replacement character/string for regular expression masking	Mandatory
	regexp_flags	varchar(20)	Regular expression flags	NULL

- Delete a masking target from a masking policy

Masking type for which an argument can be specified	Argument	Data type	Description	Default value
All	action	varchar(63)	'DROP_COLUMN'	Mandatory
	column_name	varchar(63)	Masking target name	Mandatory

- Change the masking condition

Masking type for which an argument can be specified	Argument	Data type	Description	Default value
All	action	varchar(63)	'MODIFY_EXPRESSION'	Mandatory

Masking type for which an argument can be specified	Argument	Data type	Description	Default value
	expression	varchar(1024)	Masking condition to be changed	Mandatory

- Change the content of a masking policy set for a masking target

Masking type for which an argument can be specified	Argument	Data type	Description	Default value
All	action	varchar(63)	'MODIFY_COLUMN'	Mandatory
	column_name	varchar(63)	Masking target name	Mandatory
	function_type	varchar(63)	Masking type - 'FULL': Full masking - 'PARTIAL': Partial masking - 'REGEXP': Regular expression masking	'FULL'
Partial masking	function_parameters	varchar(1024)	Masking format for partial masking	Mandatory
Regular expression masking	regexp_pattern	varchar(1024)	Search pattern for regular expression masking	Mandatory
	regexp_replacement	varchar(1024)	Replacement character/string for regular expression masking	Mandatory
	regexp_flags	varchar(20)	Regular expression flags	NULL

- Change the masking policy description

Masking type for which an argument can be specified	Argument	Data type	Description	Default value
All	action	varchar(63)	'SET_POLICY_DESCRIPTION'	Mandatory
	policy_description	varchar(1024)	Masking policy description	Mandatory

- Change the masking target description

Masking type for which an argument can be specified	Argument	Data type	Description	Default value
All	action	varchar(63)	'SET_COLUMN_DESCRIPTION'	Mandatory
	column_name	varchar(63)	Masking target name	Mandatory
	column_description	varchar(1024)	Masking target description	Mandatory

Details about whether arguments can be omitted are as follows.

Argument	Mandatory or optional									
	ADD_COLUMN			DROP_COLUMN	MODIFY_EXPRESSION	MODIFY_COLUMN			SET_POLICY_DESCRIPTION	SET_COLUMN_DESCRIPTION
	Full masking	Partial masking	Regular expression masking			Full masking	Partial masking	Regular expression masking		
schema_name	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
table_name	N	N	N	N	N	N	N	N	N	N
policy_name	N	N	N	N	N	N	N	N	N	N
action	Y	Y	Y	N	N	N	N	N	N	N
column_name	N	N	N	N	-	N	N	N	-	N
function_type	Y	N	N	-	-	Y	N	N	-	-
expression	-	-	-	-	N	-	-	-	-	-
policy_description	-	-	-	-	-	-	-	-	N	-
column_description	-	-	-	-	-	-	-	-	-	N
function_parameters	-	N	-	-	-	-	N	-	-	-
regexp_pattern	-	-	N	-	-	-	-	N	-	-
regexp_replacement	-	-	N	-	-	-	-	N	-	-
regexp_flags	-	-	Y	-	-	-	-	Y	-	-

Y: Can be omitted; N: Cannot be omitted; -: Ignored when specified

Return value

Return value	Description
TRUE	Ended normally
FALSE	Ended abnormally

Execution example 1

Adding masking policy p1 to masking target c2

```
postgres=# select pgx_alter_confidential_policy(table_name := 't1', policy_name := 'p1', action :=
'ADD_COLUMN', column_name := 'c2', function_type := 'PARTIAL', function_parameters := 'VVVFVVVVFVVVV,
VVV-VVVV-VVVV, *, 4, 11');
 pgx_alter_confidential_policy
-------------------------------
 t
(1 row)
```

Execution example 2

Deleting masking target c1 from masking policy p1

```
postgres=# select pgx_alter_confidential_policy(table_name := 't1', policy_name := 'p1', action :=
'DROP_COLUMN', column_name := 'c1');
 pgx_alter_confidential_policy
-------------------------------
```

```
 t
(1 row)
```

Execution example 3

Changing the masking condition for masking policy p1

```
postgres=# select pgx_alter_confidential_policy(table_name := 't1', policy_name := 'p1', action :=
'MODIFY_EXPRESSION', expression := 'false');
 pgx_alter_confidential_policy
-------------------------------
 t
(1 row)
```

Execution example 4

Changing the content of masking policy p1 set for masking target c2

```
postgres=# select pgx_alter_confidential_policy(table_name := 't1', policy_name := 'p1', action :=
'MODIFY_COLUMN', column_name := 'c2', function_type := 'FULL');
 pgx_alter_confidential_policy
-------------------------------
 t
(1 row)
```

Execution example 5

Changing the description of masking policy p1

```
postgres=# select pgx_alter_confidential_policy(table_name := 't1', policy_name := 'p1', action :=
'SET_POLICY_DESCRIPTION', policy_description := 'this policy is an example.');
 pgx_alter_confidential_policy
-------------------------------
 t
(1 row)
```

Execution example 6

Changing the description of masking target c2

```
postgres=# select pgx_alter_confidential_policy(table_name := 't1', policy_name := 'p1', action :=
'SET_COLUMN_DESCRIPTION', column_name := 'c2', column_description := 'c2 column is FULL.');
 pgx_alter_confidential_policy
-------------------------------
 t
(1 row)
```

Description

- The arguments for the pgx_alter_confidential_policy system management function can be specified in any order.
- The action parameters below can be specified. When action parameters are omitted, ADD_COLUMN is applied.

Parameter	Description
ADD_COLUMN	Adds a masking target to a masking policy.
DROP_COLUMN	Deletes a masking target from a masking policy.
MODIFY_EXPRESSION	Changes expression.
MODIFY_COLUMN	Changes the content of a masking policy set for a masking target.
SET_POLICY_DESCRIPTION	Changes policy_description.

Parameter	Description
SET_COLUMN_DESCRIPTION	Changes column_description.

- The function_parameters argument is enabled when the function_type is PARTIAL. If the function_type is other than PARTIAL, it will be ignored.
- The arguments below are enabled when the function_type is REGEXP. If the function_type is other than REGEXP, these arguments will be ignored.
  - regexp_pattern
  - regexp_replacement
  - regexp_flags

See

- Refer to "String Constants" in the PostgreSQL Documentation for information on the strings to specify for arguments.
- Refer to "POSIX Regular Expressions" in the PostgreSQL Documentation and check pattern, replacement, and flags for information on the values that can be specified for regexp_pattern, regexp_replacement, and regexp_flags.

B.3.2 pgx_create_confidential_policy

Description

Creates masking policies

Format

The format varies depending on the masking type. The format is shown below.

```
pgx_create_confidential_policy(
[schema_name        := 'schemaName',]
table_name        := 'tableName',
policy_name         := 'policyName',
expression        := 'expr'
[, enable            := 'policyStatus']
[, policy_description    := 'policyDesc']
[, column_name        := 'colName'
     [, function_type    := 'FULL'] |
     [, function_type    := 'PARTIAL', partialOpt] |
     [, function_type    := 'REGEXP', regexpOpt]
     [, column_description    := 'colDesc']
])


partialOpt:
function_parameters    := 'maskingFmt'


regexpOpt:
regexp_pattern        := 'regexpPattern',
regexp_replacement        := 'regexpReplacementChar',
[, regexp_flags        := 'regexpFlags']
```

Argument

Details are as follows.

Masking type for which an argument can be specified	Argument	Data type	Description	Default value
All	schema_name	varchar(63)	Schema name of table for which the masking policy is created	'public'
	table_name	varchar(63)	Name of table for which the masking policy is created	Mandatory
	policy_name	varchar(63)	Masking policy name	Mandatory
	expression	varchar(1024)	Masking condition	Mandatory
	enable	boolean	Masking policy status - 't': Enabled - 'f': Disabled	't'
	policy_description	varchar(1024)	Masking policy description	NULL
	column_name	varchar(63)	Masking target name	NULL
	function_type	varchar(63)	Masking type - 'FULL': Full masking - 'PARTIAL': Partial masking - 'REGEXP': Regular expression masking	'FULL'
	column_description	varchar(1024)	Masking target description	NULL
Partial masking	function_parameters	varchar(1024)	Masking format for partial masking	Mandatory
Regular expression masking	regexp_pattern	varchar(1024)	Search pattern for regular expression masking	Mandatory
	regexp_replacement	varchar(1024)	Replacement character/string for regular expression masking	Mandatory
	regexp_flags	varchar(20)	Regular expression flags	NULL

Details about whether arguments can be omitted are as follows.

Argument	Mandatory or optional		
	Full masking	Partial masking	Regular expression masking
schema_name	Y	Y	Y
table_name	N	N	N
policy_name	N	N	N
expression	N	N	N
enable	Y	Y	Y
policy_description	Y	Y	Y
column_name	Y	Y	Y
function_type	Y	Y	Y
column_description	Y	Y	Y
function_parameters	-	N	-
regexp_pattern	-	-	N
regexp_replacement	-	-	N

Argument	Mandatory or optional		
	Full masking	Partial masking	Regular expression masking
regexp_flags	-	-	Y

Y: Can be omitted; N: Cannot be omitted; -: Ignored when specified

Return value

Return value	Description
TRUE	Ended normally
FALSE	Ended abnormally

Execution example 1

Creating masking policy p1 that does not contain a masking target

```
postgres=# select pgx_create_confidential_policy(table_name := 't1', policy_name := 'p1',
expression := '1=1');
 pgx_create_confidential_policy
--------------------------------
 t
(1 row)
```

Execution example 2

Creating masking policy p1 that contains masking target c1 of which the masking type is full masking

```
postgres=# select pgx_create_confidential_policy(schema_name := 'public', table_name := 't1',
policy_name := 'p1', expression := '1=1', enable := 't', policy_description := 'this policy is an
example.', column_name := 'c1', function_type := 'FULL', column_description := 'c1 column is FULL.');
 pgx_create_confidential_policy
--------------------------------
 t
(1 row)
```

Execution example 3

Creating masking policy p1 that contains masking target c2 of which the masking type is partial masking

```
postgres=# select pgx_create_confidential_policy( table_name := 't1', policy_name := 'p1',
expression := '1=1', column_name := 'c2', function_type := 'PARTIAL', function_parameters :=
'VVVFVVVVFVVVV, VVV-VVVV-VVVV, *, 4, 11');
 pgx_create_confidential_policy
--------------------------------
 t
(1 row)
```

Execution example 4

Creating masking policy p1 that contains masking target c3 of which the masking type is regular expression masking

```
postgres=# select pgx_create_confidential_policy( table_name := 't1', policy_name := 'p1',
expression := '1=1', column_name := 'c3', function_type := 'REGEXP', regexp_pattern := '(.*)(@.*)',
regexp_replacement := 'xxx\2', regexp_flags := 'g');
 pgx_create_confidential_policy
--------------------------------
 t
(1 row)
```

Description

- The arguments for the pgx_create_confidential_policy system management function can be specified in any order.
- If column_name is omitted, only masking policies that do not contain masking target will be created.
- One masking policy can be created for each table. Use the pgx_alter_confidential_policy system management function to add a masking target to a masking policy.
- The function_parameters argument is enabled when the function_type is PARTIAL. If the function_type is other than PARTIAL, it will be ignored.
- The arguments below are enabled when the function_type is REGEXP. If the function_type is other than REGEXP, these arguments will be ignored.
  - regexp_pattern
  - regexp_replacement
  - regexp_flags

Note

If a table for which a masking policy is to be applied is deleted, delete the masking policy as well.

See

- Refer to "String Constants" in the PostgreSQL Documentation for information on the strings to specify for arguments.
- Refer to "POSIX Regular Expressions" in the PostgreSQL Documentation and check pattern, replacement, and flags for information on the values that can be specified for regexp_pattern, regexp_replacement, and regexp_flags.

B.3.3 pgx_drop_confidential_policy

Description

Deletes masking policies

Format

```
pgx_drop_confidential_policy(
[schema_name    := 'schemaName', ]
table_name     := 'tableName',
policy_name    := 'policyName'
)
```

Argument

Details are as follows.

Argument	Data type	Description	Default value
schema_name	varchar(63)	Schema name of table for which a masking policy is deleted	'public'
table_name	varchar(63)	Name of table for which a masking policy is deleted	Mandatory
policy_name	varchar(63)	Masking policy name	Mandatory

Details about whether arguments can be omitted are as follows.

Argument	Mandatory or optional
schema_name	Y
table_name	N
policy_name	N

Y: Can be omitted; N: Cannot be omitted

Return value

Return value	Description
TRUE	Ended normally
FALSE	Ended abnormally

Execution example

Deleting masking policy p1

```
postgres=# select pgx_drop_confidential_policy(table_name := 't1', policy_name := 'p1');
 pgx_drop_confidential_policy
------------------------------
 t
(1 row)
```

Description

The arguments for the pgx_drop_confidential_policy system management function can be specified in any order.

Note

If a table for which a masking policy is to be applied is deleted, delete the masking policy as well.

See

Refer to "String Constants" in the PostgreSQL Documentation for information on the strings to specify for arguments.

B.3.4 pgx_enable_confidential_policy

Description

Enables or disables masking policies

Format

```
pgx_enable_confidential_policy(
[schema_name    := 'schemaName', ]
table_name     := 'tableName',
policy_name    := 'policyName',
enable        := 'policyStatus'
)
```

Argument

Details are as follows.

Argument	Data type	Description	Default value
schema_name	varchar(63)	Schema name of table for which a masking policy is enabled or disabled	'public'
table_name	varchar(63)	Name of table for which a masking policy is enabled or disabled	Mandatory
policy_name	varchar(63)	Masking policy name	Mandatory
enable	boolean	Masking policy status - 't': Enabled - 'f': Disabled	Mandatory

Details about whether arguments can be omitted are as follows.

Argument	Mandatory or optional
schema_name	Y
table_name	N
policy_name	N
enable	N

Y: Can be omitted; N: Cannot be omitted

Return value

Return value	Description
TRUE	Ended normally
FALSE	Ended abnormally

Execution example

Enabling masking policy p1

```
postgres=# select pgx_enable_confidential_policy(table_name := 't1', policy_name := 'p1', enable :=
't');
 pgx_enable_confidential_policy
--------------------------------
 t
(1 row)
```

Description

The arguments for the pgx_enable_confidential_policy system management function can be specified in any order.

See

Refer to "String Constants" in the PostgreSQL Documentation for information on the strings to specify for arguments.

B.3.5 pgx_update_confidential_values

Description

Changes replacement characters when full masking is specified for masking type

Format

```
pgx_update_confidential_values(
[number_value    := 'numberValue']
[, char_value    := 'charValue']
[, varchar_value    := 'varcharValue']
[, date_value    := 'dateValue']
[, ts_value    := 'tsValue']
)
```

Argument

Details are as follows.

Argument	Data type	Description
number_value	integer	Replacement character in numeric type
char_value	varchar(1)	Replacement character in char type
varchar_value	varchar(1)	Replacement character in varchar type
date_value	date	Replacement character in date type
ts_value	timestamp	Replacement character in timestamp type

Return value

Return value	Description
TRUE	Ended normally
FALSE	Ended abnormally

Execution example

Using '*' as a replacement character in char type and varchar type

```
postgres=# select pgx_update_confidential_values(char_value := '*', varchar_value := '*');
 pgx_update_confidential_values
--------------------------------
 t
(1 row)
```

Description

- The arguments for the pgx_update_confidential_values system management function can be specified in any order.
- Specify one or more arguments for the pgx_update_confidential_values system management function. A replacement character is not changed for an omitted argument.

Refer to "String Constants" in the PostgreSQL Documentation for information on the strings to specify for arguments.

B.4 VCI Data Load Control Function

The table below lists the function that loads VCI data to buffer cache.

Table B.4 VCI data load control function

Name	Return type	Description
pgx_prewarm_vci(vci_index regclass)	int8	Loads the VCI data to buffer cache.

pgx_prewarm_vci loads the specified VCI data to buffer cache and returns the number of blocks of the loaded VCI data.

The aggregation process using VCI may take time immediately after an instance is started, because the VCI data has not been loaded to buffer cache. Therefore, the first aggregation process can be sped up by executing pgx_prewarm_vci after an instance is started.

The amount of memory required for preloading is the number of blocks returned by pgx_prewarm_vci multiplied by the size of one block.

This function can only be executed if the user has reference privilege to the VCI index and execution privilege to the pg_prewarm function.

B.5 High-Speed Data Load Control Functions

The table below lists the functions that can be used for high-speed data load.

Table B.5 High-speed data load control functions

Name	Return type	Description
pgx_loader	bigint	Creates dynamic shared memory, starts parallel workers and loads data
pgx_loader_recovery	smallint	Resolves in-doubt transactions

The pgx_loader command executes the above functions internally.

Appendix C System Views

This appendix describes how to use the system views in FUJITSU Enterprise Postgres.

See

Refer to "System Views" under "Internals" in the PostgreSQL Documentation for information on other system views.

C.1 pgx_tablespaces

The pgx_tablespaces view provides information related to the encryption of tablespaces.

Table C.1 pgx_tablespaces view

Column	Type	References	Description
spctablespace	oid	pg_tablespace.oid	Tablespace OID
spcencalgo	text		Tablespace encryption algorithm

The spcencalgo string displays one of the following values:

- none: Tablespace is not encrypted
- AES128: AES with key length of 128 bits
- AES256: AES with key length of 256 bits

C.2 pgx_stat_lwlock

The pgx_stat_lwlock view displays statistics related to lightweight locks, with each type of content displayed on a separate line.

Table C.2 pgx_stat_lwlock view

Column	Type	Description
lwlock_name	name	Name of the lightweight lock
total_waits	bigint	Number of waits caused by the lightweight lock
total_wait_time	double precision	Number of milliseconds spent in waits caused by the lightweight lock
stats_reset	timestamp with timezone	Last time at which this statistics was reset

C.3 pgx_stat_latch

The pgx_stat_latch view displays statistics related to latches, with each type of wait information within FUJITSU Enterprise Postgres displayed on a separate line.

Table C.3 pgx_stat_latch view

Column	Type	Description
latch_name	name	Name of the latch
total_waits	bigint	Number of waits caused a wait
total_wait_time	double precision	Number of milliseconds spent in waits caused by the latch
stats_reset	timestamp with timezone	Last time at which this statistic was reset

C.4 pgx_stat_walwriter

The pgx_stat_walwriter view displays statistics related to WAL writing, in a single line.

Table C.4 pgx_stat_walwriter view

Column	Type	Description
dirty_writes	bigint	Number of times old WAL buffers were written to the disk because the WAL buffer was full when WAL records were added
writes	bigint	Number of WAL writes
write_blocks	bigint	Number of WAL write blocks
total_write_time	double precision	Number of milliseconds spent on WAL writing
stats_reset	timestamp with timezone	Last time at which this statistic was reset

C.5 pgx_stat_sql

The pgx_stat_sql view displays statistics related to SQL statement executions, with each type of SQL statement displayed on a separate line.

Table C.5 pgx_stat_sql view

Column	Type	Description
selects	bigint	Number of SELECT statements executed In database multiplexing mode, this number includes the SELECT statements executed in Mirroring Controller. Mirroring Controller executes the SELECT statement using the interval specified for the heartbeat_interval of the server definition file (milliseconds).
inserts	bigint	Number of INSERT statements executed
deletes	bigint	Number of DELETE statements executed
updates	bigint	Number of UPDATE statements executed
selects_with_parallelism	bigint	Number of times parallel scan was used in SELECT statements
inserts_with_parallelism	bigint	Not used
deletes_with_parallelism	bigint	Not used
updates_with_parallelism	bigint	Not used
copies_with_parallelism	bigint	Not used
declares	bigint	Number of DECLARE statements executed (number of cursor OPENs)
fetches	bigint	Number of FETCH statements executed
checkpoints	bigint	Number of CHECKPOINT statements executed
clusters	bigint	Number of CLUSTER statements executed
copies	bigint	Number of COPY statements executed
reindexes	bigint	Number of REINDEX statements executed
truncates	bigint	Number of TRUNCATE statements executed
locks	bigint	Number of times a lock occurred
stats_reset	timestamp with timezone	Last time at which this statistic was reset

C.6 pgx_stat_gmc

The pgx_stat_gmc view provides information about the GMC areas.

Table C.6 pgx_stat_gmc view

Column	Type	Description
searches	bigint	Number of times the cache table is searched.
hits	bigint	Number of times the cache table is hit.
size	bigint	The current amount of memory (bytes) used in the GMC area.
stats_reset	timestamp with timezone	Last time these statistics were reset.

C.7 pgx_stat_progress_loader

The pgx_stat_progress_loader view provides overall progress information for pgx_loader command.

The pgx_stat_progress_loader view displays the sum of the progress information of the back-end processes and the number of parallel worker processes when pgx_loader runs.

Table C.7 pgx_stat_progress_loader view

Column	Type	Description
pid	integer	Process ID of the backend.
datid	Oid	Oid of the database to connect to.
datname	name	Name of the database to connect to.
relid	Oid	Oid of the table to load.
command	text	Command executes the load process. (Always "COPY FROM"for pgx_loader)
type	text	Type of data source for the load operation.
bytes_processed	bigint	Size of the data at the end of the load. (Backend and worker totals)
bytes_total	bigint	Size of the data to load. (Backend and worker totals)
tuples_processed	bigint	Number of rows that have completed loading. (Backend and worker totals)
tuples_excluded	bigint	Number of rows skipped during the load process. (Backend and worker totals)

Appendix D Tables Used by Transparent Data Encryption

This appendix explains tables tables used by the transparent data encryption feature.

D.1 pgx_tde_master_key

Provides information about the master encryption key being used when using the key management system as a keystore.

Column	Type	Description
kms_name	text	Key management system name
key_id	text	Key ID in key management system
local_key_id	integer	Sequence of keys used internally by FUJITSU Enterprise Postgres
status	enum	in-use: Current master encryption key in use used: 過Master encryption key used in the past scheduled: A new encryption key that was requested to update the master encryption key and is to be used.

Execution example

```
postgres=# select * from pgx_tde_master_key;
 kms_name  |                key_id                | local_key_id  | status
-----------+--------------------------------------+---------------+---------
 mykmipsvr | a0eebc99-9c0b-0000-0000-000000000000 |           1   | in-use
(1 row)
```

Note

Do not use queries with "*" in the selection list, as the order of the columns may change or columns may be added.

Appendix E Tables Used by Data Masking

This appendix explains tables used by the data masking feature.

Note

These tables are updated by the data masking control function, so do not use SQL statements to directly update these tables.

E.1 pgx_confidential_columns

This table provides information on masking target for which masking policies are set.

Column	Type	Description
schema_name	varchar(63)	Schema name of table for which a masking policy is applied
table_name	varchar(63)	Name of table for which a masking policy is applied
policy_name	varchar(63)	Masking policy name
column_name	varchar(63)	Masking target name
function_type	varchar(63)	Masking type - 'FULL': Full masking - 'PARTIAL': Partial masking - 'REGEXP': Regular expression masking
function_parameters	varchar(1024)	Masking format for partial masking
regexp_pattern	varchar(1024)	Search pattern for regular expression masking
regexp_replacement	varchar(1024)	Replacement character/string for regular expression masking
regexp_flags	varchar(20)	Regular expression flags
column_description	varchar(1024)	Masking target description

Execution example

```
postgres=# select * from pgx_confidential_columns;
 schema_name | table_name | policy_name | column_name | function_type |
function_parameters           | regexp_pattern | regexp_replacement | regexp_flags |
column_description
-------------+------------+-------------+-------------+---------------
+---------------------------------------+----------------+--------------------+-------------
+--------------------
 public      | t1         | p1          | c1          | FULL          |
|                |                     |             |
 public      | t1         | p1          | c2          | PARTIAL       | VVVFVVVVFVVVV, VVV-VVVV-VVVV,
*, 4, 11 |                |                     |             |
(2  row)
```

E.2 pgx_confidential_policies

This table provides information on masking policies.

Column	Type	Description
schema_name	varchar(63)	Schema name of table for which a masking policy is applied

Column	Type	Description
table_name	varchar(63)	Name of table for which a masking policy is applied
policy_name	varchar(63)	Masking policy name
expression	varchar(1024)	Masking condition
enable	boolean	Masking policy status - 't': Enabled - 'f': Disabled
policy_description	varchar(1024)	Masking policy description

Execution example

```
postgres=# select * from pgx_confidential_policies;
 schema_name | table_name | policy_name | expression | enable | policy_description
-------------+------------+-------------+------------+--------+--------------------
 public      | t1         | p1          | 1=1        | t      |
(1 row)
```

E.3 pgx_confidential_values

This table provides information on replacement characters when full masking is specified for masking type.

Column	Data type	Description	Default value
number_value	integer	Numeric	0
char_value	varchar(1)	char type	Spaces
varchar_value	varchar(1)	varchar type	Spaces
date_value	date	date type	'1970-01-01'
timestamp_value	timestamp	timestamp type	'1970-01-01 00:00:00'

Execution example

```
postgres=# select * from pgx_confidential_values;
 number_value | char_value | varchar_value | date_value |      ts_value
--------------+------------+---------------+------------+---------------------
            0 |            |               | 1970-01-01 | 1970-01-01 00:00:00
(1 row)
```

Appendix F Tables Used by High-Speed Data Load

This appendix describes the tables used by high-speed data load.

F.1 pgx_loader_state

The pgx_loader_state table provides information about transactions prepared by high-speed data load.

Column	Type	Description
id	serial	Unique identifier. This value is assigned from the pgx_loader_state_id_seq sequence.
gid	text	Global transaction identifier assigned to a transaction.
state	text	State of the transaction. The value can be one of the following: - commit: The prepared transaction has been committed. - rollback: The prepared transaction is in in-doubt state.
leader_pid	integer	Process ID of the backend process (leader process) that executed the pgx_loader control function.
role_oid	integer	Role identifier (OID). A prepared transaction can only be completed by the same user who executed the original transaction or by a superuser.
relation_oid	integer	Object identifier (OID).

Note

The pgx_loader_state table and pgx_loader_state_id_seq sequence are updated by high-speed data load. Do not update these database objects directly using SQL.

Appendix G Starting and Stopping the Web Server Feature of WebAdmin

To use WebAdmin for creating and managing a FUJITSU Enterprise Postgres instance on a server where FUJITSU Enterprise Postgres is installed, you must first start the Web server feature of WebAdmin.

- Using WebAdmin in a single-server configuration

  You must start the Web server on the server on which FUJITSU Enterprise Postgres and WebAdmin are installed.

- Using WebAdmin in a multiserver configuration

  You must start the Web server on all servers on which WebAdmin has been installed.

This appendix describes how to start and stop the Web server feature of WebAdmin.

Note that "<*x*>" in paths indicates the product version.

See

Refer to "Installing WebAdmin in a Multiserver Configuration" in the Installation and Setup Guide for Server for information on multiserver installation.

G.1 Starting the Web Server Feature of WebAdmin

Follow the procedure below to start the Web server feature of WebAdmin.

1. Change to superuser

   Acquire superuser privileges on the system.

   Example

   ```
   $ su -
   Password:******
   ```

2. Start the Web server feature of WebAdmin

   Execute the WebAdminStart command to start the Web server feature of WebAdmin.

   Example

   If WebAdmin is installed in /opt/fsepv<*x*>webadmin:

   ```
   # cd /opt/fsepv<x>webadmin/sbin
   # ./WebAdminStart
   ```

G.2 Stopping the Web Server Feature of WebAdmin

This section describes how to stop the Web server feature of WebAdmin.

Follow the procedure below to stop the Web server feature of WebAdmin.

1. Change to superuser

   Acquire superuser privileges on the system.

   Example

   ```
   $ su -
   Password:******
   ```

2. Stop the Web server feature of WebAdmin

   Execute the WebAdminStop command to stop the Web server feature of WebAdmin.

Example

If WebAdmin is installed in /opt/fsepv<*x*>webadmin:

```
# cd /opt/fsepv<x>webadmin/sbin
# ./WebAdminStop
```

Appendix H WebAdmin Wallet

This appendix describes how to use the Wallet feature of WebAdmin.

When a remote instance or a standby instance is created, it is necessary to provide user name and password for authentication with the remote machine or the database instance.

The Wallet feature in WebAdmin is a convenient way to create and store these credentials.

Once created, these credentials can be repeatedly used in one or more instances.

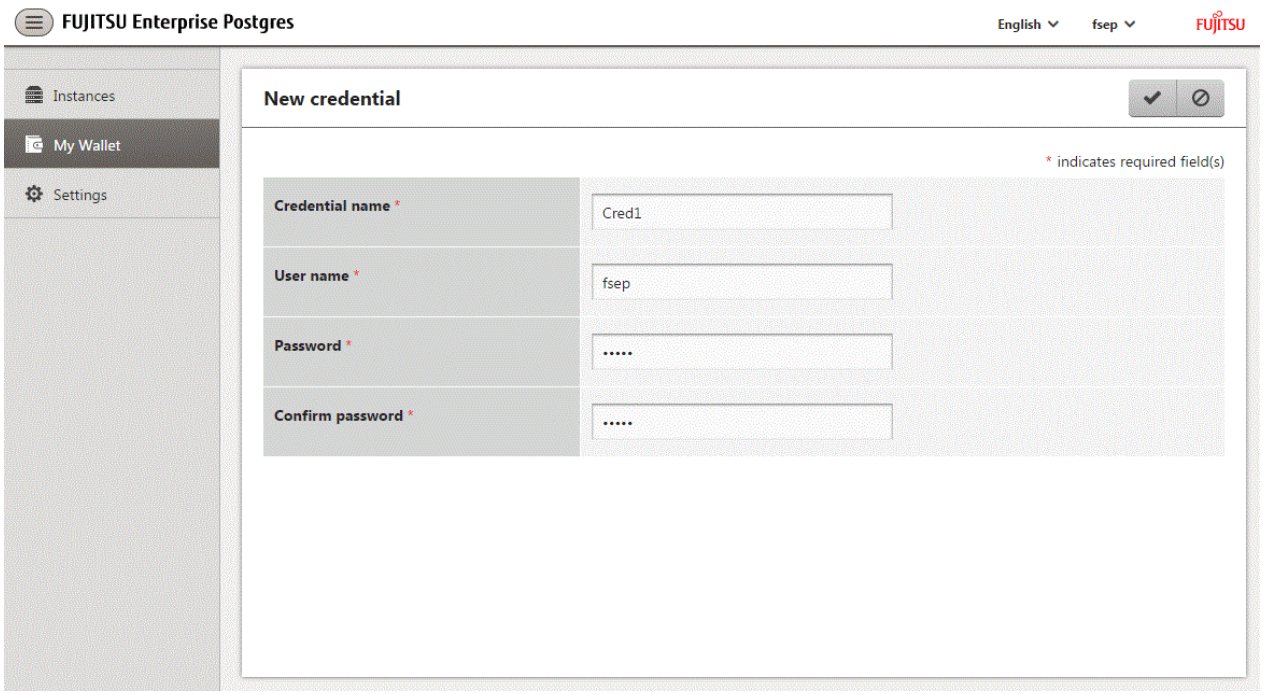
Note

It is not mandatory to create a credential in the Wallet. It is possible to create a remote instance or a standby instance without creating any credential in the Wallet.

If no credential is created beforehand, a user name and password can be entered in the instance creation page. When creating a "Remote" instance, if operating system credentials are entered without using a credential stored in the Wallet, WebAdmin automatically creates a credential with the given user name and password, and stores it in the user's wallet for future use.

H.1 Creating a Credential

1. In the [My Wallet] tab, click ➕. The [New credential] page will be displayed.
2. Enter the information for the credentials.



Enter the following items. Credential name, User name and Password should not contain hazardous characters. Refer to "Appendix I WebAdmin Disallow User Inputs Containing Hazardous Characters".

- [Credential name]: Name of the credential

  The name must meet the conditions below:

  - Maximum of 16 characters
  - The first character must be an ASCII alphabetic character
  - The other characters must be ASCII alphanumeric characters

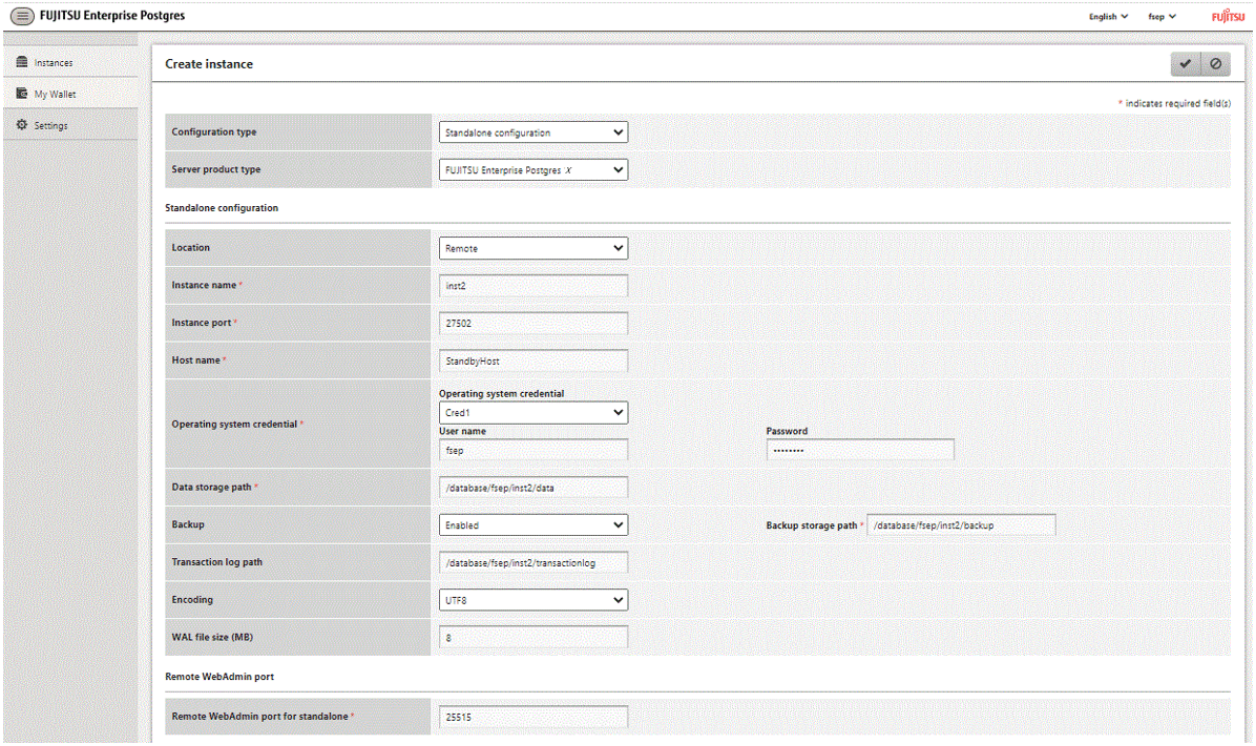
- [User name]: The operating system user name or database instance user name that will be used later
- [Password]: Password for the user
- [Confirm password]: Reenter the password.

3. Click ✔ to store the credential.

H.2 Using a Credential

Once a credential is created in the Wallet, it can be used during remote instance creation or standby instance creation.

The following page uses the credential that was created in the previous section.



When "Cred1" is selected in [Operating system credential], the user name and password are automatically populated from the credential.

Appendix I WebAdmin Disallow User Inputs Containing Hazardous Characters

WebAdmin considers the following as hazardous characters, which are not allowed in user inputs.

```
| (pipe sign)

& (ampersand sign)

; (semicolon sign)

$ (dollar sign)

% (percent sign)

@ (at sign)

' (single apostrophe)

" (quotation mark)

\' (backslash-escaped apostrophe)

\" (backslash-escaped quotation mark)

<> (triangular parenthesis)

() (parenthesis)

+ (plus sign)

CR (Carriage return, ASCII 0x0d)

LF (Line feed, ASCII 0x0a)

, (comma sign)

\ (backslash)
```

Appendix J Collecting Failure Investigation Data

If the cause of an error that occurs while building the environment or during operations is unclear, data must be collected for initial investigation.

This appendix describes how to collect data for initial investigation.

Use the pgx_fjqssinf command to collect data for initial investigation.

See

Refer to the Reference for information on the pgx_fjqssinf command.

Appendix K Operation of Transparent data Encryption in File-based Keystores

This appendix explains about the operation of transparent data encryption in file-based.

K.1 Setting the Master Encryption Key

To use transparent data encryption, you must create a keystore and set the master encryption key.

1. In the keystore_location parameter of postgresql.conf, specify the directory to store the keystore.

   Specify a different location for each database cluster.

   ```
   keystore_location = '/key/store/location'
   ```

   Refer to "Appendix A Parameters" for information on postgresql.conf.

   After editing the postgresql.conf file, either start or restart the instance.

   - Using WebAdmin

     Refer to "2.1.1 Using WebAdmin", and restart the instance.

   - Using the pg_ctl command

     Specify the following in the pg_ctl command:

     - Specify "restart" as the mode.
     - Specify the data storage destination directory in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.
     - Specify the -w option. This means that the command returns after waiting for the instance to start. If the -w option is not specified, it may not be possible to determine if the starting of the instance completed successfully or if it failed.

     Example

     ```
     > pg_ctl restart -w -D /database/inst1
     ```

2. Execute an SQL function, such as the one below, to set the master encryption key. This must be performed by the superuser. Execute it as the database superuser.

   ```
   SELECT pgx_set_master_key('passphrase');
   ```

   The value "passphrase" is the passphrase that will be used to open the keystore. The master encryption key is protected by this passphrase, so avoid specifying a short simple string that is easy to guess.

   Refer to "B.2 Transparent Data Encryption Control Functions" for information on the pgx_set_master_key function.

 Note

Note that if you forget the passphrase, you will not be able to access the encrypted data. There is no method to retrieve a forgotten passphrase and decrypt data. Do not, under any circumstances, forget the passphrase.

The pgx_set_master_key function creates a file with the name keystore.ks in the keystore storage destination. It also creates a master encryption key from random bit strings, encrypts it with the specified passphrase, and stores it in keystore.ks. At this point, the keystore is open.

K.2 Opening the Keystore

To create encrypted tablespaces and access the encrypted data, you must first open the keystore. When you open the keystore, the master encryption key is loaded into the database server memory and becomes usable for encryption and decryption.

You need to open the keystore each time you start the instance. To open the keystore, the database superuser must execute the following SQL function.

```
SELECT pgx_open_keystore('passphrase');
```

The value "passphrase" is the passphrase specified during creation of the keystore.

Refer to "B.2 Transparent Data Encryption Control Functions" for information on the pgx_open_keystore function.

Note that, in the following cases, the passphrase must be entered when starting the instance, because the encrypted WAL must be decrypted for recovery. In this case, the above-mentioned pgx_open_keystore function cannot be executed.

- If performing crash recovery at the time of starting the instance
- If performing recovery using continuous archiving

For the above cases, specify the --keystore-passphrase option in the pg_ctl command, and then start the instance. This will display the prompt for the passphrase to be entered, as shown below.

```
> pg_ctl --keystore-passphrase start
Enter the passphrase:
The server is starting
>
```

Point

When using an automatically opening keystore, you do not need to enter the passphrase and you can automatically open the keystore when the database server starts. Refer to "K.5.3 Enabling Automatic Opening of the Keystore" for details.

K.3 Encrypting a Tablespace

Refer to "5.5 Encrypting a Tablespace".

K.4 Checking an Encrypted Tablespace

Refer to "5.6 Checking an Encrypted Tablespace".

K.5 Managing the Keystore

This section describes how to manage the keystore and the master encryption key to guard against the threat of theft.

K.5.1 Changing the Master Encryption Key

Using the same encryption key for an extended period gives attackers an opportunity to decipher the encrypted data. It is recommended that you change the key at regular intervals, or whenever the key is exposed to risk.

Adhere to the industry's best practices for encryption algorithms and key management when considering how often the key should be changed. For example, the NIST in the United States has published "NIST Special Publication 800-57". The PCI DSS also refers to this publication. This publication recommends changing the master encryption key once a year.

To change the master encryption key, execute the pgx_set_master_key function, which is the same function used for configuring the key. Refer to "K.1 Setting the Master Encryption Key" for details.

After changing the master encryption key, you must immediately back up the keystore.

K.5.2 Changing the Keystore Passphrase

In security policies for organizations, it is usually a requirement that the passphrase be changed whenever a security administrator who knows the passphrase is removed from duties due to transfer or retirement. It is also recommended that the passphrase be changed if it is ever exposed to risks due to deception such as social engineering.

To change the keystore passphrase, execute the following SQL function as a superuser.

```
SELECT pgx_set_keystore_passphrase('oldPassphrase', 'newPassphrase');
```

After changing the passphrase, you must immediately back up the keystore.

Refer to "B.2 Transparent Data Encryption Control Functions" for information on the pgx_set_keystore_passphrase function.

K.5.3 Enabling Automatic Opening of the Keystore

When using an automatically opening keystore, you do not need to enter the passphrase and you can automatically open the keystore when the instance starts. Execute the pgx_keystore command to enable automatic opening of the keystore.

```
> pgx_keystore --enable-auto-open /key/store/location/keystore.ks
Enter the passphrase:
Automatic opening of the keystore is now enabled
>
```

See

Refer to "pgx_keystore" in the Reference for information on pgx_keystore command.

When automatic opening is enabled, an automatically opening keystore is created in the same directory as the original keystore. The file name of the automatically opening keystore is keystore.aks. The file keystore.aks is an obfuscated copy of the decrypted content of the keystore.ks file. As long as this file exists, there is no need to enter the passphrase to open the keystore when starting the instance.

Do not delete the original keystore file, keystore.ks. It is required for changing the master encryption key and the passphrase. When you change the master encryption key and the passphrase, keystore.aks is recreated from the original keystore file, keystore.ks.

Protect keystore.ks, keystore.aks, and the directory that stores the keystore so that only the user who starts the instance can access them.

Configure the permission of the files so that only the user who starts the instance can access the SQL functions and commands that create these files. Accordingly, manually configure the same permission mode if the files are restored.

Example

```
# chown -R fsepuser:fsepuser /key/store/location
# chmod 700 /key/store/location
# chmod 600 /key/store/location/keystore.ks
# chmod 600 /key/store/location/keystore.aks
```

An automatically opening keystore will only open on the computer where it was created.

To disable automatic opening of the keystore, delete keystore.aks.

Note

- To use WebAdmin for recovery, you must enable automatic opening of the keystore.
- Refer to "5.8 Backing Up and Restoring/Recovering the Database" after enabling or reconfiguring encryption to back up the database.
- Specify a different directory from those below as the keystore storage destination:
  - Data storage destination
  - Tablespace storage destination
  - Transaction log storage destination
  - Backup data storage destination

K.5.4 Backing Up and Recovering the Keystore

Back up the keystore at the following times in case it is corrupted or lost. Note that you must store the database and the keystore on separate data storage media. Storing both on the same data storage medium risks the danger of the encrypted data being deciphered if the medium is stolen. A passphrase is not required to open an automatically opening keystore, so store this type of keystore in a safe location.

- When the master encryption key is first configured
- When the master encryption key is changed
- When the database is backed up
- When the keystore passphrase is changed

Point

Do not overwrite an old keystore when backing up a keystore. This is because during database recovery, you must restore the keystore to its state at the time of database backup. When the backup data of the database is no longer required, delete the corresponding keystore.

Example

- Back up the database and the keystore on May 1, 2020.

```
> pgx_dmpall -D /database/inst1
> cp -p /key/store/location/keystore.ks /keybackup/keystore_20200501.ks
```

  Specify the following in the pgx_dmpall command:

  - Specify the data storage destination in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

- Change the master encryption key, and back up the keystore on May 5, 2020.

```
> psql -c "SELECT pgx_set_master_key('passphrase')" postgres
> cp -p /key/store/location/keystore.ks /keybackup/keystore_20200505.ks
```

  Specify the following in the psql command:

  - Specify the SQL function that sets the master encryption key in the -c option.
  - Specify the name of the database to be connected to as the argument.

If the keystore is corrupted or lost, restore the keystore containing the latest master encryption key. If there is no keystore containing the latest master encryption key, restore the keystore to its state at the time of database backup, and recover the database from the database backup. This action recovers the keystore to its latest state.

Example

- Restore the keystore containing the latest master encryption key as of May 5, 2020.

```
> cp -p /keybackup/keystore_20200505.ks /key/store/location/keystore.ks
```

- If there is no backup of the keystore containing the latest master encryption key, recover the keystore by restoring the keystore that was backed up along with the database on 1 May 2020.

```
> cp -p /keybackup/keystore_20200501.ks /key/store/location/keystore.ks
> pgx_rcvall -B /backup/inst1 -D /database/inst1 --keystore-passphrase
```

  Specify the following in the pgx_rcvall command:

  - Specify the data storage directory in the -D option. If the -D option is omitted, the value of the PGDATA environment variable is used by default.

- Specify the backup data storage directory in the -B option.
- The --keystore-passphrase option prompts you to enter the passphrase to open the keystore.

If you have restored the keystore, repeat the process of enabling automatic opening of the keystore. This ensures that the contents of the automatically opening keystore (keystore.aks) are identical to the contents of the restored keystore.

It is recommended that you do not back up the automatically opening keystore file, keystore.aks. If the database backup medium and the backup medium storing the automatically opening keystore are both stolen, the attacker will be able to read the data even without knowing the passphrase.

If the automatically opening keystore is corrupted or lost, you must again enable automatic opening. The keystore.aks file will be recreated from keystore.ks at this time.

Refer to "pgx_rcvall" and "pgx_dmpall" in the Reference for information on the pgx_rcvall and pgx_dmpall commands.

Refer to "psql" under "Reference" in the PostgreSQL Documentation for information on the psql command.

Refer to "B.2 Transparent Data Encryption Control Functions" for information on the pgx_set_master_key function.

Refer to "K.5.3 Enabling Automatic Opening of the Keystore" for information on how to enable automatic opening of the keystore.

K.6 Backing Up and Restoring/Recovering the Database

Refer to "5.8 Backing Up and Restoring/Recovering the Database".

You do not need to back up the Opencryptoki token directory.

K.7 Importing and Exporting the Database

Refer to "5.9 Importing and Exporting the Database".

K.8 Encrypting Existing Data

Refer to "5.10 Encrypting Existing Data".

K.9 Operations in Cluster Systems

This section describes how to use transparent data encryption on cluster systems such as high-availability systems, streaming replication, and database multiplexing.

K.9.1 HA Clusters that do not Use Database Multiplexing

Take the following points into account when using transparent data encryption in an HA cluster environment that does not use database multiplexing.

Placement and automatic opening of the keystore file

There are two alternatives for placing the keystore file:

- Sharing the keystore file
- Placing a copy of the keystore file

Sharing the keystore file

This involves using the same keystore file on the primary server and the standby server.

As the standby server is not active while the primary server is running, this file would not be accessed simultaneously, and therefore, it can be shared.

To manage the keystore file in a more secure manner, place it on the key management server or the key management storage isolated in a secure location.

Enable the automatic opening of the keystore on both the primary and standby servers.

Placing a copy of the keystore file

This involves placing a copy of the primary server keystore file on the standby server.

You can do this if you cannot prepare a shared server or disk device that can be accessed from both the primary and standby servers.

However, if you change the master encryption key and the passphrase on the primary server, you must copy the keystore file to the standby server again.

To manage the keystore file in a more secure manner, prepare the key management server or the key management storage isolated in a secure location for both the primary and standby servers, and place the keystore files there.

Enable the automatic opening of the keystore on both the primary and standby servers. Note that copying the automatically opening keystore file (keystore.aks) to the standby server does not enable the automatic opening of the keystore.

K.9.2 Database Multiplexing Mode

Note the following when using transparent data encryption in environments that use streaming replication, or database multiplexing with streaming replication.

Placing the keystore file

Place a copy of the primary server keystore file on the standby server.

This is required as the keystore file cannot be shared, and both servers may need to access it simultaneously.

To manage the keystore file in a more secure manner, place it on the key management server or the key management storage isolated in a secure location. A keystore used by both the primary and standby servers can be managed on the same key management server or key management storage.

However, create different directories for the keystores to be used by the primary server and the standby server. Then copy the keystore for the primary server to the directory used on the standby server.

Automatically opening the keystore

You must enable automatic opening of the keystore.

To do this, enable automatic opening of the keystore in all servers that make up database multiplexing. The settings for automatic opening of the keystore include information unique to each server, so simply copying the file does not enable it.

Changing the passphrase

Changes to the passphrase are reflected in all servers that make up database multiplexing, so no special operation is required.

Building and starting a standby server

Before using the pg_basebackup command or pgx_rcvall command to build a standby server, copy the keystore file from the primary server to the standby server. When using an automatically opening keystore, use the copied keystore file to enable automatic opening on the standby server.

Open the keystore each time you start the standby server. This step is necessary for decrypting and restoring encrypted WAL received from the primary server. To open the keystore, specify the --keystore-passphrase option in the pg_ctl command or pgx_rcvall command and enter the passphrase, or use an automatically opening keystore.

Changing the master encryption key and the passphrase

Change the master encryption key and the passphrase on the primary server. You need not copy the keystore from the primary server to the standby server. You need not even restart the standby server or reopen the keystore. Changes to the master encryption key and the passphrase are reflected in the keystore on the standby server.

 See

Refer to "pgx_rcvall " in the Reference for information on pgx_rcvall command.

Refer to "pg_ctl" under "Reference" in the PostgreSQL Documentation for information on pg_ctl command.

Refer to "pg_basebackup" under "Reference" in the PostgreSQL Documentation for information on pg_basebackup command.

Refer to "High Availability, Load Balancing, and Replication" under "Server Administration" in the PostgreSQL Documentation for information on how to set up streaming replication.

K.10 Security-Related Notes

Refer to "5.12 Security-Related Notes".

K.11 Tips for Installing Built Applications

Refer to "5.13 Tips for Installing Built Applications".

Appendix L Utilize zEnterprise Data Compression (zEDC)

In conjunction with a feature called zEDC, IBM Z enables faster compression and decompression. The functions of zEDC are available by using zlib library and gzip command corresponding to zEDC. This product can use zEDC because it also uses zlib and gzip.

Refer to IBM documentation for zEDC compression characteristics, required hardware, software requirements, and more.

The compression and decompression processes available with zEDC are as follows:

Feature	How to specify compression/decompression operations that enable zEDC	Target
pg_basebackup	The output format is tar and gzip compression is enabled with the -z, --gzip, -Z, and --compress option.	A base backup
pg_dump	Compression of custom-format archive or directory-format archive.	Custom-format archive or directory-format archive
pg_restore	Decompression of custom-format achive or directory-format archive.	Custom-format archive or directory-format archive
pg_receivewal	Compressed by -Z and -compress options.	Received WAL
pgcrypto	The following functions compress with option compress-algo of 1 or 2: - pgp_sym_encrypt(data text, psw text [, options text]) returns bytea - pgp_sym_encrypt_bytea(data bytea, psw text [, options text]) returns bytea - pgp_pub_encrypt(data text, key bytea [, options text]) returns bytea - pgp_pub_encrypt_bytea(data bytea, key bytea [, options text]) returns bytea Further, the encrypted compressed data by the above functions is decrypted as follows: - pgp_sym_decrypt(msg bytea, psw text [, options text]) returns text - pgp_sym_decrypt_bytea(msg bytea, psw text [, options text]) returns bytea - pgp_pub_decrypt(msg bytea, key bytea [, psw text [, options text]]) returns text - pgp_pub_decrypt_bytea(msg bytea, key bytea [, psw text [, options text]]) returns bytea	In the encrypt functions, the data argument In the decrypt functions, the msg argument
pgx_dmpall	Compressed by -Z and -compress options in pgx_dmpall command. Compressed by -Z in archive_command.	Backup data Archive logs
pgx_rcvall	Decompression process when restoring compressed backup data.	Backup data Archive logs
pg_rman	When the backup data is compressed with -z or --compress-data option. When restoring compressed backup data.	Backup data
Streaming replication	Compressed by streaming_wal_compression in postgresql.conf of standby server.	WAL data

Note

By default, zEDC is enabled only at compression level 1 of zlib and gzip.If necessary, change the compression level at which zEDC is enabled with the DFLTCC_LEVEL_MASK environment variable.

Refer to IBM documentation for more information on zEDC because IBM may change the specification of zEDC.

For pgcrypto functions, change the compression level with compress-level and specify whether to use zEDC.

For streaming replication feature, change the compression level with streaming_wal_compression and specify whether to use zEDC. Because compression is performed on the primary server, if you want to change the behavior of the zEDC, change the environment variable when you start the primary server. Similarly, decompression is performed on the standby server, so if you want to change the behavior of zEDC, change the environment variable when the standby server starts.

For pg_rman compression, the default compression level is used. (In general, the default compression level is 6.)

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FUJITSU

J2UL-2749-02ZLZ0(00)
September-2022

Preface

Purpose of this document

This document describes security when building and operating a FUJITSU Software Enterprise Postgres (hereinafter referred to as "FUJITSU Enterprise Postgres") database system.

Intended readers

This document is intended for those who are:

- Considering installing FUJITSU Enterprise Postgres
- Designing, building, and operating the security operating environment in FUJITSU Enterprise Postgres
- Accessing FUJITSU Enterprise Postgres database systems

Readers of this document are assumed to have general knowledge of:

- Business operations
- FUJITSU Enterprise Postgres
- Linux

Structure of this document

This document is structured as follows:

References

This document contains abstracts from the following document:

- Database Security Guideline Version 2.0
  (Database Security Consortium (DBSC))

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Issue date and version

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Edition 2.0: September 2022
Edition 1.0: February 2022
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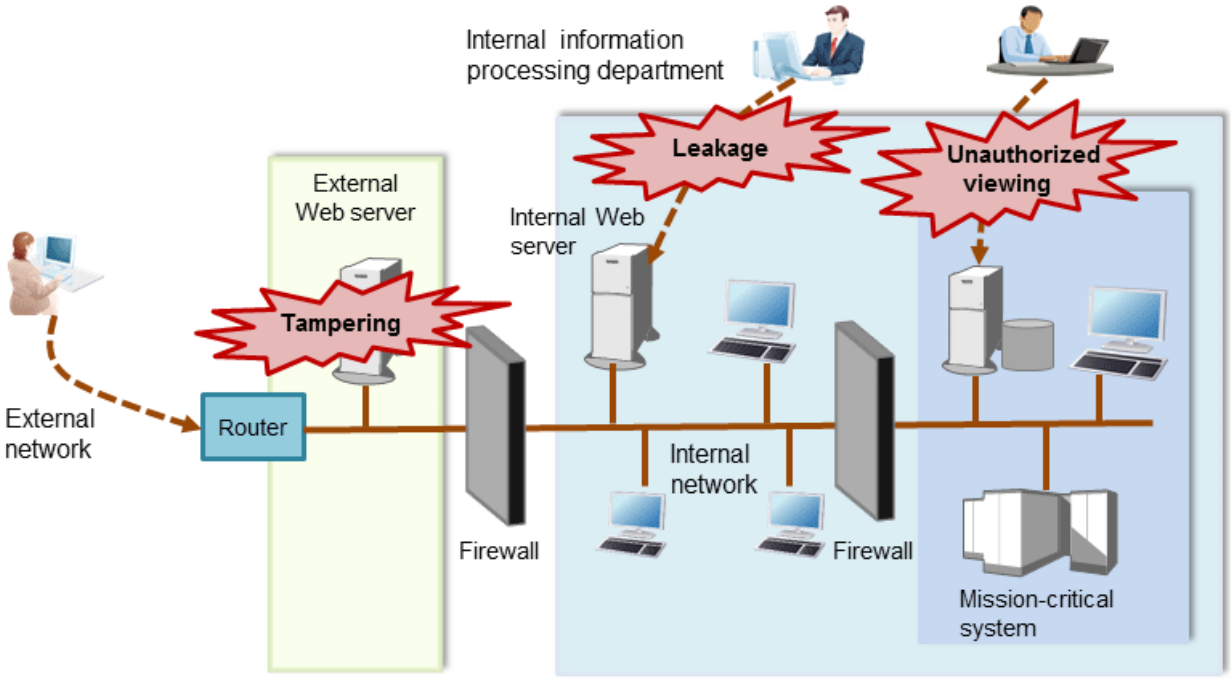
Contents

Chapter 1 Overview of Security

1.1 What is Security?

Computer security is the protection of information systems and data from risks such as leakage or tampering of information, attacks, intrusions, eavesdropping from external sources, and interference with information services. Security measures are essential for the advance prevention of security threats in order for information systems to gain trust as social infrastructure.

Figure 1.1 Security threats



The security measures in information systems can be classified as follows:

- Network
- Web
- Application
- Database
- PC

This document focuses on database security measures when using FUJITSU Enterprise Postgres.

1.2 Security Requirements

Below are the necessary security requirements for information systems.

Maintenance of security policies

A security policy clarifies the approach the company should take in relation to information assets, and the actions employees should take.

It is necessary to undertake security of information systems while maintaining security policies.

Integrated security management

Security has the aspects below. It is necessary to manage information in an integrated manner based on these aspects.

Confidentiality

Access to the information is restricted to prevent leakage of information outside of the company

Example measures: Prevention of information leakage or setup of access privileges

Integrity

Integrity is guaranteed, ensuring information does not become corrupted or tampered with

Example measures: Prevention or detection of tampering

Availability

Failure is prevented and normal operation is maintained so that information can be used when needed

Example measures: Power supply measures, system mirroring

1.3 Security Threats

A security threat is defined as something that threatens the confidentiality, integrity, and availability indicated in "1.2 Security Requirements" in respect to information assets. This includes technical threats such as accessing a database, but does not include physical destruction.

Threats are considered to be a combination of type of user who is the source of the threat, information assets that need to be protected, techniques, and unauthorized actions. For example, a threat might be a general user exploiting a database vulnerability to obtain database management information, and then tampering with that information.

When considering security measures, it is firstly necessary to clarify what kind of threats there are. A list of possible threats is shown in the table below. Refer to "Types of user" and "Information assets" for details on the definition of each type of user and information assets that should be protected.

Possible threats

Type of user	Information asset	Technique	Unauthorized action
General user Internal user System manager System developer System administrator System operator	Database management information	Eavesdropping of packets	Unauthorized acquisition (viewing) of information Unauthorized tampering or destruction (updating) of information
		Dictionary attack of passwords	
		Unauthorized acquisition of IDs/ passwords through social engineering	
		Unauthorized acquisition of information through misuse of settings	
		Unauthorized acquisition of information through exploiting a database vulnerability	
		Acquisition by an unauthorized route	
General user Internal user	General database information	Acquisition by a normal route	Misuse of information that can be acquired normally (taking data outside of the company)
		SQL issued with the aim of obstructing a job	Obstructing a job (resource depletion)
General user Internal user	General database information	Eavesdropping of packets	Unauthorized tampering or destruction (updating) of information
		Dictionary attack of passwords	
		Unauthorized acquisition of IDs/ passwords through social engineering	

Type of user	Information asset	Technique	Unauthorized action
		Unauthorized acquisition of information through exploiting configuration errors	
		Unauthorized acquisition of information through exploiting a database vulnerability	
		Acquisition by an unauthorized route	
System manager System developer System administrator System operator	General database information	Eavesdropping of packets	Unauthorized acquisition (viewing) of information Unauthorized tampering or destruction (updating) of information
		Dictionary attack of passwords	
		Unauthorized acquisition of IDs/ passwords through social engineering	
		Unauthorized acquisition of information through exploiting configuration errors	
		Unauthorized acquisition of information through exploiting a database vulnerability	
		Acquisition by an unauthorized route	
System developer	Database management information	Creation of a backdoor	Unauthorized acquisition (viewing) of information Unauthorized tampering or destruction (updating) of information
	General database information		
System manager System administrator	Database management information	Unauthorized acquisition of information by creating an unauthorized database administrator account	Unauthorized acquisition (viewing) of information Unauthorized tampering or destruction (updating) of information
	General database information		
System manager System operator	Database management information	Unauthorized acquisition of information by tampering with database-related files (definition file, physical file, and so on)	Unauthorized acquisition (viewing) of information Unauthorized tampering or destruction (updating) of information
	General database information		
Database administrator	Database management information	Misuse of information (taking information outside of the company) after obtaining it through the normal route	Misuse of information that can be acquired normally (taking information outside of the company)
		Unauthorized use of IDs/ passwords from the management information	Tampering with or destroying information that can be acquired
		Unauthorized acquisition of information by tampering with management information	

Type of user	Information asset	Technique	Unauthorized action
		SQL issued with the aim of obstructing a job	Obstructing a job (resource depletion)
	General database information	Eavesdropping of packets	Unauthorized acquisition (viewing) of information Unauthorized tampering or destruction (updating) of information
		Misuse of information (taking information outside of the company) after obtaining it through an unauthorized route	
Database operator	Database management information	Eavesdropping of packets	Unauthorized acquisition (viewing) of information Unauthorized tampering or destruction (updating) of information
		Dictionary attack of passwords	
		Unauthorized acquisition of IDs/ passwords through social engineering	
		Unauthorized acquisition of information by exploiting configuration errors	
		Unauthorized acquisition of information through exploiting a database vulnerability	
		Acquisition by an unauthorized route	
	General database information	Acquisition by a normal route	Misuse of information that can be acquired normally (taking data outside of the company)
		SQL issued with the aim of obstructing a job	Obstructing a job (resource depletion)

Types of user

In database security, the persons involved with databases and their roles are defined below.

Type of user	Role
System manager	Manages developers, administrators, and operators
System developer	Builds the network around the database server Builds the database server
System administrator	Operates devices of the surrounding database network Operates the database server
System operator	Operates the surrounding database network
Database administrator	Builds the database system Operates the database system
Database operator	Performs business operations
Internal user	End user inside the company
General user	End user outside the company

Information assets

In database security, it is necessary to protect the information assets to be stored on the database server.

Such assets are defined below.

Database management information

- Database configuration information (system catalog, user ID/password, and so on)
- Database logs (such as access logs)

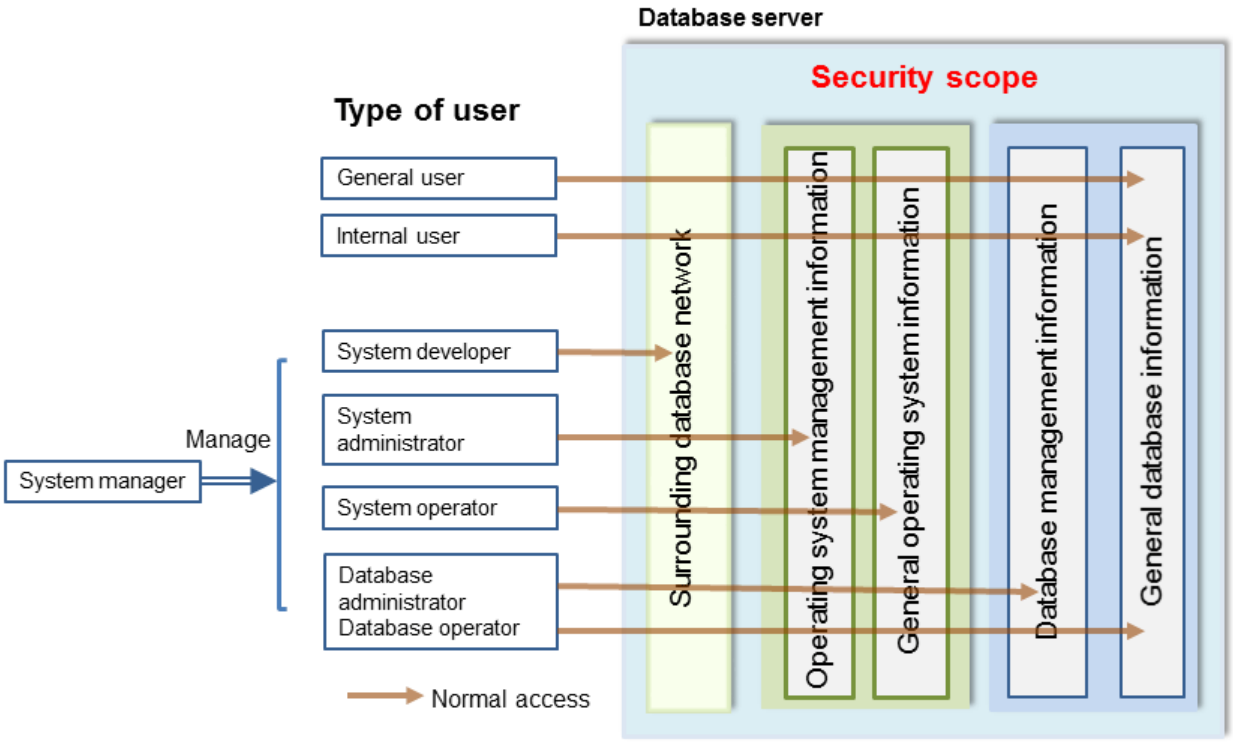
General database information

- Job data
- Applications

1.4 Security Scope

In database systems, both the database server and the surrounding database network are part of the security scope. It is necessary to clarify the extent of the security scope that each type of user is involved with, and consider security measures for the same.

The relationship of the security scope and the types of user is shown below.



1.5 Security Provided by FUJITSU Enterprise Postgres

FUJITSU Enterprise Postgres provides security features that satisfy the security requirements indicated in "1.2 Security Requirements".

This section describes security provided by FUJITSU Enterprise Postgres.

1.5.1 Roles Targeted For Security

In FUJITSU Enterprise Postgres database systems, the roles targeted in relation to security are "Manager", "Administrator", and "User". In order to build a robust security system, it is necessary to put security measures in place for each role.

The roles targeted for security and the mapping of Types of user indicated in "1.3 Security Threats" are shown in the table below.

Role targeted for security	Type of user
Manager	System manager
Administrator	System developer
	System administrator
	System operator
	Database administrator
	Database operator
User	General user
	Internal user

Manager

The manager establishes a security policy and decides on an operations policy for the organization as a whole.

Refer to "Chapter 3 Tasks of the Manager" for details.

Administrator

Administrators design, build and operate a system. While doing this, the administrators must implement the security measures in accordance with the security policy established by the manager.

Refer to "Chapter 4 Tasks of Administrators" for details.

User

A user is a person other than the manager or an administrator who accesses a database. There may be any number of users. It is necessary for users to be registered in the database system, and that access to the database is restricted according to the access privileges.

Refer to "Chapter 5 Tasks of Users" for details.

1.5.2 Security Features

FUJITSU Enterprise Postgres provides the following security features:

- Authentication
- Access control
- Encryption
- Audit log
- Data masking

This section describes each of these features.

Authentication

The databases that can be accessed can be restricted by authenticating the database users who access the database. Additionally, authentication of the server can be performed to prevent spoofing of the database server.

Refer to "Client Authentication" in "Server Administration" in the PostgreSQL Documentation for details on authentication.

Refer to "Secure TCP/IP Connections with SSL" in "Server Setup and Operation" in the PostgreSQL Documentation for details on server authentication.

Access control

Database objects can only be used by the object creator or database user who was specified as the owner when the object was created (both persons are hereinafter referred to as "owner"), or instance administrator, when objects are in their initial state. By having the object owner

or instance administrator control access privileges for database users, it is possible to control what kind of tables the database users who connect to the database can access, and what kind of operations they can perform.

Refer to "Privileges" in "The SQL Language" in the PostgreSQL Documentation for details on object access control.

Encryption

FUJITSU Enterprise Postgres provides a transparent data encryption feature that satisfies the requirements below.

- Confidential information can be changed into an unidentifiable state.
- The encryption key and data are managed separately.
- The encryption key is replaced at regular intervals.

PostgreSQL provides an encryption feature called "pgcrypto" that can also be used in FUJITSU Enterprise Postgres, however, it is recommended to use the transparent data encryption features because it will otherwise be necessary to modify the applications that consider encryption. Refer to "Protecting Storage Data Using Transparent Data Encryption" in the Operation Guide for details.

Additionally, if communication data transferred between a client and a server contains confidential information, it is necessary to encrypt the communication data to protect it against threats, such as eavesdropping on the network.

Refer to "Configuring Secure Communication Using Secure Sockets Layer" in the Operation Guide for details on encryption of communication data.

Audit log

A feature that addresses threats such as misuse of administrator privileges, unauthorized access to a database by a user, and other such threats. Information for tracing the processing of administrators and users is retrieved and stored as an audit log.

By periodically viewing and monitoring audit logs, the administrators can detect events that are impacting on the system in some way, or are depleting system resources as a result of incorrect operations by users, and can take appropriate measures to prevent information leakages or system failures in advance.

Refer to "Chapter 6 Audit Log Feature" for details.

Data masking

A feature that changes part of the data to make it available for reference in response to queries issued by an application.

For example, for a query of employee data, digits except the last four digits of an eight-digit employee number can be changed to "*" so that it can be used for reference without exposing the actual data.

Specifically, the data changed by the data masking feature can be transferred to a test database so that users who perform testing or development can reference the data. During testing, it is desirable to use the data that will be used on a production environment database. However, actual production data should not be used as is for testing because of the risk of leakage of confidential data. This feature enables data that is similar to actual production data to be safely used in test and development environments.

Refer to "Data Masking" in the Operation Guide for details on data masking.

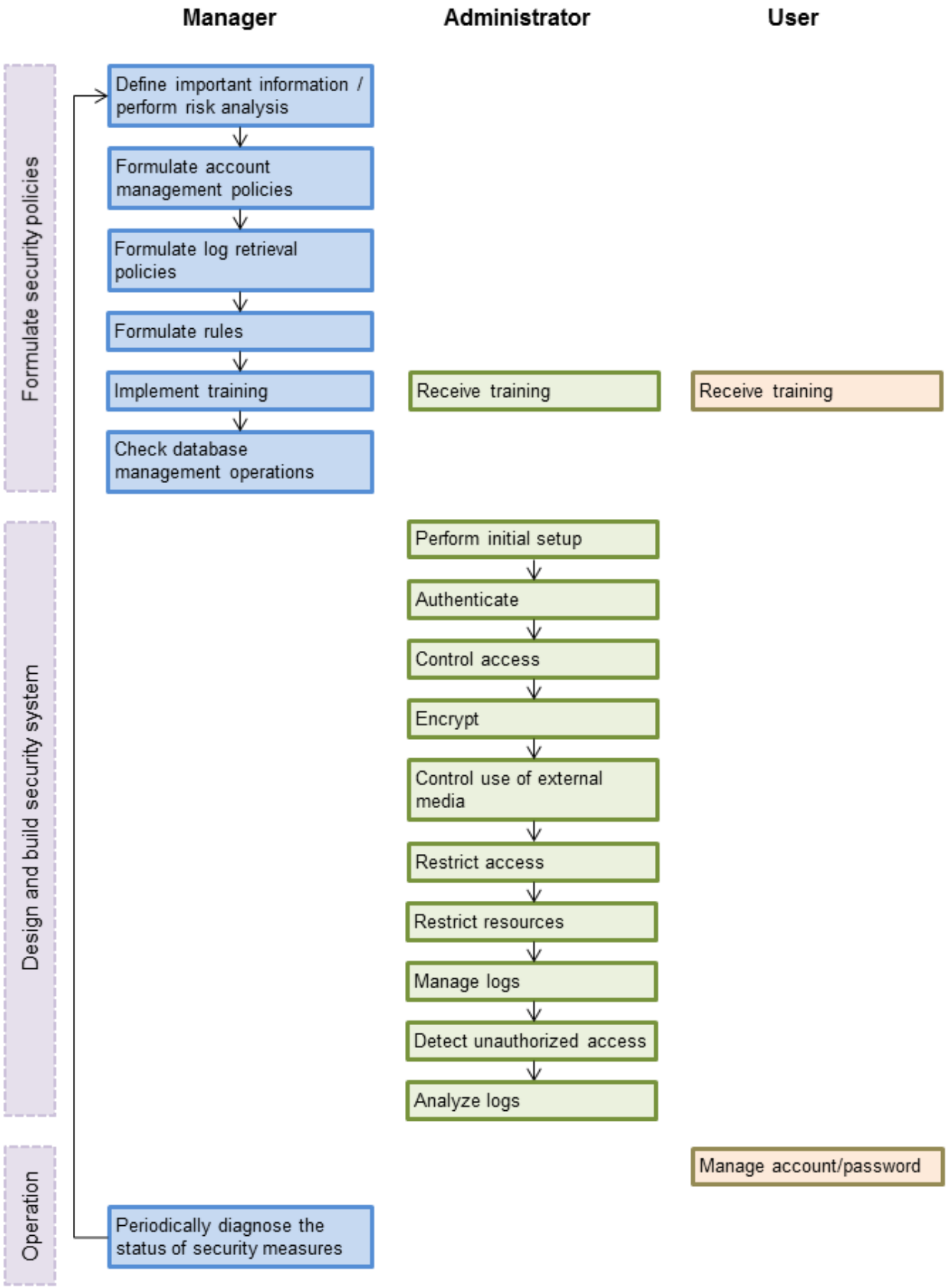
Chapter 2 Overview of Security Operation

2.1 Security Operation Flow

This section shows the flow of work when building a security environment and performing security operation in FUJITSU Enterprise Postgres.

When performing security operation, there are technical measures to be implemented to address security threats by equipping the system with security features, and manual work, such as the implementation of security guidelines, a training system, and the establishment of usage rules.

Figure 2.1 Security operation flow



Chapter 3 Tasks of the Manager

The manager formulates security policies, which become guidelines for security measures.

3.1 Defining Important Information and Risk Analysis

Before formulating security policies, define important information and perform risk analysis. Based on the importance of the information and the result of risk analysis, decide what kind of security measures to put in place.

In defining the important information, identify what should be protected and classify it by importance in order to effectively implement the security measures. Information that should be protected includes "database management information" and "general database information", as indicated in "Information assets". Examples of information classifications are "personal information" and "confidential information".

In the risk analysis, refer to "Possible threats" to identify threats that may arise, and analyze the risks in respect to such threats.

Additionally, by performing a risk analysis once annually as a guide, it is possible to identify threats that may adversely impact the business and related vulnerabilities.

3.2 Formulating Account Management Policies

In formulating an account management policy, implement the following and document the formulated policy.

Organize system users and roles

Identify the necessary roles of the relevant system based on "Types of user". Additionally, organize personnel for each role.

Organize accounts

Organize accounts with the appropriate privileges for each role, and decide on account policies.

- Database administrator account
  - Organize separate accounts for database administrators and database operators
  - Ensure that the database administrator account can only be used by specific persons
  - Perform tasks that do not require database administrator privileges using a separate account without database administrator privileges
- General account

  Create an account for general users by application usage.

Review account management policy

Review the accounts in order to effectively implement security measures.

- Regularly check the accounts mentioned above and their privileges, and determine if they are still appropriate
- If there have been system or operational changes, review the accounts and privileges
- If unsuitable accounts and privileges are discovered, modify them as required

3.3 Formulating Log Retrieval Policies

In formulating a log retrieval policy, implement the following and document the formulated policy.

Organize the purpose of log retrieval

To clarify what logs will be retrieved for, define their reason for retrieval.

Examples of the purpose might include, "To use for investigation in the event of unauthorized access", and "To submit to investigating authorities as evidence if any issues arise".

Decide on the types of logs to be retrieved

In order to retrieve appropriate logs, organize the types of logs that can be retrieved in the target system, and decide on the logs to be retrieved.

Examples of log types are "operating system logs", "application run logs", and "database audit logs".

Organize log retrieval target access

In order to decide on access for log retrieval targets, organize what kind of access will take place.

For example, the following access is possible:

- Access related to important information
  - Access to personal information, confidential information, and database management information
  - Access outside of business hours
  - Login
  - Specific SQL
- Access suspected to be unauthorized
  - Large amount of search access
  - Access from different locations
  - Access outside of business hours

Decide on the log retrieval content

In order to effectively use retrieved logs, organize the required content as a log, and decide on the retrieval content.

For example, the following output content is possible:

- When (time)
- Who (database account, application user)
- What (object ID, table name)
- Where from (machine name, IP address)
- How (SQL type, SQL statement)
- Execution result (success/fail)

Formulate log maintenance policy

In order to use the logs as purposed, formulate the log maintenance policy.

For each log, define its location, storage medium, retention period, access control, and so on.

3.4 Formulating Rules

Formulate the rules that will become the standard for security measures of the target system. Additionally, prescribe penalties for security violations. For example, formulate rules and penalties as below:

- Rules
  - Applying security patches and update programs
  - Prohibiting unauthorized acquisition of information from the database
  - Prohibiting the saving of acquired information to media that is not permitted for use
- Penalties
  - Prescribe penalties in the company's employment policies and procedures

- Set fines

3.5 Implementing Training

In order to have administrators and users recognize the importance and necessity of information security, and to prevent unauthorized access due to operational omissions and mistakes, implement and promote security-related training for administrators and users.

For example, implement promotion of security policies, formulation of training schedules, and formulation of training materials.

3.6 Checking the Database Management Operations

In order to prevent operational errors and unauthorized actions by administrators, implement the measures below:

- Always collect the latest information on security incidents and vulnerabilities related to databases
- Implement management operations only after providing advance notice
- Retain records of management operations

3.7 Periodic Diagnosis of the Status of Security Measures

In order to check if the security measures are effective, periodically diagnose if the security measures have been put in place appropriately based on the security threats.

Additionally, evaluate if the current security measures and policies are effective for the threats and vulnerabilities, and if there are any issues, review the security policies and security measures.

Chapter 4 Tasks of Administrators

Administrators perform the actions below as security measures when designing, building, and operating the system in accordance with the security policies formulated by the manager.

Preparation

- Implement training

Measures to protect against unauthorized behavior

- Perform initial setup
- Authenticate
- Control access
- Encrypt
- Control use of external media
- Restrict access
- Restrict resources

Measures to detect and trace unauthorized behavior

- Manage logs
- Detect unauthorized access
- Analyze logs

4.1 Receiving Training

Administrators receive security-related training in accordance with the training schedule formulated by the manager. Additionally, administrators instruct users to receive training.

4.2 Initial Setup

To minimize database vulnerabilities and the possibility of unauthorized access, implement the security measures below in the initial stage of system building. Additionally, configure the database server so that it primarily operates the database system only.

Making the server more robust

Configure the operating system and network to prevent intrusion into or destruction of a database server, so that the system operates on a secure server.

- Remove unnecessary features or services on the operating system
- Enable only the necessary protocols
- Implement the security features for services, protocols, and daemons considered to have a relatively low security level, such as file sharing and FTP

Installing the latest version

Always download and apply the latest patches in order to reflect the latest security measures.

Installing the minimum necessary features

Install only the necessary features in order to prevent unauthorized use of the system.

Additionally, delete or disable features and services that will not be used.

Changing the port

To prevent unauthorized use of the system, change the default port that is set during installation.

Point

Specify the port during setup of FUJITSU Enterprise Postgres. Refer to the Installation and Setup Guide for Server for details.

Access restrictions for communication features

To prevent unauthorized use of the system using the communication features, implement access restrictions for communication features.

Settings for prohibiting the access path to database configuration files

To prevent database destruction, implement the measures below:

- Restrict users who are permitted to access database configuration files, and periodically review the permissions
- Allow only administrators to access table or definition scripts

Restrictions on the access path to the database

To prevent unauthorized use or operating errors for the database, restrict the distribution range of applications used to access the database only to devices used by users who are permitted access.

Dealing with unauthorized programs

To prevent unauthorized intrusions into a system through a backdoor, such as by tampering with the program source code of an application, document the author of the program to be run and perform checking and testing so that the program will not be tampered with. Additionally, employ safe coding techniques so that issues with general coding vulnerabilities can be addressed.

System security settings

In cases where it is clear that the system security settings will impact security, set reliable security settings in the initial setup stage, such as setting appropriate security parameters.

4.3 Authentication

When accessing a database, authentication must always be performed in order to prevent tampering or information leakage from spoofing by a malicious user.

Password authentication is used when logging on to a database, and the account and password used for authentication are to be strictly managed by administrators.

Additionally, authentication must also be implemented reliably for connections to a database from clients, so that only permitted users can access the database.

4.3.1 Managing Accounts

For account management, perform the actions below.

Create the required accounts

To prevent unauthorized use of accounts, such as spoofing, implement the measures below when creating an account:

- Select the required account
- Specify the user privileges
- Create database administrator accounts and general user accounts separately according to the privileges

Point

Accounts are created using the CREATE ROLE statement. Refer to "CREATE ROLE" in the PostgreSQL Documentation for details.

Delete unnecessary accounts

Remove accounts not used on a daily basis, such as unused accounts and accounts not needed for operations that are created by default during product installation.

Point

Accounts are deleted using the DROP ROLE statement. Refer to "DROP ROLE" in the PostgreSQL Documentation for details.

Set up account lockout

The usage frequency of accounts is to be checked periodically, and if there are any accounts that have not been used for a long period, lock those accounts. Set a limit for failed login attempts, and if this limit is exceeded, lock the account. Additionally, set the period until a locked account is reenabled.

Point

Account locking can be performed by using LDAP authentication. Refer to "LDAP Authentication" in the PostgreSQL Documentation for details.

Manage database administrator accounts

Manage database administrator accounts in accordance with the account management policy formulated by the manager.

Manage development environment and production environment accounts

To prevent unauthorized use of accounts used in a development environment, delete accounts used in the development environment before operation starts in the production environment. In cases where it is unavoidable to use an account used in the development environment in the production environment, use different passwords in each environment.

Set up a temporary use account

If a temporary user will use the system, either provide a shared account with a temporary password for each use, or create a temporary account.

4.3.2 Managing Passwords

Manage passwords as below.

Make strong passwords

The use of account passwords that can easily be guessed by others, such as a password that matches the ID, or the default password provided during installation, is prohibited. Set a complex and strong password.

Change passwords regularly

Change passwords regularly to prevent others from accessing the account in case the password is obtained by unauthorized means. Additionally, configure the settings to force a password change when prompted after the first use.

Set the password expiry period

To encourage regular changing of passwords, set a password expiry period.

Point

Password setting and changing is specified using the CERATE ROLE statement or ALTER ROLE statement. Refer to "CREATE ROLE" and "ALTER ROLE" in the PostgreSQL Documentation for details.

Additionally, by using passwordcheck and LDAP authentication, the actions below can be performed:

- The default password set during installation can be changed
- The password expiry period can be set
- The number and types of characters used for the password can be checked

Refer to "passwordcheck" and "LDAP Authentication" in the PostgreSQL Documentation for details.

4.3.3 Configuring Connections and Authentication

Configure connections and authentication so that the database can only be accessed by permitted users.

Point

Client authentication is configured in pg_hba.conf. Refer to "Client Authentication" in the PostgreSQL Documentation for details.

4.4 Access Control

If appropriate access privileges are not set for administrators and users, security incidents may occur, such as information leakage resulting from access to information by an unauthorized person. To minimize such incidents, it is necessary to implement the security measures below for the access privileges and perform rule-based access control.

Point

Notes when setting access privileges

- The creation of a special account that allows granting of privileges to all users is prohibited
- The creation of a general account that allows access to general information such as operations data is prohibited

Identifying the database access requirements

To set the appropriate access privileges for each usage purpose for the database, follow the procedure below to identify the access requirements:

1. Classify the usage purpose of the account, such as "For database management", "For object management", and "For data access".
2. Classify the required privileges for each usage purpose, such as "By feature" and "By object".
3. Categorize the accounts based on each privilege.
4. Identify the minimum necessary range of data and minimum necessary access content (view, update, create, delete) to be accessed for each categorized account, and decide on the database access requirements.

Setting the access privileges

Assign the minimum necessary privileges based on the database access requirements for each categorized account. Additionally, restrict accounts when assigning administrator privileges.

Reviewing access privileges

To reflect changes in access requirements in the system, periodically review the access privileges and check if there are any access privileges that are no longer needed. If any unnecessary access privileges have been set, promptly modify the access privileges.

Point

Access privileges are set using the GRANT statement or REVOKE statement. Refer to "GRANT" and "REVOKE" in the PostgreSQL Documentation for details.

4.5 Encryption

To prevent unauthorized usage of data in the event information leakage occurs due to data theft, eavesdropping of communication, and other such activities, implement the encryption measures below.

Encrypt communication

To protect data from eavesdropping over the network between a database server and clients, use the encryption feature to encrypt communications.

Refer to "Configuring Secure Communication Using Secure Sockets Layer" in the Operation Guide for details.

Encrypt data

To protect data from theft, use the encryption feature to encrypt the data. The data below is targeted for encryption:

- Data to be stored on the database
- Backup data
- Data files

Refer to "Protecting Storage Data Using Transparent Data Encryption" in the Operation Guide for details.

Manage encryption keys

Restrict the persons who can access the encryption key to a minimum number of database administrators.

Additionally, to ensure the encrypted information will not be easily decrypted, create a mechanism for appropriately managing the encryption key for the entire life cycle (generation, distribution, saving, and disposal), and strictly manage the encryption key.

Refer to "Configuring Secure Communication Using Secure Sockets Layer" and "Protecting Storage Data Using Transparent Data Encryption" in the Operation Guide for details.

4.6 Controlling Use of External Media

Information leakage can be prevented by controlling use of external media (such as CD/DVD, USB drive, and external hard disk) and PCs that are connected to the database, and restricting the removal of data from the database.

Restricting connection of external media

Remove external media and printers that will not be used in operations, and restrict connection of external media to which information may be written.

Restricting use of external media

Restrict connections for external media and printers to control the writing of information to these devices.

Controlling use of connected PCs

Prevent leakage of information from PCs connected to the database:

- Limit connections of external media to PCs
- Implement security measures to make the PC robust
- Implement individual authentication for access from the PC
- Manage the installed software and monitor the software usage status
- Limit connections to printers

4.7 Security Measures for Servers/Applications

An even more robust security system can be achieved by strengthening security for servers and applications in addition to the security measures for databases. Implement the security measures below for servers and applications:

Restrict access

Implement the measures below and restrict access to the database server:

- Install the database server inside the firewall to prevent direct access to the database server from many unspecified PCs.
- In the local network, implement measures such as using the router to restrict IP addresses, and restrict PCs and segments that can directly access the database server.

Restrict resources

Restrict excessive use of CPU resources by general users to prevent the disruption of service and extraction of large amounts of data.

4.8 Log Management

Logs are a feature that addresses threats such as misuse of administrator privileges, and unauthorized access to a database by a user. Information for investigating/tracing processes and operations performed for the database is retrieved and managed as logs for identifying the cause in the event information leakage or unauthorized access occurs.

FUJITSU Enterprise Postgres provides the audit log feature for retrieving and managing logs. Refer to "Chapter 6 Audit Log Feature" for details.

This section describes the information that should be obtained as logs and how to maintain logs, as a measure for managing information leakage and unauthorized access.

4.8.1 Retrieving Logs

The audit logs below are retrieved in accordance with the log retrieval policy formulated by the manager.

Login information

Retrieves logs during login and logout.

Database access information (view/update)

Retrieves all access relating to the information below:

- General database information (such as personal information and confidential information used in the business)
- Database management information (system catalog, user ID/password, and so on)

Changed information of database objects

Retrieves logs related to creating, changing, and deleting database objects such as database accounts and tables.

Operation logs for audit logs

To prevent suppression of retrieved audit logs, operations such as initialization of audit logs, and stoppage of the audit log feature are retrieved as logs.

4.8.2 Maintaining Logs

Logs are maintained in accordance with the log retrieval policy formulated by the manager.

Storing logs

Perform the actions below and store logs securely so that the retrieved logs will not be updated by others:

- Save logs to external media, and store the external media in a secure location, such as lockable storage
- Restrict the viewing of logs to administrators only, and set access restrictions for logs, such as not assigning update rights
- Decide on the log retention period, with consideration to cases where investigation tracing back to the time of discovery of an issue is required

Preventing tampering of logs

Implement measures to prevent tampering of logs, such as retaining multiple copies of logs and using storage that cannot be rewritten.

Encrypting logs

Encrypt logs so that logs are not easily viewed.

4.9 Detecting Unauthorized Access

To address unauthorized access, it is necessary to establish a mechanism for detecting unauthorized access to databases and monitor access.

Communicating unauthorized access

Create a mechanism that notifies of detected unauthorized access, such as notifying the manager and the administrator, if an account lock occurs due to the limit for failed login attempts being exceeded.

Checking access times

Create a mechanism that can check for suspicious access to the information below outside of normal access hours, together with implementing measures to address such access.

Detecting access to database management information

- Monitor logs and detect access during timeframes that have not been applied for
- In the event a request for access permission outside of normal access hours is made, the log is checked for any discrepancies in the requested content and work result

Detecting access to general database information

- Decide on the timeframes during which access to the database is permitted for each general account
- Detect access outside of normal access hours from session information logs

Checking the connection source where access is not permitted

To detect access from connection sources that are not permitted, define the sources from where access is permitted, and detect access from connection sources that are not permitted.

Define the access patterns (connection source, operating system user and account) of database administrator accounts and general accounts, and check for access outside of these patterns.

4.10 Analyzing Logs

Create a mechanism that analyzes logs to detect unauthorized behavior in cases where information leakage, unauthorized access, or other such activity, is suspected. Analyses should include those shown below.

Periodic analysis of session information

Analyze session information of logs from the perspectives below to detect unauthorized logins:

- Trend of sessions with a large number of failed login attempts
- Trend of sessions with accounts that are logged in for long periods of time
- Trend of sessions in which a large amount of resources are used

Periodic analysis of database access information

Analyze SQL statements from the perspectives below to detect unauthorized access to the database:

- Trend of SQL being executed over a long period of time
- Trend of SQL using a large amount of resources

Chapter 5 Tasks of Users

The user performs the actions below as security measures when using the system.

5.1 Receiving Training

The user must receive security-related training as instructed by the manager or the administrator to learn about security. By having users with a common awareness relating to security, an even more stable security system can be established.

5.2 Managing Accounts/Passwords

Users can use the database system by using the account and password provided by the administrator. At such times, the user is to implement the measures below so that the account and password are not misused by others:

- Be responsible for managing the ID and password in a manner that ensures the account does not become locked during login
- Change the password regularly
- Comply with the expiry period set for the password by promptly changing the password when it is about to expire

Chapter 6 Audit Log Feature

In PostgreSQL, logs output as server logs can be used as audit logs by using the log output feature. There are, however, logs that cannot be analyzed properly, such as SQL runtime logs, which do not output the schema name. Additionally, because the output conditions cannot be specified in detail, log volumes can be large, which may lead to deterioration in performance.

The audit log feature of FUJITSU Enterprise Postgres enables retrieval of details relating to database access as an audit log by extending the feature to pgaudit. Additionally, audit logs can be output to a dedicated log file or server log. This enables efficient and accurate log monitoring.

Note

The audit log feature cannot be used if PostgreSQL is running in single-user mode.

6.1 Audit Log Output Modes

In pgaudit, the two types of audit log below can be output.

Session Audit Logging

Session Audit Logging outputs information related to SQL executed in backend processes (processes generated when connection requests are received from clients), information related to starting and connecting databases, and information related to errors, as a log. In Session Audit Logging, by specifying the log output conditions and filtering the logs to be output, performance degradation due to outputting large volumes of logs can be prevented.

Refer to "6.4 Session Audit Logging" for details.

Object Audit Logging

When SELECT, INSERT, UPDATE, and DELETE are executed for specific objects (tables, columns), Object Audit Logging outputs these as a log. TRUNCATE is not supported. Object Audit Logging outputs object operations for which privileges have been assigned to specified roles, as a log. Object Audit Logging can control log output at an even finer level of granularity than Session Audit Logging.

Refer to "6.5 Object Audit Logging" for details.

Information

Depending on the application or command, FUJITSU Enterprise Postgres may execute SQL internally and the audit logs may be retrieved.

Also, the audit logs of multiple SQLs with the same statement ID may be retrieved. This is because before the user executes the SQL, another SQL is executed internally by FUJITSU Enterprise Postgres.

6.2 Setup

This section describes the setup method of pgaudit.

1. Copy the pgaudit files

   As superuser, run the following command. Note that "<*x*>" in paths indicates the product version.

   ```
   $ su -
   Password:******
   # cp -r /opt/fsepv<x>server64/OSS/pgaudit/* /opt/fsepv<x>server64
   ```

2. Create the pgaudit configuration file

   Create the pgaudit configuration file, which describes the information required for pgaudit actions. Create the file using the same encoding as used for the database.

   In addition, set write permissions for the database administrator only in the pgaudit configuration file so that policies related to the audit log are not viewed by unintended users.

Refer to "6.3 pgaudit Configuration File" for details.

Note

Do not define the rule section in the pgaudit configuration file at this point.

Example of a pgaudit configuration file

```
[output]
logger = 'auditlog'
```

3. Configure postgresql.conf

   Configure the parameters below in postgresql.conf to use audit logs:

   shared_preload_libraries

   Specify "pgaudit".

   pgaudit.config_file

   Specify the deployment destination path of the pgaudit configuration file.

   If a relative path is specified, the path will be relative to the data storage directory.

   log_replication_commands

   Specify "on".

   log_min_messages

   Check if "ERROR" or higher has been specified.

   If outputting an audit log to a server log ("serverlog" is specified in the logger parameter of the pgaudit configuration file), check the parameters below relating to server logs.

   logging_collector

   Check if "on" has been specified.

   log_destination

   Check if "stderr" has been specified.

   log_file_mode

   Check if the server log permissions are appropriate, so that only the permitted persons can access it.

   ### Information

   The default for the log_file_mode parameter is 0600, which only allows the database administrator to have access.

   For example, to permit other members of the group to which the database administrator belongs to view the audit logs, specify 0640 for log_file_mode.

   Example

   ```
   log_file_mode = 0640
   ```

   The database administrator can also be prevented from viewing audit logs by specifying 0000. However, write privileges are assigned for outputting logs.

   If outputting an audit log to a dedicated log file ("auditlog" is specified in the logger parameter of the pgaudit configuration file), check the parameter below.

max_worker_processes

If the max_worker_processes parameter has been set, add 1 to the specified value.

See

Refer to "Error Reporting and Logging" in the PostgreSQL Documentation for details on server logs.

If using database multiplexing, refer to "6.6 Database Multiplexing" for details.

Example of postgresql.conf

In the example below, only the parameters that need to be configured when using the audit log feature are described.

```
shared_preload_libraries = 'pgaudit'
pgaudit.config_file = 'pgaudit.conf'
log_replication_commands = on
log_min_messages = WARNING
```

4. Start the instance

   Start the instance and check if the message below is output.

```
LOG: pgaudit extension initialized
```

5. Create the pgaudit extension

   Execute CREATE EXTENSION to create the pgaudit extension.

```
$ psql
=# CREATE EXTENSION pgaudit;
=# \dx
                  List of installed extensions
Name    | Version |   Schema   |     Description
--------+---------+------------+---------------------------------
pgaudit | 1.0     | public     | provides auditing functionality
plpgsql | 1.0     | pg_catalog | PL/pgSQL procedural language
(2 rows)
```

6. Configure the parameters in the pgaudit configuration file

   Add or change the parameters in the pgaudit configuration file as required.

   Refer to "6.3 pgaudit Configuration File" for details.

7. Restart the instance

   Restart the instance to apply the changes to the pgaudit configuration file. After restarting, check if the changes have been reflected correctly.

```
LOG:  log_catalog = 1
LOG:  log_level_string =
LOG:  log_level = 15
LOG:  log_parameter = 0
LOG:  log_statement_once = 0
LOG:  role =
LOG:  logger = auditlog
LOG:  log_directory = pgaudit_log
LOG:  log_filename = pgaudit-%Y-%m-%d_%H%M%S.log
LOG:  log_file_mode = 0600
LOG:  log_rotation_age = 1440
LOG:  log_rotation_size = 10240
LOG:  log_truncate_on_rotation = 0
LOG:  fifo_directory = /tmp
```

```
LOG:  Rule 0
LOG:  pgaudit extension initialized
```

6.3 pgaudit Configuration File

In the pgaudit configuration file, specify the information required for pgaudit actions. The pgaudit configuration file comprises three sections: "output section", "option section", and "rule section".

output section

The output section is specified using the format below:

- *paramName* = '*value*'

The valid parameters in the output section are shown in the table below.

Parameter name	Description	Remarks
logger	Dedicated log file (auditlog)/*serverLog* (serverlog) that will be the output destination of the audit log The default is "auditlog" (dedicated log file).	The dedicated log file is output using the same encoding as used for the database.
log_directory	Directory where the audit log is to be created Specify the full path or the relative path from the data storage directory. The default is "pgaudit_log".	Enabled only if "auditlog" is specified for the logger parameter
log_filename	File name of the audit log Specify a file name that varies according to the time, in the same manner as for log_filename in the postgresql.conf file. The default is "pgaudit-%Y-%m-%d_%H%M%S.log".	Enabled only if "auditlog" is specified for the logger parameter
log_file_mode	Specify the permissions of the audit log so that only permitted persons can access it. The parameter value is the numeric mode specified in the format permitted in chmod and umask system calls. The default is "0600". Refer to "log_file_mode" in "6.2 Setup" for information on audit log file permissions.	Enabled only if "auditlog" is specified for the logger parameter
log_rotation_age	Maximum age of the audit log file A new audit log file is generated when the time (minute units) specified here elapses. To disable generation of new log files based on time, specify "0". The valid units are "min" (minutes), "h" (hours), and "d" (days). If the unit is omitted, "min" will be used. The default is "1d" (1 day).	Enabled only if "auditlog" is specified for the logger parameter
log_rotation_size	Maximum size of the audit log file A new log file will be generated after logs of the size specified here are output to a log file. To disable generation of new log files based on size, specify "0". The valid units are "kB" (kilobytes), "MB" (megabytes), and "GB" (gigabytes). If the unit is omitted, "kB" will be used.	Enabled only if "auditlog" is specified for the logger parameter

Parameter name	Description	Remarks
	The default is "10MB".	
log_truncate_on_rotation	If rotating audit log files based on time, this parameter is used to specify whether to overwrite (on)/not overwrite (off) existing audit log files of the same name. For example, if "on" is specified, and "pgaudit-%H.log" is specified for log_filename, 24 separate log files will be generated based on time, and those files will be cyclically overwritten. The default is "off". If "off" is specified, the logs will be written to the existing audit log files.	Enabled only if "auditlog" is specified for the logger parameter
fifo_directory	FIFO (named pipe) directory to be used between the daemon process that outputs audit log files and the backend process FIFO named p.PGAUDIT.*nnnn* (*nnnn* is the postmaster PID) are created in the fifo_directories directory. The files cannot be deleted manually. The default is "/tmp".	Enabled only if "auditlog" is specified for the logger parameter

Information

If the logger parameter is set to "serverlog", audit logs will be output to the server log as log messages, therefore the status information and message severity level according to the log_line_prefix parameter in postgresql.conf will be output to the beginning of the audit log.

If the logger parameter is omitted or set to "auditlog", audit logs will be output to a dedicated log file as dedicated logs, therefore the status information and message severity level according to the log_line_prefix parameter in the postgresql.conf file will not be output.

Refer to "Output format" in "6.4 Session Audit Logging"or "Output format" in "6.5 Object Audit Logging" for information on the output format of audit logs.

Point

The pgaudit log_file_mode configuration parameter setting is separate from, and unaffected by, the log_file_mode GUC parameter setting and the -g/-allow-group-access initdb option.

When using a dedicated pgaudit log file, since the pgaudit log_directory location defaults to inside the data storage directory, it is possible for the pgaudit log_file_mode permissions to conflict with the intended file permissions specified by the -g/-allow-group-access initdb option. In this case, the pgaudit log_directory should be specified to be a directory located outside of the data storage directory.

option section

The option section is specified using the format below:

- *paramName* = '*value*'

The valid parameters in the option section are shown in the table below.

Parameter name	Description	Remarks
role	Name of roles used in Object Audit Logging If specifying a name containing uppercase characters, key words, multibyte characters and commas, enclose the name in double quotation marks.	Parameter used in Object Audit Logging only

Parameter name	Description	Remarks
log_catalog	Whether to enable (on)/disable (off) log output for pg_catalog Specify "off" if you do not want to retrieve audit logs that access pg_catalog. The default is "on" (enabled).	
log_parameter	Whether to enable (on)/disable (off) output of values passed by parameters in SQL execution The default is "off" (disabled).	
log_statement_once	Whether to control (on)/not control (off) output for the second and subsequent SQL statements if the same SQL statement is the log output target The default is "off" (do not control).	
log_level	Log level of audit logs The valid values are "DEBUG5", "DEBUG4", "DEBUG3", "DEBUG2", "DEBUG1", "INFO", "NOTICE", "WARNING", and "LOG". The default is "LOG".	Enabled only if "serverlog" is specified for the logger parameter

rule section

The rule section is used in Session Audit Logging. Refer to "6.4 Session Audit Logging" for details.

Note

Do not specify the rule section if the role parameter has been specified in the option section. If you specify the rule section, the audit logs of Object Audit Logging and Session Audit Logging will be output intermingled and you will be unable to view the logs in CSV format.

6.4 Session Audit Logging

In Session Audit Logging, specify the rules for filtering logs to be output in the rule section in the pgaudit configuration file.

Rules are specified using the formats below. Multiple values can be specified, using a comma as the delimiter.

- *paramName* = '*value*'
- *paramName* != '*value*'

If [rule] is described on its own in the rule section with no parameters specified, all audit logs will be output.

Example

```
[output]
logger = 'auditlog'
[rule]
```

If the rule section is not described ([rule] is not described), the audit logs will not be output.

Example

```
[output]
logger = 'auditlog'
```

The valid parameters in the rule section are shown in the table below.

Parameter name	Description	Example
timestamp	Timestamp range Refer to "timestamp" for details on how to specify timestamps.	timestamp = '09:00:00 - 10:00:00, 18:00:00 - 18:30:00'
database	Database name To specify a blank value, use a pair of double quotation marks (""). When specifying a name containing uppercase characters, key words, multibyte characters and commas, enclose the name in double quotation marks.	database = 'prodcut_db'
audit_role	Role name To specify a blank value, specify use a pair of double quotation marks (""). When specifying a name containing uppercase characters, key words, multibyte characters and commas, enclose the name in double quotation marks.	audit_role = 'appuser1'
class	Operation class Select from the values below. Multiple values can be specified. Refer to "class" for details on the meaning of each class. - BACKUP - CONNECT - DDL - ERROR - FUNCTION - MISC - READ - ROLE - WRITE - SYSTEM	class = 'READ, WRITE'
object_type	Object type This parameter is enabled when the class parameter is "READ" and "WRITE". Select from the values below. Multiple values can be specified. - TABLE - INDEX - SEQUENCE - TOAST_VALUE - VIEW - MATERIALIZED_VIEW - COMPOSITE_TYPE - FOREIGN_TABLE	object_type = 'TABLE, INDEX'

Parameter name	Description	Example
	- FUNCTION	
object_name	Object name This parameter is enabled when the class parameter is "READ" and "WRITE". For objects that can be modified by a schema, such as a table, modify such objects by schema name. When specifying a name containing uppercase characters, key words, multibyte characters and commas, enclose the name in double quotation marks. When specifying the object name "*schemaName.tableName*", enclose the entire object name modified by schema name in double quotation marks. To specify a blank value, use a pair of double quotation marks ("").	object_name = 'myschema.tbl1' object_name = 'myschema.tbl1, "*mySchema*.TABLE"'
application_name	Application name To specify a blank value, use a pair of double quotation marks ("").	application_name = 'myapp'
remote_host	Connection destination host name or IP address If "on" is specified for the log_hostname parameter in the postgresql.conf file, specify a host name. Otherwise, specify the IP address. If using a local host, specify "[local]". To specify a blank value, use a pair of double quotation marks ("").	remote_host = 'ap_server'

timestamp

Specify a timestamp range from "*startTime*" to "*endTime*" for the log output target. The timestamp format is 'hh:mm:dd-hh:mm:dd' (hh is expressed in 24-hour notation, and hh, mm, and dd are expressed in two-digit notation).

The start time must be earlier than the end time. If specifying multiple ranges, specify each start and end timestamp using a comma as the delimiter.

End timestamps consider milliseconds. For example, if '11:00:00 - 11:59:59' is specified for the timestamp, "11:00:00:000" to "11:59:59:999" will be the target range.

The timestamps used by evaluation in the rule section of pgaudit are different to the timestamps issued in the log entries. That is because log entries are output after evaluation by pgaudit, with the timestamp being generated at that time.

class

The meaning of each class specified in the class parameter is below:

- READ: SELECT, COPY FROM
- WRITE: INSERT, UPDATE, DELETE, TRUNCATE, COPY TO
- FUNCTION: Function call, DO
- ROLE: GRANT, REVOKE, CREATE ROLE, ALTER ROLE, DROP ROLE
- DDL: All DDLs (such as CREATE and ALTER) other than the DDLs of the ROLE class
- CONNECT: Events relating to connecting (request, authenticate, and disconnect)

- SYSTEM: Instance start, promotion to primary server
- BACKUP: pg_basebackup
- ERROR: Event completed by an error (PostgreSQL error codes other than 00). This class can be used if ERROR or lower level is specified for the log_min_messages parameter in postgresql.conf.
- MISC: Other commands (such as DISCARD, FETCH, CHECKPOINT, and VACUUM)

Evaluation of the rule section

- When a log event occurs, all expressions in the rule section are evaluated at once. Log entries are only output if all parameters in the rule section are evaluated as being true.

  For example, if the rule below has been set, of the operations performed by 'apserver' to 'myschema.tbl1', the operations applicable to classes other than 'WRITE'' in the period from 10 a.m. to 11 a.m. will be output as audit logs.

  ```
  [rule]
  timestamp = '10:00:00-11:00:00'
  remote_host = 'apserver'
  object_name = 'myschema.tbl1'
  class != 'WRITE'
  ```

- Multiple rule sections can be defined in the pgaudit configuration file. Log events are evaluated using each rule section, and an audit log is output for each matching rule section.

  For example, if the rules below are set, duplicated audit logs will be output.

  ```
  [rule]
  object_name = 'myschema.tbl1'
  [rule]
  object_name = 'myschema.tbl1'
  ```

- If the same parameter is specified multiple times in one rule section, the last specified parameter is effective.

  For example, if the rule below has been set, "object_name = 'myschema.tbl3'" will take effect.

  ```
  [rule]
  object_name = 'myschema.tbl1'
  object_name = 'myschema.tbl2'
  object_name = 'myschema.tbl3'
  ```

Output format

In Session Audit Logging, audit logs are output in the format below:

```
AUDIT: SESSION,READ,2022-03-12 19:00:58 PDT,
   (1)         (2)     (3)
[local],19944,psql,appuser,postgres,2/8, 2, 1,SELECT,,TABLE,myschema.account, ,
  (4)    (5)   (6)   (7)      (8)   (9)(10)(11)(12)(13)(14)    (15)        (16)
SELECT * FROM myschema.account;,<not logged>
       (17)                      (18)
```

No	Content
(1)	Log header Fixed as "AUDIT: SESSION".
(2)	Class
(3)	SQL start time
(4)	Remote host name

No	Content
	If using a local host, [local] is output.
(5)	Backend process ID
(6)	Application name If an application name is not specified, [unknown] is output.
(7)	User name
(8)	Database name
(9)	Virtual transaction ID
(10)	Statement ID
(11)	Substatement ID
(12)	Command tag
(13)	SQLSTATE
(14)	Object type
(15)	Object name
(16)	Error message
(17)	SQL If the SQL contains a password, such as for CREATE ROLE, and so on, it will be replaced with "<REDACTED>". Additionally, if "on" is specified for the log_statement_once parameter of the option section in the pgaudit configuration file, "<previously logged>" is output for the second and subsequent statements.
(18)	Depending on the log_parameter parameter value of the option section in the pgaudit configuration file, the output content will be as below. - log_parameter=on is specified If parameters are specified in the SQL, the parameters are concatenated and output, using a space as the delimiter. If parameters are not specified in the SQL, "<none>" is output. - log_parameter=off (default) is specified "<not logged>" is output. Additionally, if "on" is specified for the log_statement_once parameter of the option section in the pgaudit configuration file, "<previously logged>" is output for the second and subsequent statements.

Information

If accessing resources that use the features below, the command tag (12) may be output as "???".

- INSTEAD OF trigger
- RULE
- VIEW
- Security policy per row
- Table inheritance

Example

Below is an example of retrieving audit logs in Session Audit Logging.

1. Settings

   In the pgaudit configuration file, specify the rule section below.

```
[rule]
class = 'READ, WRITE'
object_name = 'myschema.account'
```

2. Retrieving logs

   Execute the SQL below from the client.

```
CREATE TABLE myschema.account
(
    id int,
    name text,
    password text,
    description text
);
INSERT INTO myschema.account (id, name, password, description) VALUES (1, 'user1', 'HASH1', 'blah,
blah');
SELECT * FROM myschema.account;
```

   The audit log below can be retrieved.

   'DDL' is not defined in the class parameter, so CREATE TABLE is not output as an audit log.

```
AUDIT: SESSION,WRITE,2022-03-12 19:00:49 PDT,[local],19944,psql,appuser,postgres,
2/7,1,1,INSERT,,TABLE,myschema.account,,"INSERT INTO myschema.account (id, name, password,
description) VALUES (1, 'user1', 'HASH1', 'blah, blah');",<not logged>
AUDIT: SESSION,READ,2022-03-12 19:00:58 PDT,[local],19944,psql,appuser,postgres,
2/8,2,1,SELECT,,TABLE,myschema.account,,SELECT * FROM myschema.account;,<not logged>
```

6.5 Object Audit Logging

In Object Audit Logging, retrieval of audit logs is achieved by using roles.

Roles are specified in the role parameter of the option section to retrieve audit logs. If there are privileges for commands executed by a role, or if privileges have been inherited from another role, those command operations are output as audit logs.

For example, after "auditor" is set for the role parameter of the option section, the SELECT and DELETE privileges for the account table are assigned to "auditor". In this case, when SELECT or DELETE is executed for the account table, audit logs are output.

Output format

In Object Audit Logging, audit logs are output in the format below:

```
AUDIT: OBJECT,1,1,READ,SELECT,TABLE,public.account,SELECT password FROM account;,<not logged>
     (1)    (2)(3)(4)  (5)    (6)        (7)               (8)                    (9)
```

No	Content
(1)	Log header Fixed as "AUDIT: OBJECT".
(2)	Statement ID
(3)	Substatement ID

No	Content
(4)	Class name
(5)	Command tag
(6)	Object type
(7)	Object name
(8)	SQL If "on" is specified for the log_statement_once parameter of the option section in the pgaudit configuration file, "<previously logged>" is output for the second and subsequent statements.
(9)	Depending on the log_parameter parameter value of the option section in the pgaudit configuration file, the output content will be as below. - When log_parameter=on If parameters are specified in the SQL, the parameters are concatenated and output, using a comma as the delimiter. If parameters are not specified in the SQL, "<none>" is output. - When log_parameter=off (default) "<not logged>" is output. Additionally, if "on" is specified for the log_statement_once parameter of the option section in the pgaudit configuration file, "<previously logged>" is output for the second and subsequent statements.

Information

If accessing resources that use the features below, the command tag (5) may be output as "???".

- INSTEAD OF trigger
- RULE
- VIEW
- Security policy per row
- Table inheritance

Example

Below is an example of retrieving logs in Object Audit Logging.

By setting the target for assigning privileges to roles in detail, log output can be controlled.

In the example below, log retrieval of the account table is controlled by the privileges assigned to the columns, however, log retrieval of the account_role_map table is controlled by the privileges assigned to the table.

1. Settings

The role parameter below is specified for the option section in the pgaudit configuration file.

```
[option]
role = 'auditor'
```

2. Defining a role

A role is defined for Object Audit Logging.

```
CREATE USER auditor NOSUPERUSER LOGIN;
```

3. Retrieving logs

Execute the SQL below from the client.

```
CREATE TABLE account
(
    id int,
    name text,
    password text,
    description text
);
GRANT SELECT (password) ON public.account TO auditor;
SELECT id, name FROM account;
SELECT password FROM account;
GRANT UPDATE (name, password) ON public.account TO auditor;
UPDATE account SET description = 'yada, yada';
UPDATE account SET password = 'HASH2';
CREATE TABLE account_role_map
(
    account_id int,
    role_id int
);
GRANT SELECT ON public.account_role_map TO auditor;
SELECT account.password, account_role_map.role_id
  FROM account
  INNER JOIN account_role_map ON account.id = account_role_map.account_id;
```

The audit log below can be retrieved.

In the account table, only the operations for columns that privileges have been assigned to are output as logs.

In the account_role_map table, privileges are assigned to the table, so operations performed for the table are output as logs.

```
AUDIT: OBJECT,4,1,READ,SELECT,TABLE,public.account,SELECT password FROM account;,<not logged>
AUDIT: OBJECT,7,1,WRITE,UPDATE,TABLE,public.account,UPDATE account SET password = 'HASH2';,<not
logged>
AUDIT: OBJECT,10,1,READ,SELECT,TABLE,public.account,"SELECT account.password,
account_role_map.role_id
        FROM account
        INNER JOIN account_role_map ON account.id = account_role_map.account_id;",<not logged>
AUDIT: OBJECT,10,1,READ,SELECT,TABLE,public.account_role_map,"SELECT account.password,
account_role_map.role_id
        FROM account
        INNER JOIN account_role_map ON account.id = account_role_map.account_id;",<not logged>
```

6.6 Database Multiplexing

This section describes audit log retrieval while in database multiplexing mode.

6.6.1 Setup

If setting up the audit log feature in a database multiplexing environment that has already been built, follow the procedure below.

1. Copy the pgaudit files

   Copy the pgaudit files on the primary server and standby server.

   Refer to step 1 in "6.2 Setup" for details on copying the pgaudit files.

2. Create the pgaudit configuration file

   Create the pgaudit configuration file on the primary server. Copy the pgaudit configuration file you created to the standby server.

   Refer to step 2 in "6.2 Setup" for details on creating the pgaudit configuration file.

3. Configure postgresql.conf

   In the postgresql.conf file on the primary server and standby server, configure the parameters for using audit logs. Set the same values for the parameters.

   Refer to step 3 in "6.2 Setup" and "6.6.2 Configuring Audit Log Retrieval" for details on the parameters to configure.

4. Configure the *serverIdentifier*.conf file of Mirroring Controller

   In the *serverIdentifier*.conf file on the primary server and standby server, configure the parameters for using audit logs.

   Refer to "6.6.2 Configuring Audit Log Retrieval" for details on the parameters to be set.

5. Start the instance

   Start the instance of the primary server and standby server.

6. Create the pgaudit extension

   Execute CREATE EXTENSION on the primary server to create a pgaudit extension.

   Refer to step 5 in "6.2 Setup" for details on creating pgaudit extensions.

7. Configure the parameters in the pgaudit configuration file

   Add/change the parameters of the pgaudit configuration file on the primary server. Copy the pgaudit configuration file with the added/changed parameters to the standby server.

   Refer to "6.3 pgaudit Configuration File" and "6.6.2 Configuring Audit Log Retrieval" for details on the parameters to set.

8. Restart the instance

   Restart the instance of the primary server and standby server.

6.6.2 Configuring Audit Log Retrieval

In database multiplexing mode, Mirroring Controller periodically accesses the database to check the multiplexing status and detect failure. Due to this, audit logs are also periodically retrieved, so log files become used up. Therefore, set the parameters below so that audit logs are not retrieved by Mirroring Controller.

postgresql.conf

log_connections

Omit, or specify "off".

log_disconnections

Omit, or specify "off".

serverIdentifier.conf file of Mirroring Controller

target_db

Specify "template1".

Note

If creating a new database, create it after stopping Mirroring Controller, or specify a name other than "template1" for the template database.

pgaudit configuration file

rule section database

Specify database != 'template1'.

6.7 View Audit Logs Using SQL

By using file_fdw of an additional module, audit logs can be accessed using SQL. This section describes how to view audit logs, using Session Audit Logging output to a dedicated log file as an example.

1. Install file_fdw

   Execute CREATE EXTENSION to install file_fdw as an extension.

```
$ psql
=# CREATE EXTENSION file_fdw;
=# \dx
                  List of installed extensions
Name     | Version |   Schema   |     Description
---------+---------+------------+-----------------------------------------
file_fdw | 1.0     | public     | foreign-data wrapper for flat file access
pgaudit  | 1.0     | public     | provides auditing functionality
plpgsql  | 1.0     | pg_catalog | PL/pgSQL procedural language
(3 rows)
```

2. Create an external server

   Use CREATE SERVER to create an external server managed by file_fdw.

```
$ psql
=# CREATE SERVER auditlog FOREIGN DATA WRAPPER file_fdw;
```

3. Create an audit log table.

   Use CREATE FOREIGN TABLE to define the table columns of audit logs, CSV file name and format.

```
$ psql
=# CREATE FOREIGN TABLE auditlog (
header text,
class text,
sql_start_time timestamp with time zone,
remote_host_name text,
backend_process_id text,
application_name text,
session_user_name text,
database_name text,
virtual_transaction_id text,
statement_id text,
substatement_id text,
command_tag text,
sqlstate text,
object_type text,
object_name text,
error_message text,
sql text,
parameter text
) SERVER auditlog
OPTIONS ( filename '/database/inst1/pgaudit_log/pgaudit-2022-03-12.log', format 'csv' );
```

Note

If an audit log file is rotated and multiple audit log files exist, it is necessary to create a table for each audit log file.

4. View audit logs

   Use SELECT and view the audit logs.

```
$ psql
=# SELECT * FROM auditlog;
```

```
     header     |  class  |     sql_start_time     | remote_host_name | backend_process_id ...
----------------+---------+------------------------+------------------+------------------- ...
AUDIT: SESSION  | WRITE   | 2022-03-12 19:00:49+09 | [local]          | 19944              ...
AUDIT: SESSION  | READ    | 2022-03-12 19:00:58+09 | [local]          | 19944              ...
```

6.8 Removing Setup

This section describes how to remove the setup of pgaudit.

1. Start the instance
2. Remove the pgaudit extension

   Execute DROP EXTENSION to remove the pgaudit extension from the database.

   ```
   $ psql -d <database name>
   =# DROP EXTENSION pgaudit;
   =# \q
   ```

3. Change postgresql.conf

   Remove the parameters below relating to pgaudit.

   - shared_preload_libraries
   - pgaudit.config_file

4. Restart the instance
5. Remove the pgaudit files

   As superuser, run the following command. Note that "<*x*>" in paths indicates the product version.

   ```
   $ su -
   Password:******
   # rm -rf /opt/fsepv<x>server64/filesCopiedDuringSetup
   ```

   Information

   The files copied during setup can be checked below.

   ```
   # find /opt/fsepv<x>server64/OSS/pgaudit
   ```

Fujitsu Enterprise Postgres 14 SP1 on IBM LinuxONE

Cluster Operation Guide

Database Multiplexing

SP1

Linux

FUJITSU

J2UL-2750-02ZLZ0(01)
April-2024

Preface

Purpose of this document

This document describes the tasks required for using the database multiplexing feature of FUJITSU Enterprise Postgres.

Intended readers

This document is intended for those who set up and use the database multiplexing feature.

Readers of this document are also assumed to have general knowledge of:

- PostgreSQL
- SQL
- Linux

Structure of this document

This document is structured as follows:

Chapter 1 Overview of Database Multiplexing Mode

Provides an overview of database multiplexing mode.

Chapter 2 Setting Up Database Multiplexing Mode

Describes how to set up database multiplexing mode.

Chapter 3 Operations in Database Multiplexing Mode

Explains periodic database multiplexing mode.

Chapter 4 Action Required when an Error Occurs in Database Multiplexing Mode

Explains the action required when an error occurs during a database multiplexing mode.

Chapter 5 Managing Mirroring Controller Using WebAdmin

Explains how to set up and manage Mirroring Controller in a streaming replication cluster using WebAdmin.

Appendix A Parameters

Explains the configuration files and parameters required for database multiplexing mode.

Appendix B Supplementary Information on Building the Primary Server and Standby Server on the Same Server

Explains supplementary information on building the primary server and standby server on the same server.

Appendix C User Commands

Explains the user commands.

Appendix D Notes on Performing Automatic Degradation Immediately after a Heartbeat Abnormality

Provides notes when performing automatic degradation unconditionally after a heartbeat abnormality is detected during heartbeat monitoring of an operating system or server.

Appendix E WebAdmin Disallow User Inputs Containing Hazardous Characters

Explains characters not allowed in WebAdmin.

Appendix F Collecting Failure Investigation Data

Explains how to collect data for initial investigation.

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Issue date and version

```
Edition 2.1: April 2024
Edition 2.0: September 2022
Edition 1.0: February 2022
```

Copyright

Revision History

Changes	Place of Change	Edition
Add Mirroring Controller disk monitoring timeout parameter (disk_check_timeout, disk_check_max_threads).	2.11.4.4 Tuning for Disk Abnormality Monitoring	Edition 2.1
	A.4.1 Server Configuration File for the Database Servers	
Add parameter (enable_promote_on_os_and_admin_network_error) to specify what happens if the management network fails and replication is disconnected.	A.4.1 Server Configuration File for the Database Servers	

Contents

Chapter 1 Overview of Database Multiplexing Mode

This chapter provides an overview of database multiplexing mode.

Point

In this and subsequent chapters, the word "Mirroring Controller" may be used in the process or management directory name or explanation.

1.1 What is Database Multiplexing Mode

Database multiplexing mode is an operation mode (log shipping mode) based on PostgreSQL streaming replication. Other software such as cluster software is not required.

This mode replicates the database on all servers that comprise the cluster system. It achieves this by transferring the updated transaction logs of the database from the server that receives the updates (primary server) to another server (standby server), and then reflecting them on the standby server. The client driver automatically distinguishes between the primary and standby servers, so applications can be connected transparently regardless of the physical server.

It consists of a feature that detects faults in the elements that are essential for the continuity of the database operation (such as the database process, disk, and network), as well as simplified switchover and standby server disconnection features. Furthermore, referencing can be performed on the standby server. The database will be copied in synchronous mode.

Note

If using WebAdmin or Mirroring Controller, FUJITSU Enterprise Postgres supports cluster systems comprising one primary server and one standby server.

- Although it is possible to connect an asynchronous standby server to the cluster system as an additional server, the standby server is not targeted for monitoring by Mirroring Controller.
- A synchronous standby server cannot be connected to the cluster system as an additional server.

See

The streaming replication feature is not described in this manual.

Refer to "High Availability, Load Balancing, and Replication" in the PostgreSQL Documentation for information on the streaming replication feature.

Figure 1.1 Failover from the primary server to the standby server

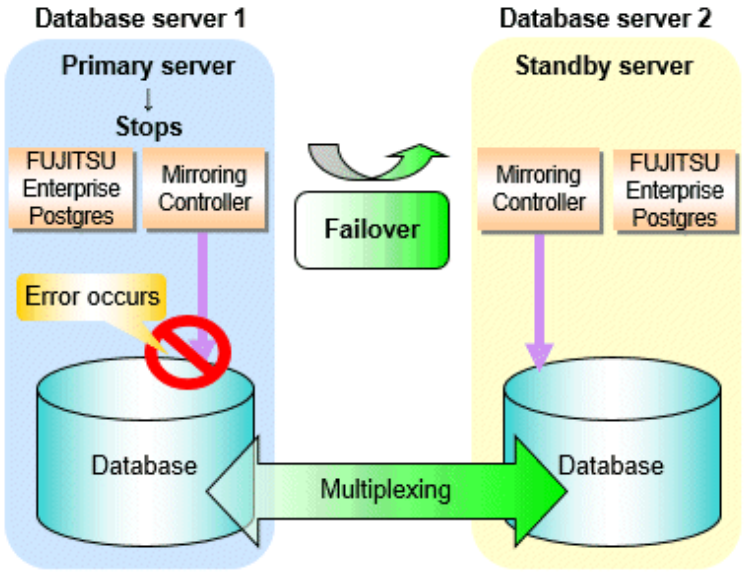
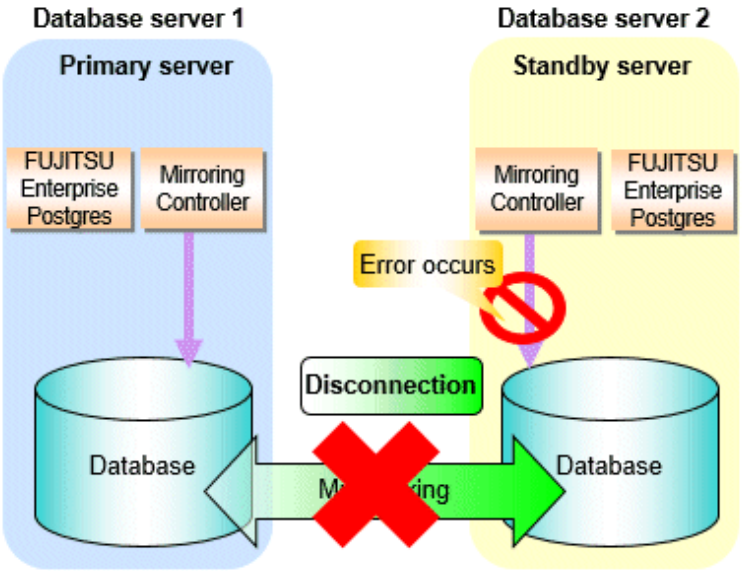


Figure 1.2 Standby server disconnection



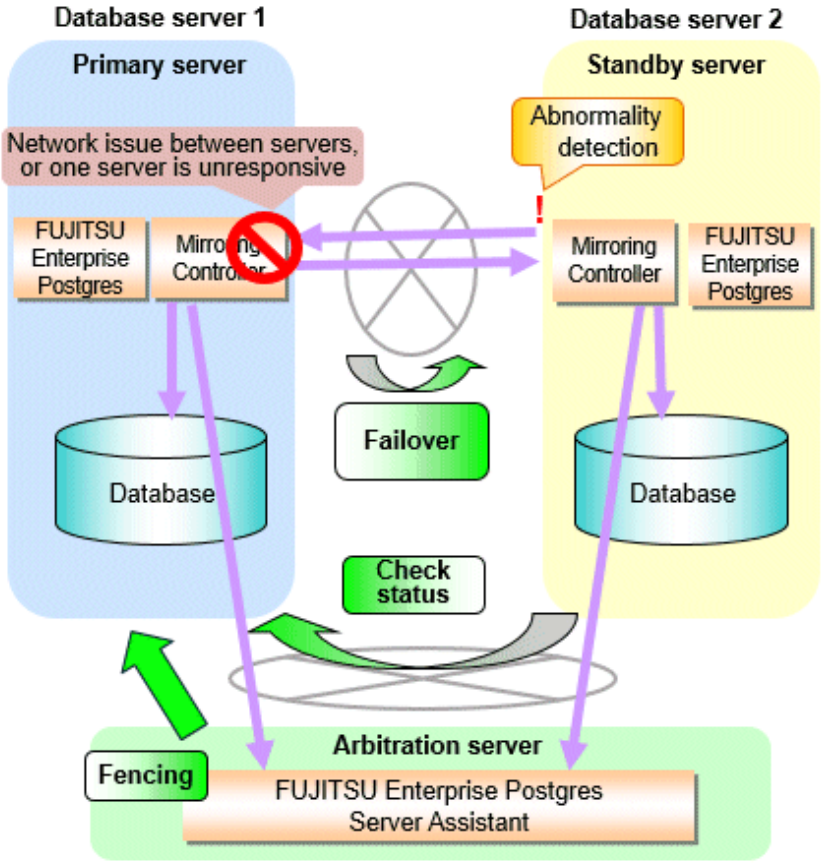
Database degradation using the arbitration server

FUJITSU Enterprise Postgres provides the Server Assistant that objectively determines the status of database servers as a third party, and if necessary, isolates affected databases if the database servers are unable to accurately ascertain their mutual statuses in database multiplexing mode, such as due to a network error between database servers, or server instability. Database degradation can be performed by using the server (arbitration server) on which the Server Assistant is installed.

For database degradation using the arbitration server, if the database servers are unable to check their mutual statuses (due to a network error between database servers or server instability), then the database server queries the arbitration server for the status of the other database server. If it is determined based on the heartbeat result that the status is unstable, the applicable database server will be isolated from the cluster system (fencing). The arbitration server periodically heartbeats the database server so that it can respond immediately to queries from the database server. The fencing process can be customized according to the environment where Mirroring Controller is used.

Additionally, the database servers are always performing their heartbeats for the arbitration server so that it can perform check requests any time.

Figure 1.3 Database degradation using the arbitration server



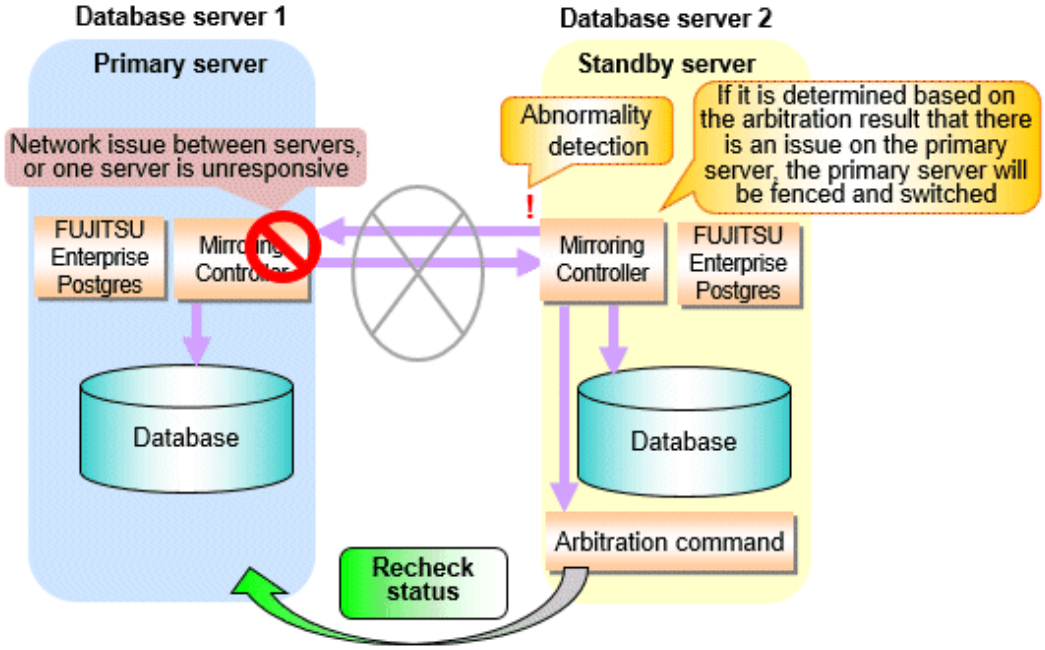
Note

Install the arbitration server on a different physical server to that of the database server. Refer to "1.2 System Configuration for Database Multiplexing Mode" for information on the system configuration when using the arbitration server.

Database degradation using the arbitration command

The arbitration command is a user command that performs arbitration processing in lieu of the arbitration server. If an arbitration server cannot be deployed, arbitration of the database server can be performed using the arbitration command.

Figure 1.4 Database degradation using the arbitration command



See

Refer to "2.6 Creating a User Command for a Database Server" or "Appendix C User Commands" for information on user commands.

1.1.1 Monitoring Using Database Multiplexing Mode

In database multiplexing mode, perform the monitoring below.

- Operating system or server failures, and no-response state

  By generating a heartbeat between Mirroring Controller on each server, operating system or server errors are detected and acknowledged between the relevant servers.

  The optimal operating method for environments where database multiplexing mode is performed can be selected from the following:

  - Use the arbitration server to perform automatic degradation (switch/disconnect)

    This is the default method.

    The arbitration server objectively determines the status of database servers, then isolates and degrades from the cluster system the ones with an unstable status.

    Refer to "Database degradation using the arbitration server" for details.

  - Call the user command that will perform the degradation decision, and perform automatic degradation

    If the arbitration server cannot be installed, select if arbitration processing can be performed by the user instead.

    Mirroring Controller queries the user command on whether to degrade. The user command determines the status of the database server, and notifies Mirroring Controller whether to perform degradation.

    Refer to "Database degradation using the arbitration command" for details.

  - Notification messages

    Use this method if using a two-database server configuration.

    Mirroring Controller outputs messages to the system log when an abnormality is detected. This ensures that a split brain will not occur due to a heartbeat abnormality - however, automatic switching will not be performed if the primary server operating system or server fails or becomes unresponsive.

  - Perform automatic degradation unconditionally after a heartbeat abnormality

    This method is not recommended, because Mirroring Controller unconditionally will perform automatic degradation after heartbeat abnormalities.

- Database process failures, and no-response state

  Mirroring Controller periodically accesses the database processes and checks the status. A process error is detected by monitoring whether an access timeout occurs.

- Disk failure

  Mirroring Controller periodically creates files on the data storage destination disk below. A disk error is detected when an I/O error occurs.

  - Data storage destination disk
  - Transaction log storage destination disk
  - Tablespace storage destination disk

  Failures that can be detected are those that physically affect the entire system, such as disk header or device power failures.

- Streaming replication issue

  Mirroring Controller detects streaming replication issues (log transfer network and WAL send/receive processes) by periodically accessing the PostgreSQL system views.

- Mirroring Controller process failure and no response

  In order to continue the monitoring process on Mirroring Controller, Mirroring Controller process failures and no responses are also monitored.

  The Mirroring Controller monitoring process detects Mirroring Controller process failures and no responses by periodically querying the Mirroring Controller process. If an issue is detected, Mirroring Controller is automatically restarted by the Mirroring Controller monitoring process.

Point

- If output of messages is selected as the operation to be performed when a heartbeat abnormality is detected during heartbeat monitoring of the operating system or server, automatic degradation will not be performed.
  However, if an issue in the WAL send process is detected on the primary server, then the standby server will be disconnected, and as a result an automatic disconnection may be performed even if the standby server operating system or server fails or becomes unresponsive.
- You can select in the parameters if the primary server will be switched if a database process is unresponsive or if tablespace storage destination disk failure is detected. Refer to "Appendix A Parameters" for details.
- If the standby server was disconnected, Mirroring Controller will automatically comment out the synchronous_standby_names parameter in the postgresql.conf file of the primary server. Accordingly, you can prevent the application processing for the primary server being stopped.

Note

If the role of primary server was switched to another server and then starts degrading, the original primary server will not become the standby server automatically. Remove the cause of the error, and then change the role of the original primary server to the server currently acting as standby server. Refer to "4.1 Action Required when Server Degradation Occurs" for details.

1.1.2 Referencing on the Standby Server

1.1.2.1 If Prioritizing the Main Job on the Primary Server

If a reference job is performed on the standby server and the primary server is switched, this may impact the main job from the point of view of load and conflict. This is because, on the new primary server (that is, the original standby server), both the main job that was being executed on the original primary server and the reference job that was being continued on the original standby server will be processed.

Therefore, to degrade the reference job (so that the impact on the main job is reduced), you can select the user command below to disconnect the reference job that was performed on the original standby server.

- Post-switch command

Note

If continuing with the referencing job after switching the primary server, give careful consideration to the server resource estimates, and the likely impact on performance.

1.1.2.2 If Performing the Referencing Job on the Synchronous Standby Server

If an issue such as a log transfer network failure obstructs the continuation of a job on the primary server, the standby server may be automatically disconnected from the cluster system.

Therefore, if operating the reference job on the assumption that the connection destination is the synchronous standby server, you can select to temporarily stop the job by using the user command or the feature below, so that unexpected referencing of past data does not occur as a result of the disconnection.

- Pre-detach command
- Forced stoppage of the standby server instance on disconnection (specify in the parameter of the server configuration file)

Additionally, if the standby server is incorporated into the cluster system, reference jobs can be started or resumed by using the user command below.

- Post-attach command

See

- Refer to "2.6 Creating a User Command for a Database Server" or "Appendix C User Commands" for information on each user command.
- Refer to "A.4.1 Server Configuration File for the Database Servers" for information on the server configuration file of the database server.

Point

Mirroring Controller will continue processing regardless of the processing result of the above user commands and features.

1.2 System Configuration for Database Multiplexing Mode

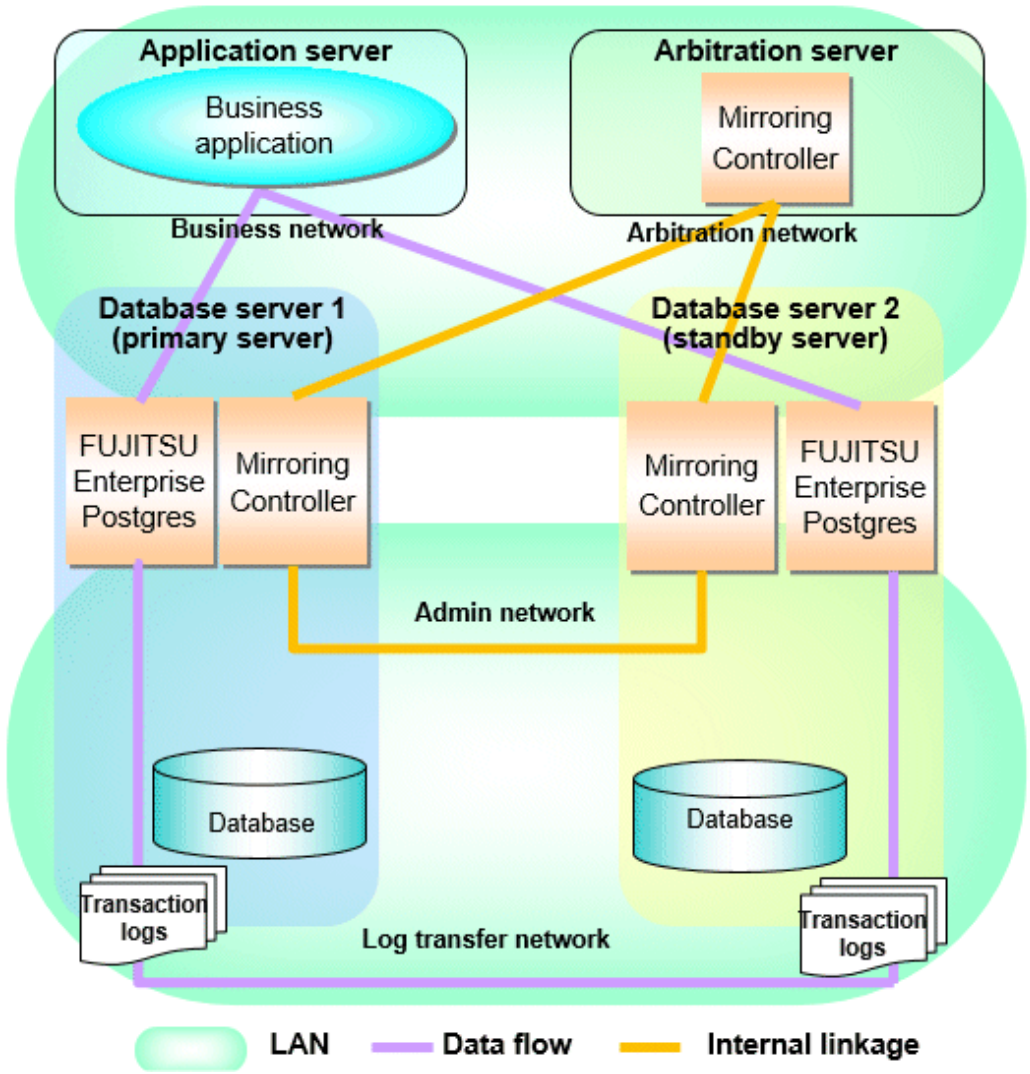
This section explains the products, features, and networks that are part of a database multiplexing system.

The following table shows the network types uses by database multiplexing systems.

Network type	Description
Job network	Network between the application that accesses the database, and the database server.

Network type	Description
Arbitration network	Network used by the arbitration server to check the status of the primary server and standby server, and communicate with Mirroring Controller of the database servers. Additionally, if the job network is disconnected from outside, it can also be used as the arbitration network. Refer to "1.4 Security in Database Multiplexing" for details on network security.
Admin network	Network used by the primary server and the standby server to monitor each other using Mirroring Controller, and to control Mirroring Controller of other servers.
Log transfer network	Network used to transfer the transaction logs of the database, which is part of database multiplexing.

Figure 1.5 System configuration for database multiplexing mode



The arbitration server is installed to check the database server status as a third party, and to perform fencing. Therefore, to obtain the intended benefits, consider the following.

- Install the arbitration server on a different server to that of the database server.
- For the arbitration network, use a network that will not be impacted by line faults or the load on the admin network or log transfer network. This is necessary to correctly determine issues on the admin network or log transfer network.

Point

- The arbitration server can also be used as an application server. However, consider the server load.
- It is recommended to link the arbitration server with other cluster systems, in order to provide redundancy.
- Use the arbitration server in combination with the same version of FUJITSU Enterprise Postgres as that of the primary server and standby server.
- The arbitration server can be built on a different platform to that of the database server.

Note

Because the ping command of the operating system is used for heartbeat monitoring of the database server, configure the network so that ICMP can be used on the admin network and the arbitration network.

1.2.1 Mirroring Controller Resources

This section describes the database server and arbitration server resources of Mirroring Controller.

1.2.1.1 Database Server Resources

The only Mirroring Controller resource is the Mirroring Controller management directory, which stores the files that define the Mirroring Controller behavior, and the temporary files that are created when Mirroring Controller is active.

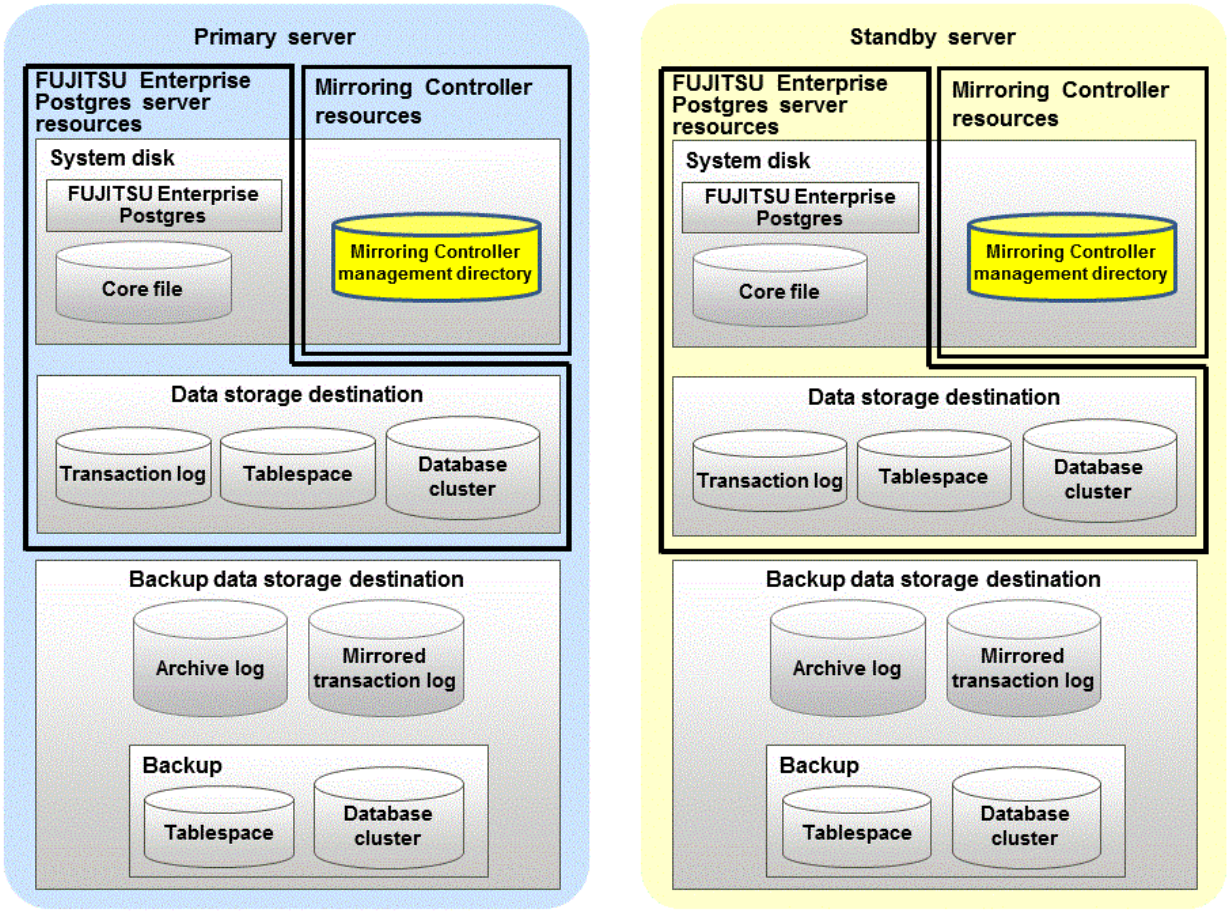
Note

- Do not create the Mirroring Controller management directory in a directory managed by FUJITSU Enterprise Postgres, otherwise it may be deleted by mistake or may cause unexpected problems when FUJITSU Enterprise Postgres recovery is performed (such as old version of files being restored).

  Refer to "Preparing Directories for Resource Deployment" in the Installation and Setup Guide for Server for information on the directories managed by FUJITSU Enterprise Postgres.
- The backup methods described in "Backing Up the Database" in the Operation Guide cannot be used to back up the Mirroring Controller resources. Therefore, users must obtain their own backup of Mirroring Controller resources, in addition to FUJITSU Enterprise Postgres server resources. Retrieve backups after stopping Mirroring Controller.
- If the automatic switch/disconnection is enabled, do not edit synchronous_standby_names for the Mirroring Controller monitoring target instance. Otherwise, if Mirroring Controller is switched after editing, data may be lost or SQL access may stop.
- If you are building on a virtual machine or cloud, make sure the virtual machines are on different physical servers. Refer to your virtual machine software and cloud vendor documentation for instructions on how to deploy virtual machines.

The content on the primary server will be backed up. You cannot tell which server is the primary server to be backed up, because switching and failback may be performed between the servers. It is also impossible to tell which server is to be restored using the backed up data. Accordingly, ensure that you create a backup of each server when it is working as the primary server.

Figure 1.6 Configuration when backing up Mirroring Controller resources



1.2.1.2 Arbitration Server Resources

The only arbitration server resource is the Mirroring Controller arbitration process management directory. This directory stores the files that define the Mirroring Controller arbitration process behavior and the temporary files created when Mirroring Controller is active.

1.2.2 Mirroring Controller Processes

This section describes the database server and arbitration server processes of Mirroring Controller.

1.2.2.1 Database Server Processes

The database server processes comprise the Mirroring Controller process and Mirroring Controller monitoring process.

Process type	Description
Mirroring Controller process	Performs operating system/server and process heartbeat monitoring and disk abnormality monitoring between database servers. Additionally, it issues arbitration requests to the arbitration server.
Mirroring Controller monitoring process	Performs heartbeat monitoring of the Mirroring Controller process. If the Mirroring Controller process returns no response or is down, the monitoring process is restarted automatically.

1.2.2.2 Arbitration Server Process

The only arbitration process is the Mirroring Controller arbitration process.

Process type	Description
Mirroring Controller arbitration process	Performs rechecks for issues detected on the primary server or the standby server. Additionally, this process performs fencing if it determines that there is an issue on the primary server or the standby server.

1.2.3 Redundancy of the Admin and Log Transfer Networks

The admin network is an important one, because it is used by Mirroring Controller to check the status of each server.

Additionally, the log transfer network is an important one, because it is necessary to ensure data freshness.

Accordingly, configure a failure-resistant network by implementing network redundancy via channel bonding provided by the operating system or network driver vendor.

1.2.4 Notes on CPU Architecture and Products

A server using only PostgreSQL streaming replication cannot be specified as the database multiplexing system log transfer destination.

1.3 Deciding on Operation when a Heartbeat Abnormality is Detected

The operation to be performed when a heartbeat abnormality is detected using operating system/server heartbeat monitoring is decided on according to the environment where database multiplexing mode is performed or the operating method.

It is possible to select from the four operations below, and specify this in the parameters of Mirroring Controller:

- Use the arbitration server to perform automatic degradation (switch/disconnect)
- Call the user command that will perform the degradation decision, and perform automatic degradation
- Notification messages
- Perform automatic degradation unconditionally (switch/disconnect)

The table below shows if jobs can be continued on the primary server when an issue is detected during heartbeat monitoring of the operating system/server.

Continuation of jobs on the primary server when an issue is detected during heartbeat monitoring of the operating system/server

Operation	Abnormal event				
	Server/operating system failures or no responses		Admin network issue	Log transfer network issue	Issue on a network for both admin and log transfer
	Primary server	Standby server			
Automatic degradation using the arbitration server	Y (switch)	Y (disconnect)	Y	Y (disconnect)	Y (disconnect)
Call a user command and perform automatic degradation	Y (switch)	Y (disconnect)	Y	Y (disconnect)	Y (disconnect)
Notification messages	N (message notification only)	N (message notification only)	Y	Y (disconnect)	Y (disconnect)
Unconditional automatic degradation	Y (switch)	Y (disconnect)	N (split brain occurs)	Y (disconnect)	N (split brain occurs)

Y: Job can be continued

N: Job cannot be continued

1.4 Security in Database Multiplexing

The database server replicates the database on all servers that comprise the cluster system. It achieves this by transferring and reflecting the updated transaction logs of the database from the primary server to the standby server.

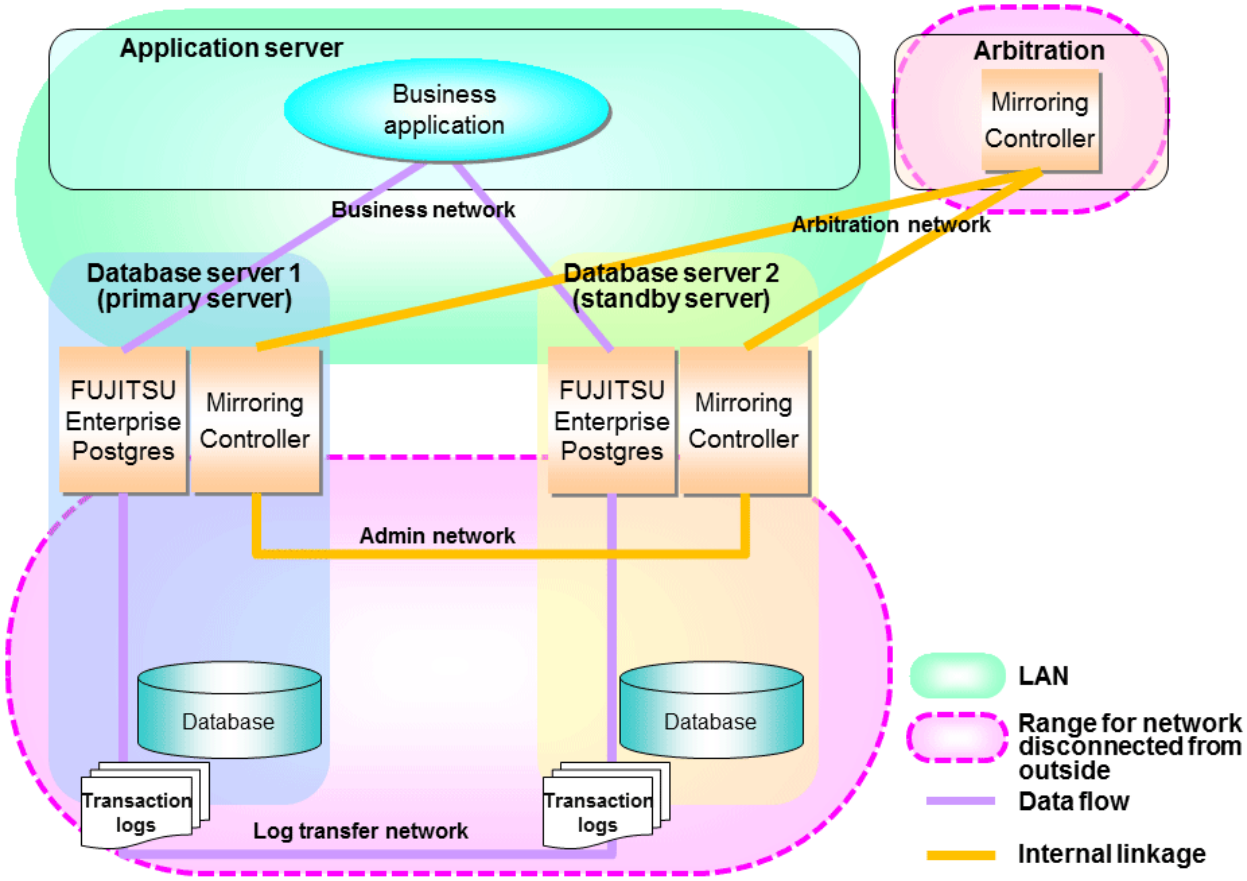
To safeguard the database against unauthorized access and preserve data confidentiality in transaction log transfers, carefully consider security and take note of the following when performing database multiplexing:

- Do not use trust authentication when using replication connection.
- Configure the admin network and the log transfer network so that they cannot be connected from the outside, as shown in Figure 1.7 Security.

Additionally, for the line on which Mirroring Controller connects from the database server to the arbitration server, take note of the following points and consider security carefully.

- Build a network with the arbitration server disconnected from outside, as shown in Figure 1.7 Security.

Figure 1.7 Security



However, it may not always be possible to adopt the configuration mentioned above. For example, you may want to place the servers in a nearby/neighboring office to minimize network delays.

In this case, combine the following features to enhance security:

- Authentication of the Standby Server
- Encryption of Transaction Logs Transferred to the Standby Server

When these features are combined, security will be achieved as shown below.

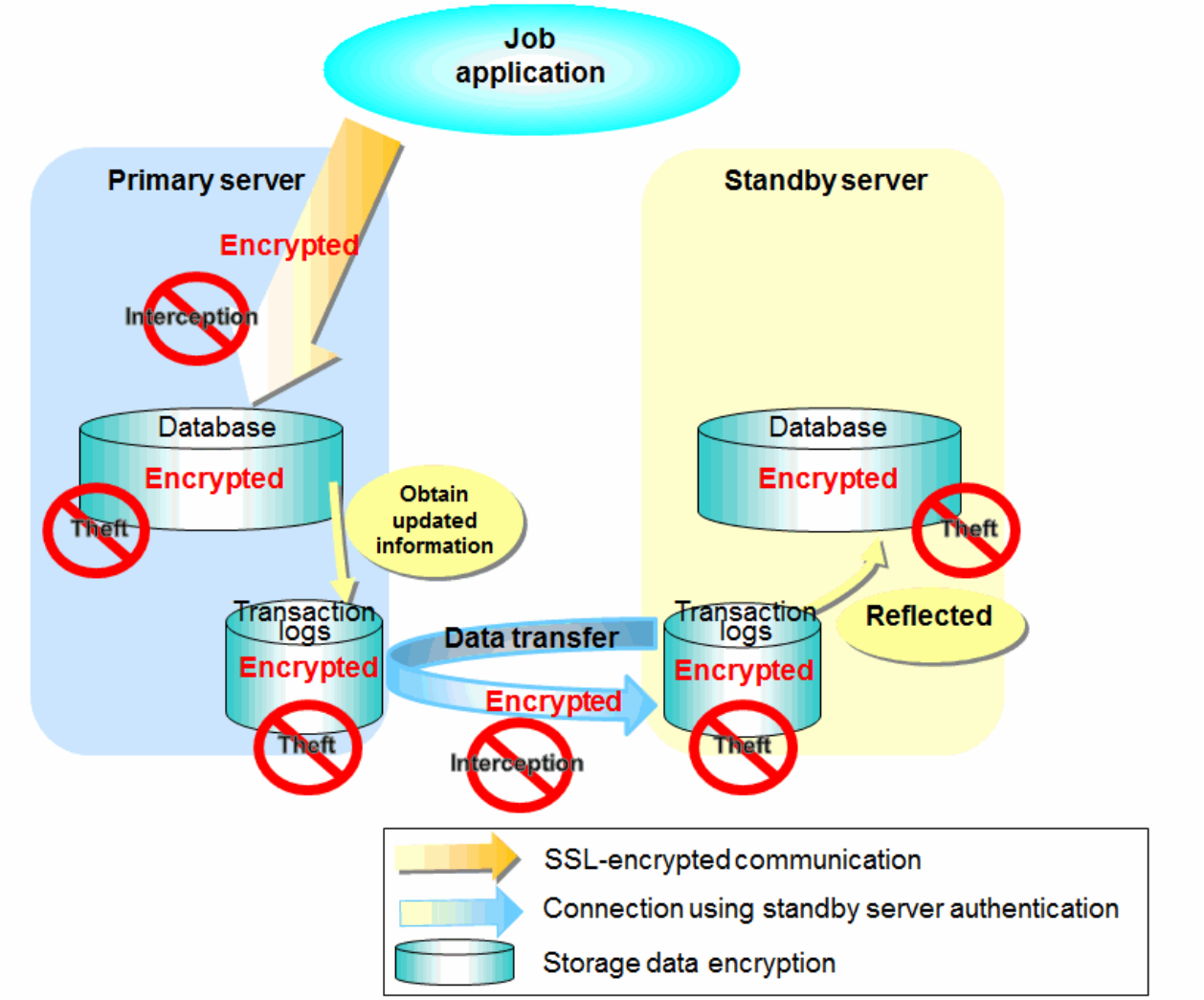
Point

If the job network is disconnected from outside, it can be used as the arbitration network. However, if a network is to be used as both a job network and arbitration network, consider the load on the network.

Note

If a port is blocked (access permission has not been granted) by a firewall, etc., enable use of the target port by granting access. Refer to the vendor document for information on how to open (grant access permission to) a port. Consider the security risks carefully when opening ports.

Figure 1.8 Security achieved when standby server authentication is combined with transaction log encryption



See

Refer to "Performing Database Multiplexing" under "Configuring Secure Communication Using Secure Sockets Layer" in the Operation Guide for information on encrypting SSL communications.

1.4.1 Authentication of the Standby Server

You can prevent spoofing connections from an external server purporting to be the standby server by using authentication with a user name and password.

Configure the setting in the primary server pg_hba.conf file so that authentication is performed for connections from the standby server in the same way as for connections from the client.

Refer to "Client Authentication" in the PostgreSQL Documentation for information on content that can be configured in pg_hba.conf.

1.4.2 Encryption of Transaction Logs Transferred to the Standby Server

In case the authentication of the standby server is breached so that a malicious user purporting to be the standby server can spoof data, the transaction log data can be encrypted to prevent it from being deciphered. The transparent data encryption feature is used to encrypt the data.

Refer to "Protecting Storage Data Using Transparent Data Encryption" in the Operation Guide for details.

Chapter 2 Setting Up Database Multiplexing Mode

This chapter describes how to set up database multiplexing mode, and how to check it.

Users who perform setup and operations on the database server

Setup and operations of the database server must be performed by the instance administrator user.

Users who perform setup and operations on the arbitration server

The following users may perform setup and operations on the arbitration server when it is used for automatic degradation.

- Any operating system user.

Point

- Mirroring Controller selects a database superuser as the user who will connect to the database instance. This enables instance administrator users and database superusers who operate the Mirroring Controller commands to run database multiplexing mode in different environments.
- The application name for connecting to the database instance is "mc_agent".

Matching the system times

Before starting the setup, ensure that the times in the primary server, standby server and arbitration server match, by using the operating system time synchronization feature, for example.

The tolerated difference is approximately one second.

If the system times are not synchronized (because the tolerated difference is exceeded, for example), problem investigation may be affected.

Configuring ICMP

Because the ping command of the operating system is used for heartbeat monitoring of the database server, configure the network so that ICMP can be used on the admin network and the arbitration network. Refer to the relevant operating system procedure for details.

Setup

The setup procedure is shown in the table below. However, the procedure on the arbitration server should be performed only when the arbitration server is used for automatic degradation. A distinction is made between the procedures on the primary server and standby server according to whether the arbitration server is used.

Step	Task			Refer to
	Primary server	Standby server	Arbitration server	
1	Installation			2.1 Installation
2	Preparing the database server		Preparing the arbitration server	2.2 Preparing for Setup
3			Configuring the arbitration server	2.3.1 Configuring the Arbitration Server
4			Creating a user command	2.3.2 Creating a User Command for the Arbitration Server
5			Starting the arbitration process	2.3.3 Starting the Mirroring Controller Arbitration Process
6	Setting up database multiplexing mode			2.4.1 Setting Up Database Multiplexing Mode on the Primary Server

Step	Task			Refer to
	Primary server	Standby server	Arbitration server	
7	Creating, setting, and registering the instance			2.4.2 Creating, Setting, and Registering the Primary Server Instance
8	Creating a user command			2.6 Creating a User Command for a Database Server
9	Starting Mirroring Controller			2.4.3 Starting Mirroring Controller on the Primary Server
10		Setting up database multiplexing mode		2.5.1 Setting Up Database Multiplexing Mode on the Standby Server
11		Creating, setting, and registering the instance		2.5.2 Creating, Setting, and Registering the Standby Server Instance
12		Creating a user command		2.6 Creating a User Command for a Database Server
13		Starting Mirroring Controller		2.5.3 Starting Mirroring Controller on the Standby Server
14	Confirming the streaming replication status			2.7 Confirming the Streaming Replication Status
15	Checking the connection status			2.8.1 Checking the Connection Status on a Database Server
16		Checking the connection status		2.8.1 Checking the Connection Status on a Database Server
17			Checking the connection status	2.8.2 Checking the Connection Status on the Arbitration Server
18	Creating applications			2.9 Creating Applications
19	Checking the behavior			2.10 Checking the Behavior

Explanations for each step are provided below.

Information

- The setup procedure is also the same when changing the mode on a single server to database multiplexing mode. In this case, omit the installation of FUJITSU Enterprise Postgres and the creation of the instance.

  Refer to "3.9.2 Changing from Single Server Mode to Database Multiplexing Mode" for details.

- The primary and standby server can be pseudo-configured on the same server for system testing, for example. In this case, the setup can be performed using the same procedure, however there will be some supplementary steps.

  Before performing the setup, refer to "Appendix B Supplementary Information on Building the Primary Server and Standby Server on the Same Server".

2.1 Installation

Refer to the manuals below, and then install the product.

See

- Refer to the Installation and Setup Guide for Server for details on how to install FUJITSU Enterprise Postgres.

- Refer to the Installation and Setup Guide for Server Assistant for information on installing the Server Assistant on the arbitration server.

Note

Do not use the arbitration server also as a database server. The arbitration server is installed to check the database server status as a third party, and to perform fencing. Using the arbitration server also as a database server nullifies the effectiveness of the arbitration server.

2.2 Preparing for Setup

This section describes the preparation required before setting up Mirroring Controller.

2.2.1 Preparing the Database Server

2.2.1.1 Preparing the Backup Disk

In Mirroring Controller, by performing a backup, recovery is possible even if all server disks are corrupted.

The content on the primary server should be backed up. However, through switching and failback, the standby server may also become the primary server. Accordingly, prepare each of the backup disk devices for the primary and standby servers. Perform backup on the primary server used at the time of the backup.

2.3 Setting Up the Arbitration Server

This section explains how to set up the arbitration server.

2.3.1 Configuring the Arbitration Server

This section explains how to set up database multiplexing mode on the arbitration server.

In database multiplexing mode, the files that are required for operations are managed in the Mirroring Controller arbitration process management directory.

There is one Mirroring Controller arbitration process management directory for each arbitration process.

Point

The arbitration process for each database multiplexing system can be started on a single arbitration server.

See

- Refer to the Reference for information on the mc_arb command.
- Refer to "Appendix A Parameters" for information on the parameters to be edited for the setup.

Perform the following procedure:

1. On the arbitration server, log in as any operating system user who starts and stops the arbitration process.
2. Configure the environment variables.

   Set the following environment variables:

   - PATH

     Add the installation directory "/bin".

- MANPATH

  Add the installation directory "/share/man".

- LD_LIBRARY_PATH

  Add the installation directory "/lib".

Example

The following example configures environment variables when the installation directory is "/opt/fsepv<*x*>assistant".

Note that "<*x*>" indicates the product version.

sh, bash

```
$ PATH=/opt/fsepv<x>assistant/bin:$PATH ; export PATH
$ MANPATH=/opt/fsepv<x>assistant/share/man:$MANPATH ; export MANPATH
$ LD_LIBRARY_PATH=/opt/fsepv<x>assistant/lib:$LD_LIBRARY_PATH ; export LD_LIBRARY_PATH
```

csh, tcsh

```
$ setenv PATH /opt/fsepv<x>assistant/bin:$PATH
$ setenv MANPATH /opt/fsepv<x>assistant/share/man:$MANPATH
$ setenv LD_LIBRARY_PATH /opt/fsepv<x>assistant/lib:$LD_LIBRARY_PATH
```

Note

If you execute any command other than FUJITSU Enterprise Postgres (OS commands, etc.) after LD_LIBRARY_PATH is set, remove the installation directory/lib from LD_LIBRARY_PATH.

3. Create the Mirroring Controller arbitration process management directory that will store the files required by the arbitration server.

   Use ASCII characters in the Mirroring Controller arbitration process management directory.

4. In the network configuration file (network.conf), define the Mirroring Controller network configuration that will be managed by the Mirroring Controller arbitration process.

   Create network.conf in the Mirroring Controller arbitration process management directory, based on the sample file. For network.conf, set read and write permissions only for the operating system user who starts and stops the arbitration process in step 1.

   If users other than this are granted access permissions, the mc_arb command will not work. Accordingly, users other than the operating system user who starts and stops the arbitration process in step 1 are prevented from operating the Mirroring Controller arbitration process.

   Sample file

   ```
   /installDir/share/mcarb_network.conf.sample
   ```

   In network.conf, specify the IP address or host name and port number of the primary server and standby server, and define the Mirroring Controller network configuration that will be managed by the Mirroring Controller arbitration process.

   Refer to "A.3 Network Configuration File" for details.

   A definition example is shown below.

   ```
   Example)
   The IDs of the servers are set to "server1" and "server2", and their port numbers are set to
   "27541".
   ```

   ```
   server1 192.0.3.100 27541
   server2 192.0.3.110 27541
   ```

5. In the arbitration configuration file (arbitration.conf), define the information related to control of the Mirroring Controller arbitration process.

   Create arbitration.conf in the Mirroring Controller arbitration process management directory, based on the sample file. For arbitration.conf, set read and write permissions only for the operating system user who starts and stops the arbitration process in step 1. If users other than this are granted access permissions, the mc_arb command will not work.

   Sample file

   ```
   /installDir/share/mcarb_arbitration.conf.sample
   ```

   Set the parameters shown in the table below in arbitration.conf.

Table 2.1 Parameters

Parameter	Content specified	Remarks
port	Port number of the Mirroring Controller arbitration process	The port number must be 0 to 65535. Ensure that the port number does not conflict with other software. Do not specify an ephemeral port that may temporarily be assigned by another program.
my_address	'*ipAddrOrHostNameThatAcceptsConnectionFromMirroringControllerProcessOnDbServer*' [Setting example] my_address = '192.0.3.120'	IPv4 and IPv6 addresses can be specified. Specify the IP address, enclosed in single quotation marks (').
syslog_ident	'*programName*'	Specify using single quotation marks (') to enclose the program name used to identify the Mirroring Controller arbitration process message in the system log. Use ASCII characters excluding spaces to specify this parameter. The default is 'MirroringControllerArbiter'.
fencing_command	'*fencingCmdFilePath*' [Setting example] fencing_command = '/arbiter/fencing_dir/execute_fencing.sh'	Specify the full path of the fencing command that fences a database server where it is determined that an error has occurred. Enclose the path in single quotation marks ('). Specify the path using less than 1024 bytes.
fencing_command_timeout	Timeout for fencing command (seconds)	If the command does not respond within the specified number of seconds, it is determined that fencing has failed and a signal (SIGTERM) is sent to the fencing command execution process. Specify a value between 1 and 2147483647. The default is 20 seconds.

Information

Refer to "A.4.2 Arbitration Configuration File" for information on the parameters and for other parameters.

2.3.2 Creating a User Command for the Arbitration Server

The only user command for the arbitration server is the fencing command.

The fencing command is a user command that is called by the Mirroring Controller arbitration process if Mirroring Controller performs arbitration processing and determines that a database server is unstable.

In the fencing command, the user implements a process that isolates a database server from a cluster system by, for example, stopping the target operating system or server. The fencing command that was created is to be specified for the parameter in the arbitration configuration file. Refer to "A.4.2 Arbitration Configuration File" for information on the parameters.

- Fencing the primary server during the switch
  - Prevent the Mirroring Controller management process on the primary server from communicating with the Mirroring Controller management process on the other server.
  - Prevent applications from connecting to the primary server instance.
- Fencing the standby server during disconnection
  - Prevent the Mirroring Controller management process on the standby server from communicating with the Mirroring Controller management process on the other server.
  - Prevent applications from connecting to the standby server instance.
  - Prevent the standby server from continuing streaming replication.

See

Refer to "Appendix C User Commands" for information on user commands.

2.3.3 Starting the Mirroring Controller Arbitration Process

This section explains how to start the Mirroring Controller arbitration process.

An operating system user who has logged in to the arbitration server can start the Mirroring Controller arbitration process by executing the mc_arb command in start mode.

Example)

```
$ mc_arb start -M /mcarb_dir/arbiter1
```

2.4 Setting Up the Primary Server

This section explains how to set up the primary server.

2.4.1 Setting Up Database Multiplexing Mode on the Primary Server

This section explains how to set up database multiplexing mode on the primary server.

In database multiplexing, the files that are required for operations are managed in the Mirroring Controller management directory.

There is one Mirroring Controller management directory for each instance.

Note

- Do not place the Mirroring Controller management directory in a directory managed by FUJITSU Enterprise Postgres, otherwise it may be deleted by mistake with the directories managed by FUJITSU Enterprise Postgres, and an old version of files may be restored.

See

- Refer to "Preparing Directories for Resource Deployment" in the Installation and Setup Guide for Server for details on the directories that are managed by FUJITSU Enterprise Postgres.
- Refer to "mc_ctl" in Reference for information on the command.
- Refer to "Appendix A Parameters" for details on each parameter to be edited for the setup.

Perform the following procedure:

1. Log in to the primary server.
2. Create the Mirroring Controller management directory that will store the files required by database multiplexing.

   Use ASCII characters in the Mirroring Controller management directory.

   Additionally, grant "Write" permission to the instance administrator user for the Mirroring Controller management directory.
3. In the network configuration file (network.conf), define the network configuration that will link between the Mirroring Controller processes.

   Create the network.conf file in the Mirroring Controller management directory, based on the sample file. For network.conf, set read and write permissions for the instance administrator user only.

   If users other than the instance administrator user are granted access, the mc_ctl command will not work. In this way, users other than the instance administrator user are prevented from operating Mirroring Controller.

   Sample file

   ```
   /installDir/share/mc_network.conf.sample
   ```

   In network.conf, specify the IP address or host name and port number of the primary server and standby server, and define the network configuration that will link between the Mirroring Controller processes, and between Mirroring Controller processes and the Mirroring Controller arbitration process.

   Refer to "A.3 Network Configuration File" for details.

   A definition example is shown below.

   The content to be defined depends on the operation settings at the time a heartbeat abnormality is detected.

   ### When automatic degradation by the arbitration server is selected

   ```
   Example)
   The IDs of the primary server and standby server are set to "server1" and "server2", and their
   port numbers are set to "27540" and "27541". The ID of the server of the Mirroring Controller
   arbitration process is set to "arbiter", and its port number is set to "27541".
   ```

   ```
   server1 192.0.2.100,192.0.3.100 27540,27541 server
   server2 192.0.2.110,192.0.3.110 27540,27541 server
   arbiter 192.0.3.120 27541 arbiter
   ```

   Ensure that the port numbers set for the primary server, standby server, and arbitration server do not conflict with other software. In addition, when the arbitration server is used for automatic degradation, use a network in which the arbitration network is not affected by a line failure in the admin network.

   When the server type is "server", two IP addresses or host names, and two port numbers need to be specified in the following order:

   - IP address or host name of the database server used as the admin network
   - IP address or host name of the database server used as the arbitration network
   - Port number of the database server used as the admin network
   - Port number of the database server used as the arbitration network

   If the server type is "arbiter", specify the IP address or host name set for the my_address parameter and the port number set for the port parameter in arbitration.conf of the arbitration server.

When operation other than automatic degradation by the arbitration server is selected

```
Example)
The IDs of the servers are set to "server1" and "server2", and their port numbers are set to
"27540".
```

```
server1 192.0.2.100 27540
server2 192.0.2.110 27540
```

Ensure that the port numbers for the primary and standby server do not conflict with other software.

Register in /etc/services the port number of the primary server, because programs such as WebAdmin use it to search for available port numbers.

Register any name as the service name.

4. Define the information related to Mirroring Controller monitoring and control in the *serverIdentifier*.conf file.

   Create the *serverIdentifier*.conf file in the Mirroring Controller management directory, based on the sample file.

   For *serverIdentifier*.conf, set read and write permissions for the instance administrator user only. If users other than the instance administrator user are granted access, the mc_ctl command will not work.

   As the file name for the *serverIdentifier*.conf file, use the server identifier name that was specified in the network.conf file in step 3.

   Sample file

   ```
   /InstallDir/share/mc_server.conf.sample
   ```

   Set the parameters shown in the table below in the *serverIdentifier*.conf file.

Table 2.2 Parameters

Parameter	Content specified	Remarks
db_instance	'*dataStorageDestinationDir*'	Use ASCII characters, enclosed in single quotation marks (').
db_instance_password	'*passwordOfInstanceAdminUser*'	If password authentication is performed, you must specify this parameter in the settings used when Mirroring Controller connects to a database instance. Use ASCII characters, enclosed in single quotation marks ('). If the specified value of this parameter includes ' or \, write \' or \\, respectively.
enable_hash_in_password	on or off	Specify on to treat the # in the db_instance_password specification as a password character, or off to treat it as a comment. The default is "off".
syslog_ident	'*programName*'	Specify the program name to be used to identify the Mirroring Controller messages in the system log. Use ASCII characters excluding spaces, enclosed in single quotation marks ('). Use the same program name as the parameter in the postgresql.conf file ensures that the Mirroring Controller output content can be referenced transparently, so log reference is easy.

Parameter	Content specified	Remarks
remote_call_timeout	Admin communication timeout	Specify the timeout value (milliseconds) of the Mirroring Controller agent process for communication between servers. Specify a value that is less than the operation system TCP connection timeout.
heartbeat_error_action	Operation when a heartbeat abnormality is detected using operating system or server heartbeat monitoring	arbitration: Perform automatic degradation using the arbitration server. command: Call a user command to determine degradation, and perform automatic degradation if required. message: Notify messages. fallback: Perform automatic degradation unconditionally. Set the same value on the primary server and standby server.
heartbeat_interval	Interval time for abnormality monitoring during heartbeat monitoring of the operating system or server (milliseconds)	Abnormality monitoring of the operating system or server is performed at the interval (milliseconds) specified in heartbeat_interval. This parameter setting is used as the default for database process heartbeat monitoring, streaming replication abnormality monitoring, and disk abnormality monitoring. When setting the monitoring time, there are some considerations to take into account to optimize degradation using abnormality monitoring. Refer to "2.11.4.1 Tuning for Abnormality Monitoring of the Operating System or Server" for details.
heartbeat_timeout	Timeout for abnormality monitoring during heartbeat monitoring of the operating system or server (seconds)	
heartbeat_retry	Number of retries for abnormality monitoring during heartbeat monitoring of the operating system or server (number of times)	
fencing_command	'*fencingCmdFilePath*' [Setting example] fencing_command = '/mc/fencing_dir/execute_fencing.sh'	Specify the full path of the fencing command that fences a database server where an error is determined to have occurred. Enclose the path in single quotation marks ('). This parameter must be specified when "command" is set for heartbeat_error_action. Specify the path using less than 1024 bytes.
fencing_command_timeout	Fencing command timeout (seconds)	If the command does not respond within the specified number of seconds, fencing is determined to have failed and a signal (SIGTERM) is sent to the fencing command execution process. Specify a value between 1 and 2147483647. The default is 20 seconds.
arbitration_timeout	Timeout for arbitration processing in the Mirroring Controller arbitration process (seconds)	The specified value must be at least equal to the heartbeat monitoring time of the operating system or server + fencing_command_timeout in the arbitration configuration file.

Parameter	Content specified	Remarks
		If there is no response for at least the number of seconds specified, the primary server will not be switched and the standby server will not be disconnected. Therefore, perform degradation manually. Specify a value between 1 and 2147483647. This parameter does not need to be set for operation that does not use the arbitration server.
arbitration_command	'*arbitrationCmdFilePath*' [Setting example] arbitration_command = '/mc/arbitration_dir/execute_arbitration_command.sh'	Specify the full path of the arbitration command to be executed when an abnormality is detected during heartbeat monitoring of the operating system or server. Enclose the path in single quotation marks ('). This parameter must be specified when "command" is set for heartbeat_error_action. Specify the path using less than 1024 bytes.
arbitration_command_timeout	Timeout for arbitration command (seconds)	If the arbitration command does not respond within the specified number of seconds, it is determined that execution of the arbitration command has failed and a signal (SIGTERM) is sent to the arbitration command execution process. Specify a value between 1 and 2147483647. This parameter can be specified only when "command" is set for heartbeat_error_action.

Information

Refer to "A.4.1 Server Configuration File for the Database Servers" for information on the parameters and for other parameters.

2.4.2 Creating, Setting, and Registering the Primary Server Instance

This section explains how to create, set, and register the primary server instance.

See

- Refer to "Client Authentication" in the PostgreSQL Documentation for information on the pg_hba.conf file.
- Refer to "A.1 Parameters Set on the Primary Server" for information on the postgresql.conf file.
- Refer to "mc_ctl" in Reference for information on the command.

Perform the following procedure:

1. Refer to "Setup" in the Installation and Setup Guide for Server, and then perform the FUJITSU Enterprise Postgres setup and create the FUJITSU Enterprise Postgres instance.

   Use ASCII characters in the data storage destination directory.

Note

- If degradation starts occurring due to an error during operations in database multiplexing mode, recovery is required for the standby server. There are some conditions to execute the pg_rewind command to recover the standby server. One of the conditions can be satisfied by enabling checksums when executing the initdb command. This is not mandatory. Refer to "4.1.1.1.3 Identify cause of error and perform recovery" for details.

2. When using transparent data encryption, configure the encryption settings for the storage data.

   Create a keystore file.

   If you want to use the key management system as a keystore, set the connection information for the key management system and declare the master encryption key.

   Refer to "Protecting Storage Data Using Transparent Data Encryption" or "Using Transparent Data Encryption with Key Management Systems as Keystores" in the Operation Guide for details, and then configure the settings.

3. Add the following entry to the pg_hba.conf file to authenticate connections from the standby server.

   Copy the file to the standby server later.

```
# TYPE    DATABASE        USER        ADDRESS                     METHOD
  host    replication     fsep        standbyServerAddress        authenticationMethod
  host    replication     fsep        primaryServerAddress        authenticationMethod
```

   For the primary and standby server addresses, specify the IP address that will connect to the log transfer network.

   Additionally, all servers can be used as the primary server or the standby server, so add entries for the addresses of all servers that comprise the database multiplexing system.

Point

Setting an authentication method other than trust authentication

If the primary server becomes the standby server, to perform automatic authentication of connections to the primary server, create the .pgpass file in the home directory of the instance administrator user, and then specify a password for the replication database. Accordingly, the instance administrator operating system user and the user registered in the database will be the same, so you can verify that the connection was not made by an unspecified user. Additionally, the password that was set beforehand will be used in the authentication, so that the connection will be automatic.

Note

If trust authentication is set, all OS users who can log in to the primary server will be able to connect, and if one of these is a malicious user, then that user can corrupt the standby server data, or cause the job system to fail, by sending an erroneous transaction log. Therefore, decide on the authentication method according to the security requirements of the system using database multiplexing mode.

Refer to "Authentication Methods" in the PostgreSQL Documentation for details on the authentication methods that can be set.

4. Configure this setting to enable the instance administrator user of the primary server to connect as a database application.

   This setting enables the connection to the instance using the user name of the instance administrator user, so that Mirroring Controller can monitor instance errors. Configure this setting to enable the connection to the postgres database.

   - If password authentication is used

     In the db_instance_password parameter of the *serverIdentifier*.conf file, specify the password for the instance administrator user. This password is used to connect to the database instance. If a password is not specified in the db_instance_password parameter, the connection to the database instance from Mirroring Controller will fail, and it will not be possible to perform the process monitoring of the instance.

- If password authentication is not used

  There is no need to specify the password in the db_instance_password parameter.

  Even if the password for the instance administrator user is specified in the db_instance_password parameter, it will be ignored.

- If certificate authentication using SSL is used

  Specify connection parameters for SSL in the db_instance_ext_ pq_conninfo parameter and db_instance_ext_jdbc_conninfo parameter in the *serverIdentifier*.conf file. If the pasrameters are not specified, the connection to the database instance from Mirroring Controller will fail, and it will not be possible to perform the process monitoring of the instance. If certificate authentication using SSL is not performed, the parameters specification is not required.

An example of setting the authentication method is shown below.

```
# TYPE    DATABASE        USER        ADDRESS         METHOD
  host    postgres        fsep        127.0.0.1/32    authenticationMethod
```

Note

Mirroring Controller uses the PostgreSQL JDBC 4.2 driver to connect to the database instance. Therefore, for the authentication method, specify a method supported by the JDBC driver. If an authentication method not supported by the JDBC driver is specified, Mirroring Controller will fail to start. Refer to the PostgreSQL JDBC Driver Documentation for information on authentication methods supported by the JDBC driver.

5. To use database multiplexing mode, specify the parameters shown in the table below in the postgresql.conf file.

   The postgresql.conf file is copied when the standby server instance is created. Accordingly, set the required parameters in the standby server.

   To use database multiplexing mode, specify the parameters shown in the table below in the postgresql.conf file. After editing the postgresql.conf file, restart the instance.

Table 2.3 Parameters

Parameter	Content specified	Remarks
wal_level	replica or logical	Specify "logical" when logical decoding is also to be used.
max_wal_senders	2 or more	Specify "2" when building a Mirroring Controller cluster system. When additionally connecting asynchronous standby servers to the cluster system, add the number of simultaneous connections from these standby servers.
synchronous_standby_names	'*standbyServerName*'	Specify the name that will identify the standby server. Enclose the name in single quotation marks ('). Do not change this parameter while Mirroring Controller is running. Do not specify multiple names to this parameter as the Mirroring Controller can manage only one standby server.
hot_standby	on	
wal_keep_size	WAL save size (megabytes)	If a delay exceeding the value set in this parameter occurs, the WAL segment required later by the primary server may be deleted. Additionally, if you stop a standby server (for maintenance, for example), consider the stop time and set a value that will not cause the WAL segment to be deleted.

Parameter	Content specified	Remarks
		Refer to "Estimating Transaction Log Space Requirements" in the Installation and Setup Guide for Server for information on estimating the WAL save size.
wal_log_hints	on	When using the pg_rewind command to recover a standby server, specify this parameter or enable checksums when executing the initdb command.
wal_sender_timeout	Timeout (milliseconds)	Specify the time period after which it is determined that an error has occurred in the transaction log transfer on the primary server. By aligning this value with the value for the database process heartbeat monitoring time, you can unify the time after which it is determined that an error has occurred.
archive_mode	on	Specify the archive log mode.
archive_command	'*installDir*/bin/pgx_walcopy.cmd "%p" "*backupDataStorageDestinationDirectory*/archived_wal/%f"'	Specify the command and storage destination to save the transaction log.
backup_destination	Backup data storage destination directory	Specify the name of directory where to store the backup data. Set the permissions so that only the instance administrator user can access the specified directory. Specify the same full path on all servers, so that the backup data of other servers can be used to perform recovery.
max_connections	Number of simultaneous client connections to the instance + superuser_reserved_connections	The value specified is also used to restrict the number of connections from client applications and the number of connections for the management of instances. Refer to "When an Instance was Created with the initdb Command" in the Installation and Setup Guide for Server, and "Connections and Authentication" in the PostgreSQL Documentation, for details.
superuser_reserved_connections	Add the number of simultaneous executions of mc_ctl status (*1) + 2	Specify the number of connections reserved for connections from database superusers. Add the number of connections from Mirroring Controller processes. Also reflect the added value in the max_connections parameter.
wal_receiver_timeout	Timeout (milliseconds)	Specify the time period after which it is determined that an error has occurred when the transaction log was received on the standby server. By aligning this value with the value for the heartbeat monitoring time of the database process, you can unify the time after which it is determined that an error has occurred.
restart_after_crash	off	If "on" is specified, or the default value is used for this parameter, behavior equivalent to restarting FUJITSU Enterprise Postgres, including crash recovery, will be performed when some server processes end abnormally. However, when database multiplexing monitoring is used, a failover will occur after an error is detected when some server processes end abnormally, and the restart of those

Parameter	Content specified	Remarks
		server processes is forcibly stopped. Specify "off" to prevent behavior such as this from occurring for no apparent reason.
synchronous_commit	on or remote_apply	Specify up to what position WAL send is to be performed before transaction commit processing returns a normal termination response to a client. The recommended value is "on" or "remote_apply" to prevent data loss caused by operating system or server down immediately after a switch or switch.
recovery_target_timeline	latest	Specify "latest" so that the new standby server (original primary server) will follow the new primary server when a switch occurs. This parameter is required when the original primary server is incorporated as a new standby server after the primary server is switched.

*1: Number of simultaneous executions of the mc_ctl command in the status mode.

2.4.3 Starting Mirroring Controller on the Primary Server

This section explains how to start Mirroring Controller on the primary server.

When the arbitration server is used for automatic degradation, start the Mirroring Controller arbitration process on the arbitration server in advance.

1. Start the Mirroring Controller process.

   Enabling automatic switch/disconnection

   As the instance administrator user, execute the mc_ctl command in start mode.

   Example)

```
$ mc_ctl start -M /mcdir/inst1
```

   Disabling automatic switch/disconnection

   As the instance administrator user, execute the mc_ctl command in start mode with the -F option specified.

   Example)

```
$ mc_ctl start -M /mcdir/inst1 -F
```

Note

- When the arbitration server is used for automatic degradation, the database server must connect to the arbitration server, and as a result, Mirroring Controller startup may take longer than when the arbitration server is not used.
- If the parameter for heartbeat monitoring of operating systems or servers set by the abitration server is greater than parameter for heartbeat monitoring of operating systems and servers of the Mirroring Controller, the Mirroring Controller may fail to start. In this case, check the contents of the message notification and review the parameters for heartbeat monitoring of operating systems or servers for the arbitration server or Mirroring Controller.
- If the heartbeat_error_action parameter in *serverIdentifier*.conf is set to "message", even if automatic switch/disconnection is enabled and Mirroring Controller is started, only message output is performed when a heartbeat abnormality is detected during heartbeat monitoring of operating systems and servers - switch/disconnection is not performed.
- Mirroring Controller startup usually fails if the standby server is mistakenly started as the primary server or if the old primary server is not recovered after the switch and is then mistakenly started as the primary server. However, if the admin network is

disconnected, then startup does not fail, and both servers may become primary servers. Therefore ensure that the admin network is connected before starting Mirroring Controller.

Point

- The mc_ctl command fails if the Mirroring Controller arbitration process has not been started on the arbitration server when the arbitration server is used for automatic degradation. However, if the Mirroring Controller arbitration process cannot be started in advance, it can be started by specifying the --async-connect-arbiter option in the mc_ctl command.
- After Mirroring Controller is started, automatic switch/disconnection can be enabled or disabled using the enable-failover or disable-failover mode of the mc_ctl command.

2. Obtain the backup.

   Use the pgx_dmpall command to collect the backup.

2.5 Setting Up the Standby Server

This section explains how to set up the standby server.

2.5.1 Setting Up Database Multiplexing Mode on the Standby Server

This section explains how to set up database multiplexing mode on the standby server.

In database multiplexing, the files that are required for operations are managed in the Mirroring Controller management directory.

There is one Mirroring Controller management directory for each instance.

Note

- Do not place the Mirroring Controller management directory in a directory managed by FUJITSU Enterprise Postgres, otherwise it may be deleted by mistake with the directories managed by FUJITSU Enterprise Postgres, and an old version of files may be restored.
- When creating a standby server for a large database, stop job system operations, specify a large value for the wal_keep_size parameter, or use replication slots.
  This is because WALs generated after the standby server is built using the pg_basebackup command, but before it is started, need to be retained. However, the number of WAL segments that can be retained is constrained by the wal_keep_size parameter.
  Additionally, setting the wal_keep_size parameter requires consideration regarding stabilization of the database multiplexing mode (refer to "2.11.1 Tuning to Stabilize the Database Multiplexing Mode" for details).

See

- Refer to "Preparing Directories for Resource Deployment" in the Installation and Setup Guide for Server for details on the directories that are managed by FUJITSU Enterprise Postgres.
- Refer to "pg_basebackup" in "Reference" in the PostgreSQL Documentation for information on the pg_basebackup command.
- Refer to "mc_ctl" in Reference for information on the command.
- Refer to "Appendix A Parameters" for details on each parameter to be edited for the setup.
- Refer to "Replication Slots" in the PostgreSQL Documentation for information on replication slots.

Perform the following procedure:

1. Log in to the standby server.

2. Create the Mirroring Controller management directory that will store the files required by database multiplexing.

   Use ASCII characters in the Mirroring Controller management directory.

   Additionally, grant "Write" permission to the instance administrator user for the Mirroring Controller management directory.

3. Copy, and then deploy, the network.conf file of the primary server.

   Copy the network.conf file that was defined in the primary server setup, and deploy it to the Mirroring Controller management directory of the standby server.

   Set read and write permissions for the instance administrator user only. If users other than the instance administrator user are granted access, the mc_ctl command will not work. Accordingly, users other than the instance administrator user are prevented from operating Mirroring Controller.

   Register in /etc/services the port number of the standby server that was specified in the network.conf file, because programs such as WebAdmin use it to search for available port numbers.

   Register any name as the service name.

4. Copy, and then deploy, the *serverIdentifier*.conf file of the primary server.

   Copy the *serverIdentifier*.conf file that was defined in the primary server setup, and deploy it to the Mirroring Controller management directory of the standby server.

   Set read and write permissions for the instance administrator user only. If users other than the instance administrator user are granted access permissions, the mc_ctl command will not work.

2.5.2 Creating, Setting, and Registering the Standby Server Instance

This section explains how to create, set, and register the standby server instance.

See

- Refer to "Appendix A Parameters" for details on each parameter.
- Refer to "mc_ctl" in Reference for information on the command.

Perform the following procedure:

1. Set the kernel parameters.

   Refer to "Configuring Kernel Parameters" in the Installation and Setup Guide for Server for details.

2. When using transparent data encryption, configure the encryption settings for the storage data.

   Refer to "Protecting Storage Data Using Transparent Data Encryption" or "Using Transparent Data Encryption with Key Management Systems as Keystores" in the Operation Guide for details, and then configure the settings.

3. Execute the pg_basebackup command to create a copy of the primary server instance on the standby server.

   Example)

   ```
   $ pg_basebackup -D /database/inst1 -X fetch --waldir=/transaction/inst1 --progress --verbose -R
   --dbname='application_name=standbyServerName' -h primaryServerIpAddress -p
   primaryServerPortNumber
   ```

   ### Note

   - Use the pg_basebackup command with the -R option to create a standby.signal file. If you do not create the standby.signal file, the Mirroring Controller cannot be started as a standby server.
   - If using a method that requires password authentication for connections to the primary server, you will need to ensure that authentication is performed automatically. If the -R option is specified for the pg_basebackup command and the password

parameter is specified for the --dbname option, the pg_basebackup command will set the password in the primary_conninfo parameter in postgresql.auto.conf file, enabling connections to be performed automatically.

If a password is not set in the primary_conninfo parameter in postgresql.auto.conf file, it will be necessary to create a .pgpass file in the home directory of the instance administrator user, and specify a password for the replication database.

- The primary_conninfo parameter should not be set in the postgresql.conf file, but only in the postgresql.auto.conf file using the pg_basebackup command.
- When executing the pg_basebackup command, consider the following for collection of transaction logs.
  - When "fetch" is specified for the -X option of the command

    Transaction logs are collected at the end of the backup, so it is necessary to ensure that transaction logs that occur during backup are not deleted from the primary server. Therefore, allow for a sufficient value for the wal_keep_size parameter in postgresql.conf.
  - When the -X option is omitted or "stream" is specified for the -X option of the command

    Transaction logs are streamed, so when Mirroring Controller is running on the primary server, the connection is changed to a synchronous standby server on detection of a streaming replication connection using this command. Therefore, if a job has started on the primary server, the primary server will be impacted, therefore execute this command after stopping only the Mirroring Controller process on the primary server.

Refer to "Hot Standby" in the PostgreSQL Documentation for information on the standby.signal file.

4. Set the parameters shown in the table below in the postgresql.conf file.

Table 2.4 Parameters

Parameter	Content specified	Remarks
synchronous_standby_names	'*primaryServerName*'	Required after switching the primary server and then changing the original primary server to the new standby server. Enclose the name in single quotation marks ('). Do not change this parameter while Mirroring Controller is running. Do not specify multiple names to this parameter as the Mirroring Controller can manage only one standby server.
streaming_wal_compression	Any number from -1 to 9	Specifies that you want to send a compressed WAL by streaming replication. -1: Compress at zlib's default compression level 0: Uncompressed 1-9: Compress at specified compression level, 9 is high compression Default is uncompressed.

Refer to "WAL Compression for Streaming Replication" in the Operation Guide for information on the streaming_wal_compression.

2.5.3 Starting Mirroring Controller on the Standby Server

This section explains how to start Mirroring Controller on the standby server.

When the arbitration server is used for automatic degradation, start the Mirroring Controller arbitration process on the arbitration server in advance.

1. After ensuring that the Mirroring Controller process of the primary server has started, start Mirroring Controller on the standby server.

   Enabling automatic switch/disconnection

   As the instance administrator user, execute the mc_ctl command in start mode with the -f option specified. This action enables automatic switch/disconnection.

   If you start Mirroring Controller and the instance without specifying the -f option, automatic switch/disconnection will not be enabled. To enable both, start Mirroring Controller and then execute the mc_ctl command in enable-failover mode or restart Mirroring Controller with the -f option specified.

   Example)

   ```
   $ mc_ctl start -M /mcdir/inst1
   ```

   Disabling automatic switch/disconnection

   As the instance administrator user, execute the mc_ctl command in start mode with the -F option specified.

   Example)

   ```
   $ mc_ctl start -M /mcdir/inst1 -F
   ```

2. Check the status of the Mirroring Controller process.

   As the instance administrator user, execute the mc_ctl command in status mode. Ensure that "mirroring status" is switchable.

   Example)

   ```
   $ mc_ctl status -M /mcdir/inst1
   ```

Note

- When the arbitration server is used for automatic degradation, the time required for the database server to connect to the arbitration server is added on. Therefore, Mirroring Controller startup may take longer than when the arbitration server is not used.
- If the parameter for heartbeat monitoring of operating systems or servers set by the abitration server is greater than parameter for heartbeat monitoring of operating systems and servers of the Mirroring Controller, the Mirroring Controller may fail to start. In this case, check the contents of the message notification and review the parameters for heartbeat monitoring of operating systems or servers for the arbitration server or Mirroring Controller.
- If the heartbeat_error_action parameter in *serverIdentifier*.conf is set to "message", even if automatic switch/disconnection is enabled and Mirroring Controller is started, only message output is performed when a heartbeat abnormality is detected during heartbeat monitoring of operating systems and servers - switch/disconnection is not performed.
- Mirroring Controller startup usually fails if the standby server is mistakenly started as the primary server or if the old primary server is not recovered after the switch and is then mistakenly started as the primary server. However, if the admin network is disconnected, then startup does not fail, and both servers may become primary servers. Therefore, ensure that the admin network is connected before starting Mirroring Controller.

Point

- The mc_ctl command fails if the Mirroring Controller arbitration process has not been started on the arbitration server when the arbitration server is used for automatic degradation. However, if the Mirroring Controller arbitration process cannot be started in advance, it can be started by specifying the --async-connect-arbiter option in the mc_ctl command.
- After Mirroring Controller is started, automatic switch/disconnection can be enabled or disabled using the enable-failover or disable-failover mode of the mc_ctl command.

2.6 Creating a User Command for a Database Server

This section explains how to create a user command for a database server.

The following user commands are called by Mirroring Controller management processes.

The user can create user commands as required.

Specify the user commands that were created for the parameters in the server configuration file of the database server. Refer to "A.4.1 Server Configuration File for the Database Servers" for information on these parameters.

User command types

- Fencing command

  This user command performs fencing if Mirroring Controller performs arbitration processing and determines that a database server is unstable.

- Arbitration command

  This user command performs arbitration processing in lieu of the arbitration server when there is no arbitration server.

- State transition commands

  These user commands are called when Mirroring Controller performs state transition of a database server.
  It includes the following types:

  - Post-switch command

    This user command is called after a promotion from standby server to primary server.

  - Pre-detach command

    This user command is called before the standby server is disconnected from a cluster system.
    If the pre-detach command is specified on both the primary server and standby server, it is called first on the standby server and then on the primary server.

    If the settings are configured to forcibly stop the instance on the standby server when the standby server is disconnected, the pre-detach command is called on the standby server and then the instance on the standby server is stopped.

  - Post-attach command

    This user command is called after the standby server has been attached to a cluster system.
    If the post-attach command is specified on both the primary server and standby server, it is called first on the primary server and then on the standby server.

Point

When the arbitration server is used for automatic degradation and the requirements can be satisfied using the fencing command on the arbitration server only, the fencing command on the database server is not required. In addition, if the requirements can be satisfied using the fencing command on the database server only, create a fencing command on the arbitration server for termination processing only (without implementation).

Table 2.5 Availability of user commands, and database server calling the command

User command	Operation when a heartbeat abnormality is detected using operating system or server heartbeat monitoring				Database server calling the command	
	Message output	Automatic degradation by arbitration server	Automatic degradation by arbitration command	Unconditional automatic degradation	Primary server	Standby server
Fencing command	Y (*1)	Y (*2)	R	N	Y	Y

User command	Operation when a heartbeat abnormality is detected using operating system or server heartbeat monitoring				Database server calling the command	
	Message output	Automatic degradation by arbitration server	Automatic degradation by arbitration command	Unconditional automatic degradation	Primary server	Standby server
Arbitration command	N	N	R	N	Y	Y
Post-switch command	Y	Y	Y	Y	Y	N
Pre-detach command	Y	Y	Y	Y	Y	Y (*3)
Post-attach command	Y	Y	Y	Y	Y	Y (*3)

R: Required

Y: Can be used

N: Cannot be used

*1: Called only when the mc_ctl command is used to execute forced switching or forced disconnection.

*2: Creation of a fencing command on a database server is optional, but it must be created on the arbitration server.

*3: If message output or unconditional automatic degradation is selected, this command is called only from the primary server.

Refer to "Appendix C User Commands" for information on the interface for each user command.

2.7 Confirming the Streaming Replication Status

Before performing the setup of the database multiplexing mode, ensure that the prerequisite streaming replication feature has been set up correctly.

Perform the following procedure:

1. On the primary server, ensure that single-row searches can be performed using the pg_stat_replication statistics view.

   An example output of the psql command is shown below.

   Example)

```
postgres=# select * from pg_stat_replication;
-[ RECORD 1 ]----+------------------------------
pid              | 10651
usesysid         | 10
usename          | fsep
application_name | standby
client_addr      | 192.0.2.210
client_hostname  |
client_port      | 55098
backend_start    | 2022-03-23 11:17:49.628793+09
backend_xmin     |
state            | streaming
sent_lsn         | 0/3000060
write_lsn        | 0/3000060
flush_lsn        | 0/3000060
replay_lsn       | 0/3000060
write_lag        |
flush_lag        |
replay_lag       |
```

```
sync_priority    | 1
sync_state       | sync
reply_time       | 2022-03-23 11:23:27.703366+09
```

2. Confirm the search results of step 1.

   Ensure that the connection established with the intended standby server is in synchronous mode.

   Table 2.6 Items to be checked

Item	Required value
application_name	Value specified for synchronous_standby_names parameter in the postgresql.conf file of the primary server.
client_addr	IP address of the standby server.
state	"streaming".
sync_state	"sync".

- Refer to "The Statistics Collector" in "Server Administration" in the PostgreSQL Documentation for information on the pg_stat_replication statistics view.
- Note that the pg_stat_replication statistics view may change in the future.

2.8 Checking the Connection Status

This section explains how to check the connection status from a database server or the arbitration server.

2.8.1 Checking the Connection Status on a Database Server

This section explains how to use a database server to check the connection status of the Mirroring Controller arbitration process and the Mirroring Controller process on the primary server and standby server.

Perform the following procedure:

1. On the primary server and standby server, execute the mc_ctl command in status mode with the --arbiter option specified.

   ```
   Example)
   The mc_ctl command is executed with the --arbiter option specified, and the status is output.
   ```

```
$ mc_ctl status --arbiter -M /mcdir/inst1

arbiter_id   host            status
--------------------------------------
arbiter      192.0.3.120     online
```

2. On the primary server and standby server, check the result displayed by executing the mc_ctl command in status mode in step 1.

   Items to be checked

   Check that the output status" is "online".

Refer to the Reference for information on the mc_ctl command.

2.8.2 Checking the Connection Status on the Arbitration Server

This section explains how to use the arbitration server to check the connection status of the Mirroring Controller arbitration process and the Mirroring Controller process on the primary server and standby server.

Perform the following procedure:

1. Execute the mc_arb command in status mode on the arbitration server.

   The example below executes the mc_arb command, and shows the status.

   Example)

```
$ mc_arb status -M /mcarb_dir/arbiter1

server_id    host            status
-------------------------------------
server1      192.0.3.100     online
server2      192.0.3.110     online
```

2. Check the result displayed by executing the mc_arb command in step 1.

   Items to be checked

   Check that the output status is "online" on both lines.

 See

Refer to the Reference for information on the mc_arb command.

2.9 Creating Applications

This section explains how to create applications using database multiplexing, and points that should be noted when you create the applications.

2.9.1 Application Connection Server Settings

If database multiplexing is used and a failover occurs, it will be necessary to switch the application connection server. Accordingly, use the application connection switch feature to create applications.

 See

Refer to "Application Connection Switch Feature" in the Application Development Guide for details.

2.10 Checking the Behavior

To check if the environment setup was performed correctly, start the application and then check the behavior of the switch and rebuild.

2.11 Tuning

This section explains how to tune database multiplexing mode.

2.11.1 Tuning to Stabilize the Database Multiplexing Mode

When large amounts of data are updated, the write-to load for the database will become great, and the multiplexing state may become unstable.

Accordingly, by editing the parameters below in the postgresql.conf file, a stable multiplexing state can be maintained. Refer to "Estimating Transaction Log Space Requirements" in the Installation and Setup Guide for Server for information on transaction log space requirements.

Table 2.7 Parameters

Parameter	Content
wal_keep_size	Refer to "2.4.2 Creating, Setting, and Registering the Primary Server Instance" for details.
max_wal_size	The transaction log is written out according to the checkpoint trigger. If a transaction log with the capacity of the value specified in this parameter is generated, the checkpoint will be executed. If a large value is specified in this parameter, the time required for crash recovery will increase. If a small value is specified in this parameter, many checkpoints will be generated, which will affect the performance of the applications that connect to the primary server.

2.11.2 Tuning to Stabilize Queries on the Standby Server

Queries made using reference jobs on the standby server may be canceled by jobs executed on the primary server.

To reduce the possibility of a job being canceled, specify as large a value as possible for the max_standby_archive_delay parameter in the postgresql.conf file.

See

- Refer to "Handling Query Conflicts" in the PostgreSQL Documentation for details.
- Refer to "Standby Servers" in the PostgreSQL Documentation for details on the max_standby_archive_delay parameter.

2.11.3 Tuning to Stabilize Queries on the Standby Server (when Performing Frequent Updates on the Primary Server)

If jobs are updated on the primary server regularly and frequently, it will be easy for the query made by the reference job on the standby server to be canceled. In this case, edit one of the postgresql.conf file parameters shown in the table below.

Table 2.8 Parameters

Parameter	Description
hot_standby_feedback	When "on" is set, the deletion (vacuum) of the data area that was deleted or updated on the primary server is suppressed. Accordingly, the query on the standby server will not be canceled. (*1)
vacuum_defer_cleanup_age	The deletion (vacuum) of the data area that was deleted or updated on the primary server is delayed until the specified number of transactions is processed. Accordingly, the probability that the query on the standby server will be canceled decreases.

*1: Because the vacuum is delayed, the data storage destination disk space of the primary server comes under pressure.
Additionally, if there is conflict between accesses and queries executed on the standby server, transaction logs indicating this conflict will be transferred.
Accordingly, specify as large a value as possible for the max_standby_archive_delay parameter so that access conflicts do not occur.

See

- Refer to "Standby Servers" in the PostgreSQL Documentation for details on the hot_standby_feedback parameter.
- Refer to "Primary Server" in the PostgreSQL Documentation for details on the vacuum_defer_cleanup_age parameter.

2.11.4 Tuning for Optimization of Degradation Using Abnormality Monitoring

Mirroring Controller uses a monitoring method that outputs an error if the timeout or number of retries is exceeded when accessing resources targeted for monitoring. Setting inappropriate values in these settings may lead to misdetection or a delay in automatic degradation, so you must design these values appropriately.

For example, the following type of issue occurs if the tuning related to abnormality monitoring is not performed appropriately.

- If the timeout is too short

  Results in redundant degradation and availability falls.

- If the timeout is too long

  It takes longer for automatic degradation to be performed even when an error affecting operational continuity occurs, potentially causing downtime.

You can optimize degrading operation by editing the values for the parameters in the server configuration file described below in accordance with the system. Refer to "A.4 Server Configuration File" for information on how to edit these parameters.

2.11.4.1 Tuning for Abnormality Monitoring of the Operating System or Server

Tuning for abnormal monitoring of the operating system or server depends on the operation when heartbeat abnormality is detected by the heartbeat monitoring of operating systems or servers.

See

Refer to "1.1.1 Monitoring Using Database Multiplexing Mode" for the operation when heartbeat abnormality is detected in the the heartbeat monitoring of operating systems or servers.

2.11.4.1.1 Tuning Abnormality Monitoring for Operations that Use an Arbitration Server for Automatic Degeneration

In an operation that use an arbitration server for automatic degeneration, the database server is periodically monitored for abnormalities so that the Mirroring Controller arbitration process can immediately respond to an arbitration request from the Mirroring Controller.The automatic degradation using the arbitration server can optimize the time from error detection to automatic degradation of the operating systems or servers by editing the following parameters.

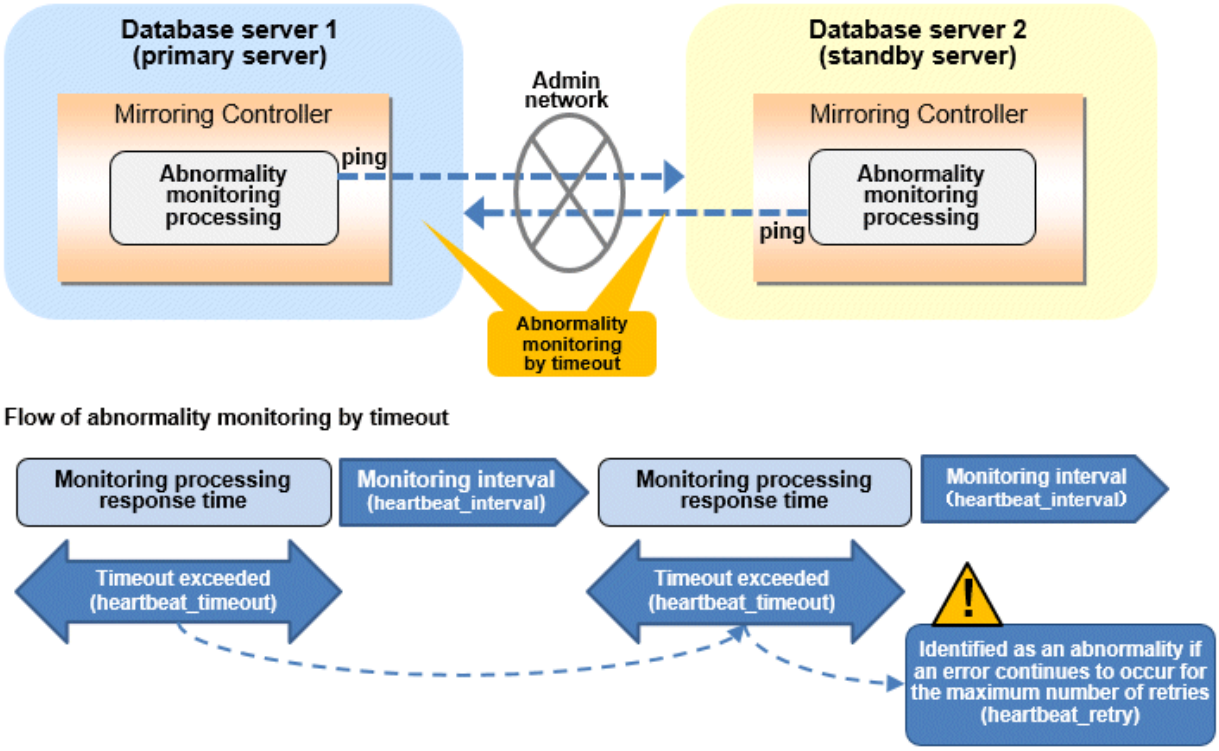
- Parameters for the abnormality monitoring of the operating system or server in the server configuration file of the database server
- Parameters for the abnormality monitoring of the operating system or server in the arbitration configuration file
- Parameters for the arbitration processing and fencing

Parameters for the abnormality monitoring of the operating system or server in the server configuration file of the database server

Table 2.9 Parameters for the abnormality monitoring of the operating system or server in the server configuration file of the database server

Parameter	Description
Abnormality monitoring interval (heartbeat_interval)	Mirroring Controller is configured so that abnormality monitoring does not place a load on the system. This parameter does not normally need to be set. (The default is 800 milliseconds.)
Abnormality monitoring timeout (heartbeat_timeout)	Take into account the time during which a load is placed continuously on the server or admin network performance. For example, it is envisaged that this parameter will be used in situations such as when performing high-load batch jobs or when a large number of online jobs occur continuously and concurrently. (The default is 1 second.)

Parameter	Description
Abnormality monitoring retries (heartbeat_retry)	This parameter can be set when needing a safety value for situations in which the value specified for heartbeat_timeout is exceeded, for example, when using systems with fluctuating loads, however, this parameter does not normally need to be set. (The default is 2 times.)



The expression for calculating the time required to detect an abnormality by Mirroring Controller is shown below.

```
Abnormality detection time of Mirroring Controller = ( heartbeat_timeout(seconds) +
heartbeat_interval(milliseconds) / 1000 ) x ( heartbeat_retry(number of times) + 1)
```

The abnormality detection time when the default value is used is shown below.

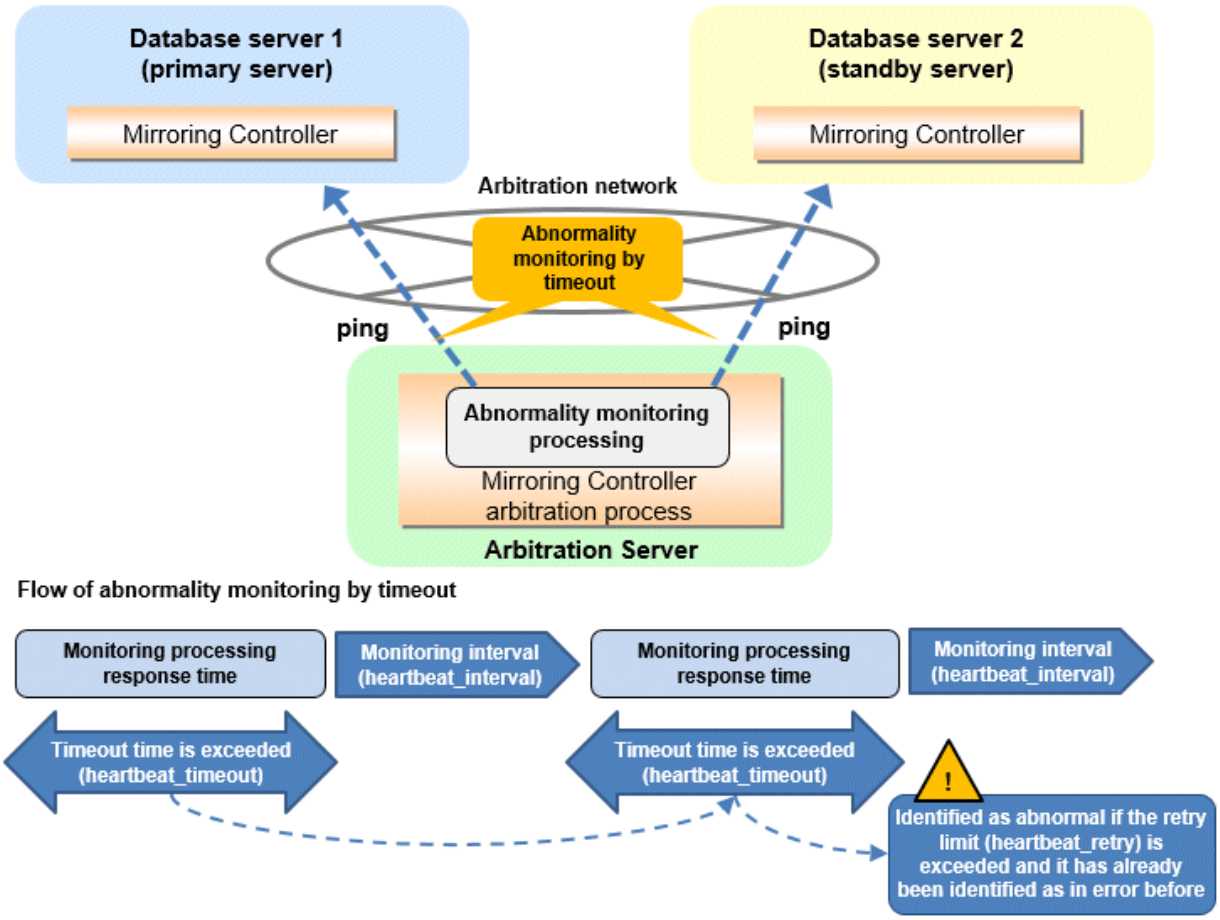
```
Abnormality detection time of Mirroring Controller = ( 1 + 800 / 1000 ) x ( 2 + 1 )
            = 5.4(seconds)
```

Parameters for the abnormality monitoring of the operating system or server in the arbitration configuration file

Table 2.10 Parameters for the abnormality monitoring of the operating system or server in the arbitration configuration file

Parameter	Description
Abnormality monitoring interval (heartbeat_interval)	Mirroring Controller arbitration process is configured so that abnormality monitoring does not place a load on the system. This parameter does not normally need to be set. (The default is the value set in heartbeat_interval in the server configuration file of the database server.) (milliseconds).
Abnormality monitoring timeout (heartbeat_timeout)	Take into account the time during which a load is placed continuously on the server and arbitration network capabilities. (The default is the value set in heartbeat_timeout in the server configuration file of the database server.) (seconds).

Parameter	Description
Abnormality monitoring retries (heartbeat_retry)	This parameter can be set when needing a safety value for situations in which the value specified for heartbeat_timeout is exceeded, for example, when using systems with fluctuating loads, however, this parameter does not normally need to be set. (The default is the value set in heartbeat_retry in the server configuration file of the database server.) (number of times)



The expression for calculating the time required to detect an abnormality by Mirroring Controller arbitration process is shown below.

```
Abnormality detection time of Mirroring Controller arbitration process = ( heartbeat_timeout(seconds)
+ heartbeat_interval(milliseconds) / 1000 ) x ( heartbeat_retry(number of times) + 1)
```

The abnormality detection time when the default value is used is shown below.

```
Abnormality detection time of Mirroring Controller arbitration process = ( 1 + 800 / 1000 ) x ( 2 + 1 )
            = 5.4(seconds)
```

Point

The abnormality detection time of the operation for automatic degradation using the arbitration server can be calculated as follows.

```
Abnormality detection time = Max(Abnormality detection time by Mirroring Controller, Abnormality
detection time by Mirroring Controller arbitration process)
```

Note

If the heartbeat_interval is set in the arbitration configuration file, the relationship between the parameter for operating system or server abnormality monitoring specified in the server configuration file of the database server file and the heartbeat_interval of the arbitration configuration file must satisfy the following relational expression.

```
 Heartbeat_interval in the arbitration configuration file (milliseconds) / 1000 ) <
( heartbeat_timeout(seconds) + heartbeat_interval(milliseconds) / 1000 ) * heartbeat_retry(number of
times) + heartbeat_timeout(seconds)
```

Parameters for the arbitration processing and fencing

Table 2.11 Parameters for the arbitration processing and fencing

Parameter	Description
Arbitration processing timeout (arbitration_timeout in the server configuration file of the database server)	Take into account the time to perform arbitration processing on the Mirroring Controller arbitration process. The value must be greater than or equal to abnormality detection time of Mirroring Controller arbitration process + fencing_command_timeout in the arbitration configuration file (seconds).
Fencing timeout (fencing_command_timeout in the arbitration configuration file)	Take into account the time to execute the fencing command (seconds).

Flow from the abnormality detection to the automatic degeneracy

When performing automatic degradation using the arbitration server, the flow from the abnormality detection in the operating system or server to the occurrence of automatic degeneracy and the parameters is shown below.

<table>
<tr><th>Flow from the abnormality detection to the automatic degeneracy</th><th>Description</th><th colspan="2">Parameter</th></tr>
<tr><td>(1) Abnormality detection</td><td>Mirroring Controller detect the database server operating system or server errors.</td><td colspan="2">Parameters for the abnormality monitoring of the operating system or server in the server configuration file of the database server</td></tr>
<tr><td>(2) Arbitration request</td><td>Mirroring Controller that detect the operating system or server error asks the Arbitration Server to check the status of the other server's operating system or server.</td><td>-</td><td rowspan="3">arbitration_timeout in the server configuration file of the database server</td></tr>
<tr><td>(3) Arbitration processing</td><td>The Mirroring Controller arbitration process checks the status of the other server's operating system or server. However, if the result of the operating system or server abnormality monitoring by the arbitration server has been determined before the arbitration request from the Mirroring Controller of the database server, this process is not performed.</td><td>Parameters for the abnormality monitoring of the operating system or server in the arbitration configuration file</td></tr>
<tr><td>(4) Fencing</td><td>If the Mirroring Controller arbitration process determines that the other server is an abnomaly of the operating system or server, it fences the other server and isolates it from the cluster system. If the Mirroring Controller arbitration process determines that the operating system or server</td><td>fencing_command_timeout in the arbitration configuration file</td></tr>
</table>

Flow from the abnormality detection to the automatic degeneracy	Description	Parameter	
	status is normal, this process and the (6) are not performed.		
(5) Return of the arbitration results	Returns the results of the arbitration to the Mirroring Controller of the database server that requested the arbitration.	-	
(6) Automatic degradation	The automatic degradation is performed. If fencing fails in (4), this procedure is not performed.	-	

-: No associated parameters

Note

If the fencing_command parameter is specified in the server configuration file of the database server, the fencing command is invoked on the database server if fencing is successful on the arbitration server. In that case, add the value of the fencing_command_timeout parameter in the server configuration file of the database server to the estimate.

Figure 2.1 When the Mirroring Controller on the primary server detects an operating system or server error

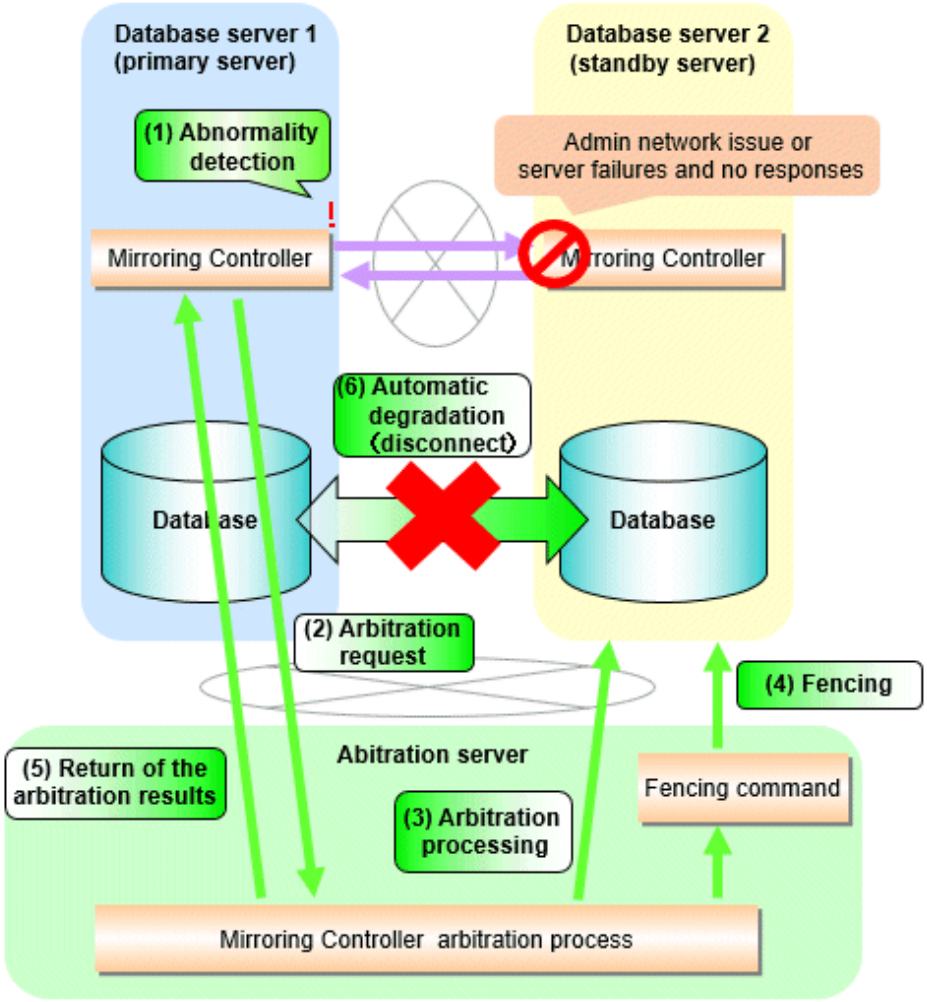
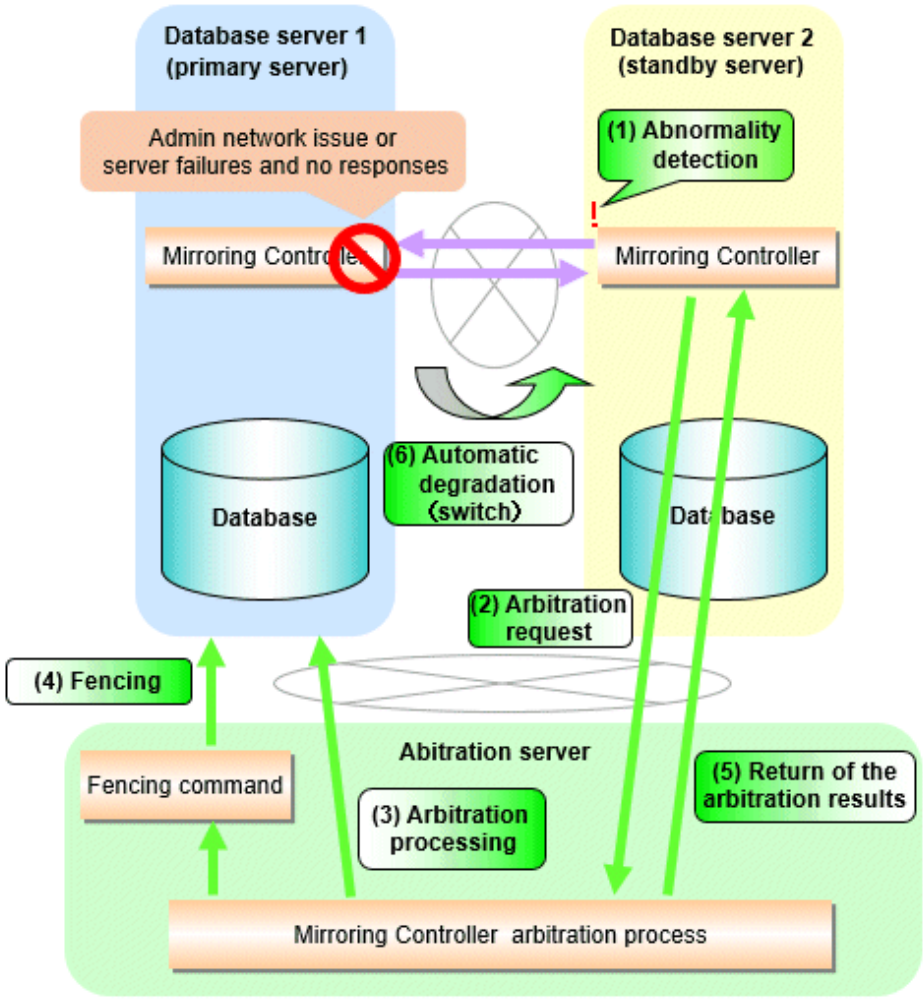


Figure 2.2 When the Mirroring Controller on the standby server detects an operating system or server error



2.11.4.1.2 Tuning Abnormality Monitoring for Operations that Perform Automatic Degeneration by Calling a User Command that Determines Degeneration

In an operation that perform automatic degeneration by calling a user command that determines degeneration, you can optimize the time from operating system or server abnormality detection to automatic degradation by editing the operating system or server abnormality monitoring parameters and parameters related to arbitration processing and fencing in the server configuration file of the database server. Refer to "Parameters for the abnormality monitoring of the operating system or server in the server configuration file of the database server" for information on the operating system or server abnormality monitoring parameters in the server configuration file of the database server.

Table 2.12 Parameters for the arbitration processing and fencing

Parameter	Description
Arbitration processing timeout (arbitration_command_timeout)	Take into account the time to execute the arbitration command(seconds).
Fencing timeout (fencing_command_timeout)	Take into account the time to execute the fencing command (seconds).

Flow from the abnormality detection to the automatic degeneracy

When performing automatic degradation by calling a user command that determines degeneration, the flow from the abnormality detection in the operating system or server to the occurrence of automatic degeneracy and the parameters is shown below.

Flow from the abnormality detection to the automatic degeneracy	Description	Parameter
(1) Abnormality detection	Mirroring Controller detect the database server operating system or server errors.	Parameters for the abnormality monitoring of the operating system or server in the server configuration file of the database server
(2) Arbitration processing	An arbitration command is executed to check the status of the other server's operating system or server.	arbitration_command_timeout in the server configuration file of the database server
(3) Fencing	If the operating system or server status of the other server is abnomal in (2), it fences the other server and isolates it from the cluster system. If the operating system or server status of the other server is nomal in (2), this process and (4) are not executed.	fencing_command_timeout in the server configuration file of the database server
(4) Automatic degradation	The automatic degradation is performed. If fencing fails in (3), this procedure is not performed.	-

-: No associated parameters

Figure 2.3 When the Mirroring Controller on the primary server detects an operating system or server error

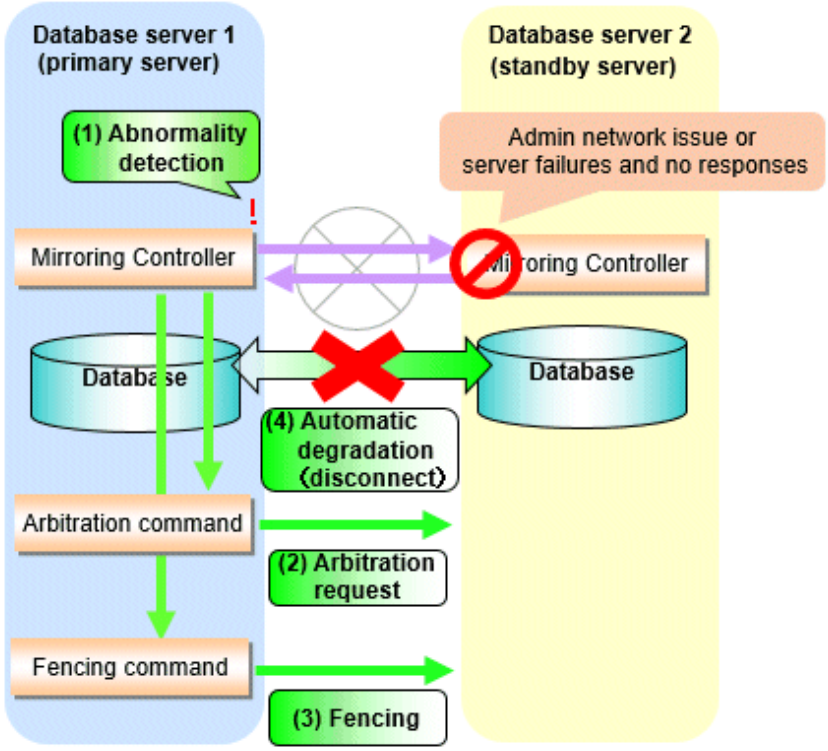
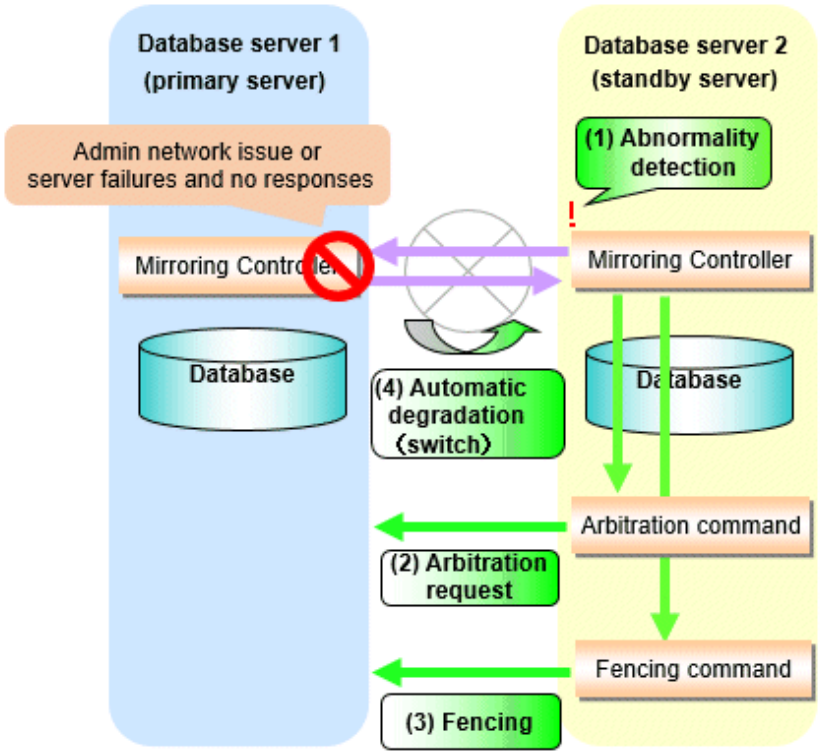


Figure 2.4 When the Mirroring Controller on the standby server detects an operating system or server error



2.11.4.1.3 Tuning Abnormality Monitoring for Operations that Notify Messages

In an operation that notify messages, you can optimize the abnormality detection time by editing the operating system or server abnormality monitoring parameters in the server configuration file of the database server. Refer to "Parameters for the abnormality monitoring of the operating system or server in the server configuration file of the database server" for information on the operating system or server abnormality monitoring parameters in the server configuration file of the database server. In addition, when the Mirroring Controller detects an error, it does not perform the arbitration processing, fencing, or automatic degradation, but only notification messages is performed.

2.11.4.1.4 Tuning Abnormality Monitoring for Operations that Perform Automatic Degenerate Unconditionally due to Heartbeat Abnormality

In an operation that perform automatic degenerate unconditionally due to heartbeat abnormality, you can optimize the time from operating system or server abnormality detection to automatic degradation by editing the operating system or server abnormality monitoring parameters in the server configuration file of the database server. Refer to "Parameters for the abnormality monitoring of the operating system or server in the server configuration file of the database server" for information on the operating system or server abnormality monitoring parameters in the server configuration file of the database server. In addition, when the Mirroring Controller detects an error, it does not perform the arbitration processing, fencing, or automatic degradation, but only automatic degenerate unconditionally is performed.

Note

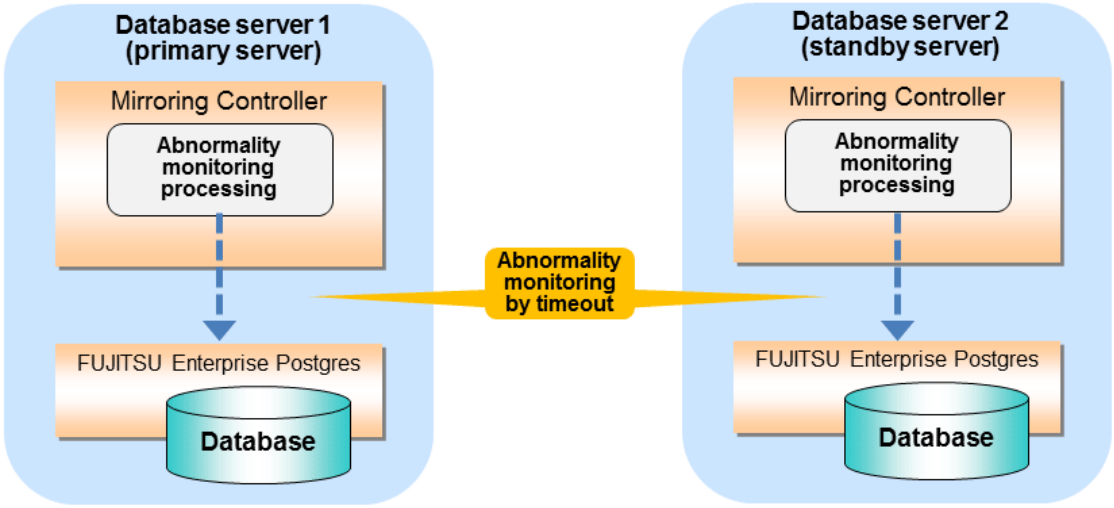
Refer to "Appendix D Notes on Performing Automatic Degradation Immediately after a Heartbeat Abnormality" for notes on the operation that perform automatic degenerate unconditionally due to heartbeat abnormality.

2.11.4.2 Tuning for Abnormality Monitoring of Darabase Processes

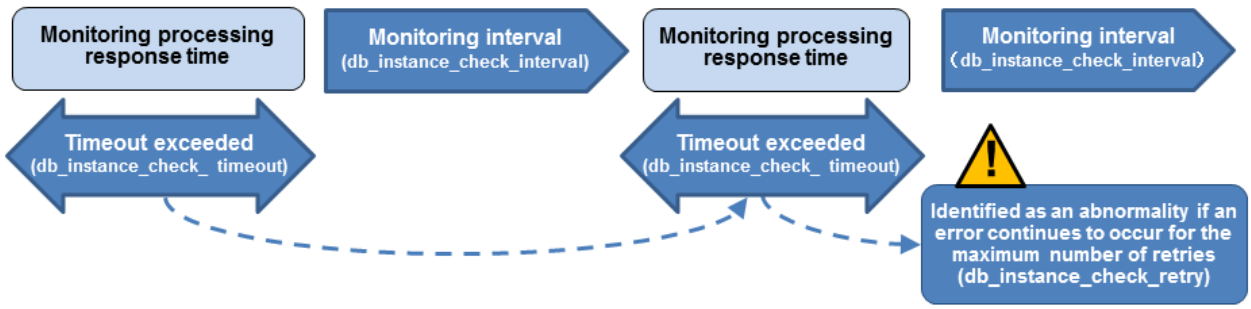
In an abnormality monitoring of database pocesses, you can optimize by editing the following parameters in the server configuration file of the database server.

Table 2.13 Parameters for abnormality monitoring of database processes

Parameter	Description
Abnormality monitoring interval (db_instance_check_interval)	Abnormality monitoring by Mirroring Controller is set so as not to place load on the system, but normally it does not need to be set. (The default is the value set in heartbeat_interval.) (milliseconds)
Timeout for abnormality monitoring of database processes (db_instance_check_timeout)	Take into account the time during which a load is placed continuously on the database. For example, it is envisaged that this parameter will be used in situations such as when performing high-load batch jobs or when a large number of online jobs occur continuously and concurrently. (The default is the value set in heartbeat_timeout.) (seconds)
Abnormality monitoring retries (db_instance_check_retry)	This parameter can be set when needing a safety value for situations in which the value specified for db_instance_check_timeout is exceeded, for example, when using systems with fluctuating loads, however, this parameter does not normally need to be set. (The default is the value set in heartbeat_retry.) (number of times)



Flow of abnormality monitoring by timeout



The expression for calculating the time required to detect an abnormality is shown below.

```
Abnormality detection time = ( db_instance_check_timeout(seconds) +
db_instance_check_interval(milliseconds) / 1000 ) x ( db_instance_check_retry(number of times) + 1 )
```

The abnormality detection time when the default value is used is shown below.

```
Abnormality detection time = ( 1 + 800 / 1000 ) x ( 2 + 1 )
             = 5.4(seconds)
```

Note

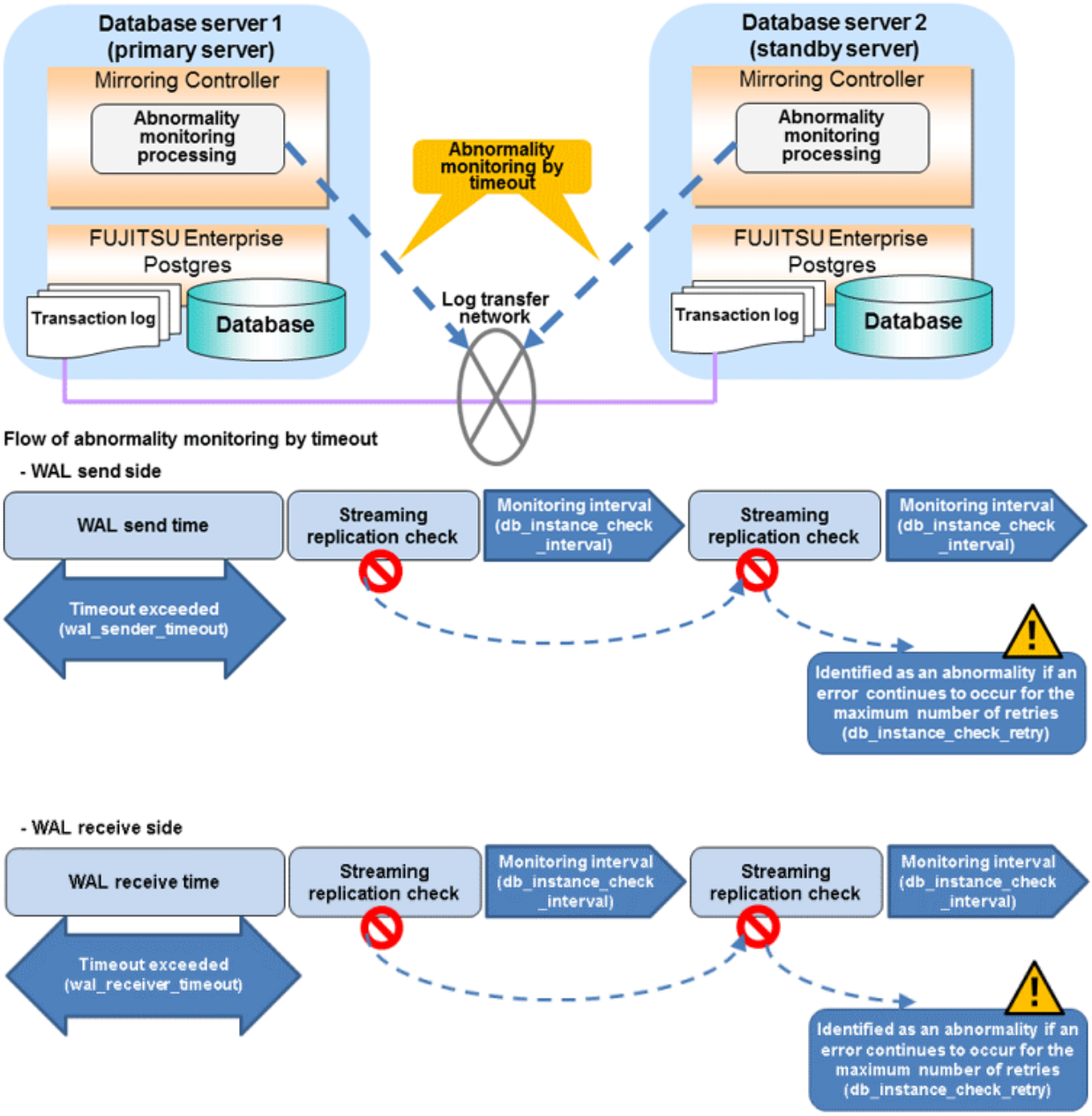
- If the db_instance_timeout_action parameter in *serverIdentifier*.conf is set to "message", and the db_instance_check_timeout parameter is set to a short value, a crash of the database process will be detected as "no response", and it may take time for automatic degradation to occur. Therefore, specify an appropriate timeout for db_instance_check_timeout.
- If a high load on the database and an event that prevents connection to an instance occur at the same time, it is judged as abnormal without retrying monitoring.

2.11.4.3 Tuning for Abnormality Monitoring of Streaming Replication

In an abnormality monitoring of streaming replication, you can optimize by editing the following parameters in the server configuration file of the database server.

Table 2.14 Parameters for abnormality monitoring of streaming replication

Parameter	Description
Abnormality monitoring interval (db_instance_check_interval)	Abnormality monitoring by Mirroring Controller is set so as not to place load on the system, but normally it does not need to be set. (The default is the value set in heartbeat_interval.) (milliseconds)
Abnormality monitoring retries (db_instance_check_retry)	This parameter can be set when needing a safety value, such as when it is anticipated that a temporary log transfer LAN error may occur, but it does not normally need to be set. (The default is the value set in heartbeat_retry.) (number of times)
Timeout for abnormality monitoring of streaming replication (wal_sender_timeout and wal_receiver_timeout in postgresql.conf)	Take into account the capacity and load of the log transfer network and the time during which a load is placed continuously on the database. For example, if there is a succession of data update jobs that generate a high WAL volume, you must configure the settings to avoid misdetection. (The default is 60 seconds.)



The expression for calculating the time required to detect an abnormality is shown below.

```
Abnormality detection time = ( wal_sender_timeout(seconds) +
db_instance_check_interval(milliseconds) / 1000 x ( disk_check_retry(number of times) + 1 ) )  Or,
            = ( wal_receiver_timeout(seconds) + db_instance_check_interval(milliseconds) / 1000 x
( disk_check_retry(number of times) + 1 ) )
```

The abnormality detection time when the default value is used is shown below.

```
Abnormality detection time = 60 + (800 / 1000 x (2 + 1))
            = 62.4(seconds)
```

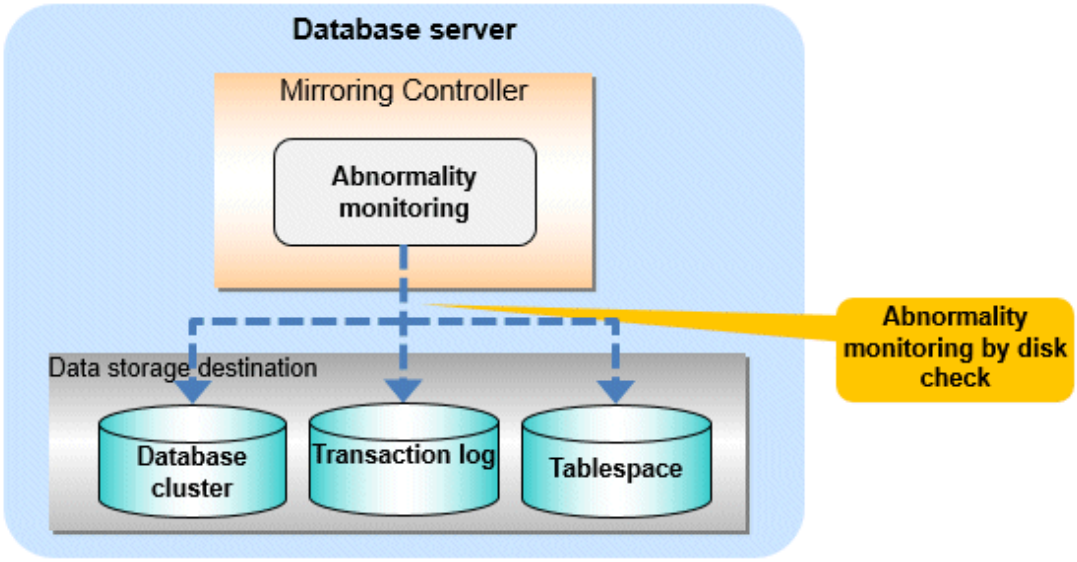
2.11.4.4 Tuning for Disk Abnormality Monitoring

In an abnormality monitoring of the disk, you can optimize by editing the following parameters in the server configuration file of the database server.

Table 2.15 Parameters for disk abnormality monitoring

Parameter	Description
Abnormality monitoring interval (disk_check_interval)	Abnormality monitoring by Mirroring Controller is set so as not to place load on the system. Set a value larger than the disk access time. (The default is the value set in heartbeat_interval.) (milliseconds)
Abnormality monitoring retries (disk_check_retry)	This parameter can be set when needing a safety value, such as when it is anticipated that a temporary disk input/output error may occur, but normally it does not need to be set. (The default is the value set in heartbeat_retry.) (number of times)
Abnormality monitoring timeout time (disk_check_timeout) (*1)	The time allowed from the start time of the next disk_check_interval after a disk error occurs until the error is determined to be due to timeout. (The default is 2147483.) (seconds). You can specify an integer between 0 and 2147483.
Upper limit on the number of threads used for abnormality monitoring (disk_check_max_threads) (*1)	Upper limit on the number of threads for disk monitoring. (The default is the number of processors available to the JVM.) You can specify an integer between 1 and 2147483647, but setting a value greater than the threads available on the machine may result in a system error. When you run the mc_ctl status command separately from the monitoring process, each mc_ctl status temporarily uses the same number of threads as the monitoring process. When setting disk_check_max_threads, consider the machine's thread limit, the number of tablespaces you plan to use, and the number of mc_ctl status commands that may be executed at the same time.

*1: Parameters available by applying bug fixes including PH23295.



In disk error monitoring, a disk check is performed, and degradation is performed when an error is first detected within the error detection time or the time set in disk_check_timeout. However, in order to disconnect the standby server when disk_check_timeout detects an error on the standby server, shutdown_detached_synchronous_standby must be set to on.

The expression for calculating the time required to detect an abnormality is shown below.

```
Abnormality detection time = disk_check_interval (milliseconds) / 1000 x ( disk_check_retry(number of times) + 1 )
```

The abnormality detection time when the default value is used is shown below.

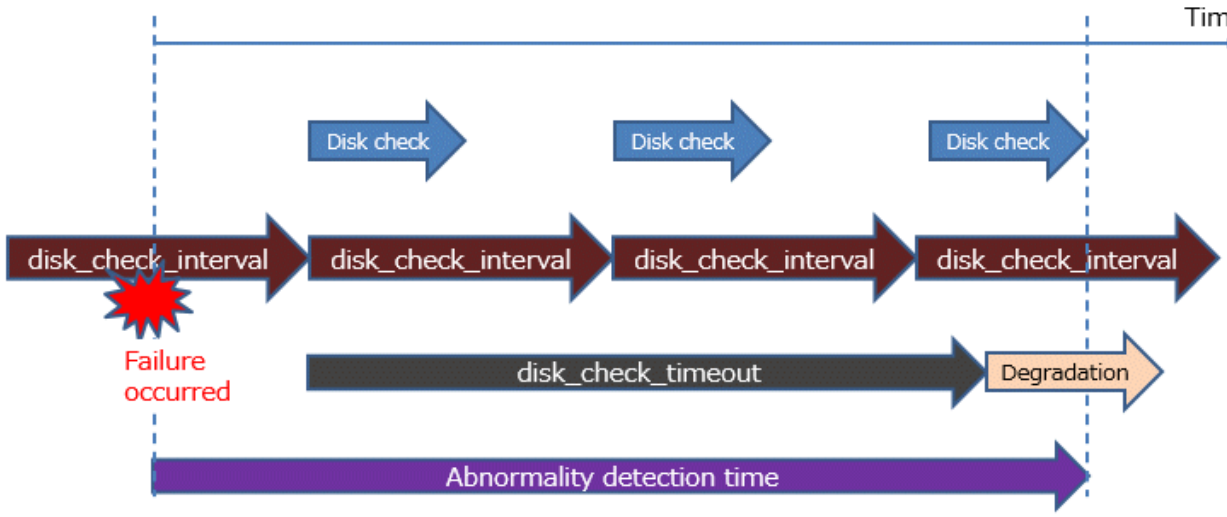
```
Abnormality detection time = 800 / 1000  x ( 2 + 1 )
            = 2.4(seconds)
```

An example of detecting disk abnormality monitoring is shown below.

Example 1)

One thread monitors one disk, set disk_check_retry = 2.

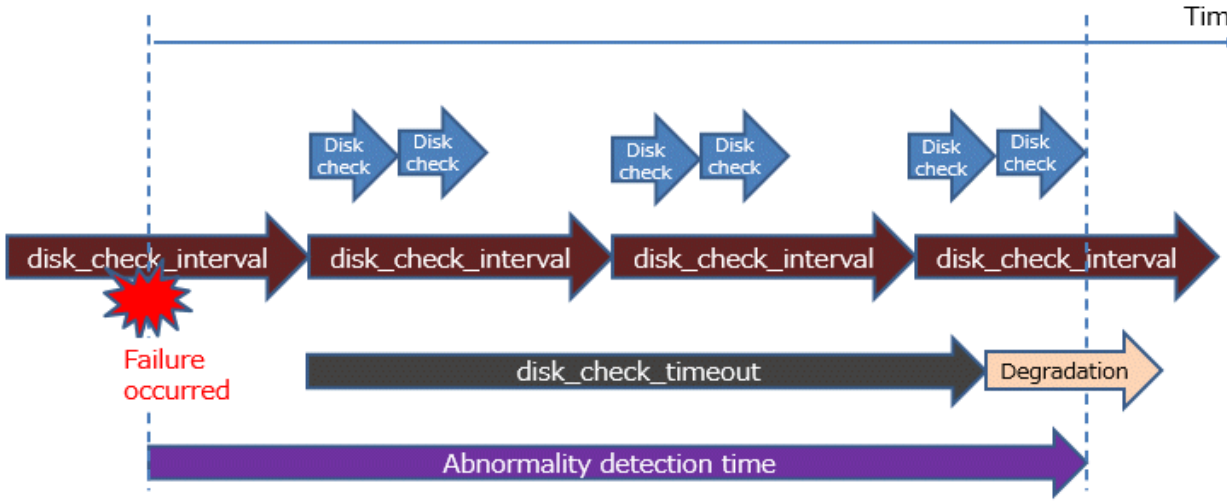
When the read or write cannot be completed within the disk access time because the response to the disk is slow.



Example 2)

One thread monitors two disks, set disk_check_retry = 2.

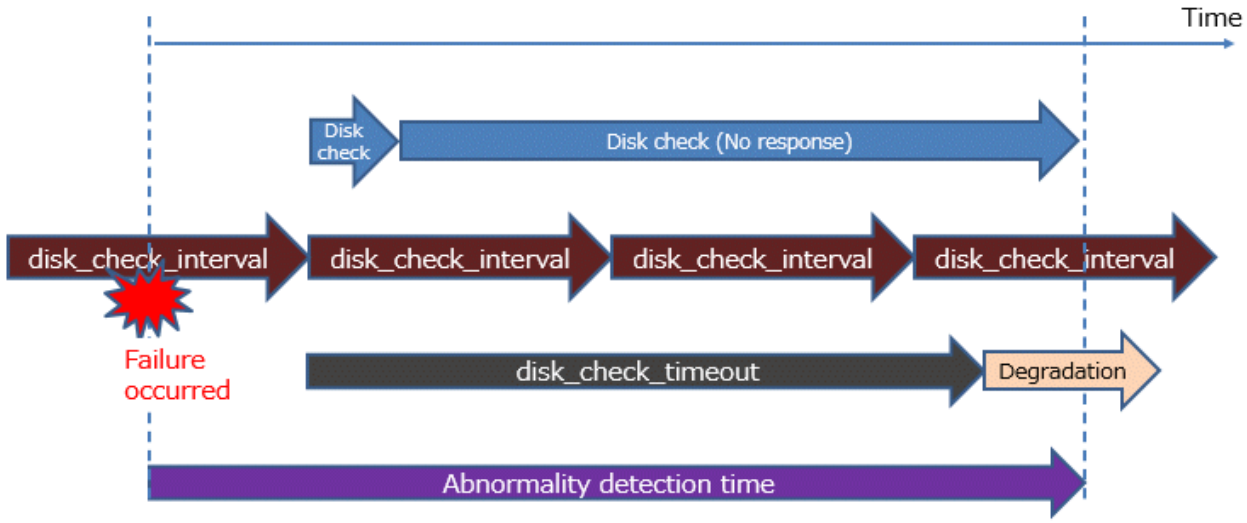
Due to the slow response to the disk, reading or writing to disk 1 could not be completed within the disk access time on the first and second attempts, but the reading or writing was successful on the third retry. All reads or writes to disk 2 fail within the disk access time.



Example 3)

One thread monitors two disks, set disk_check_retry = 2.

If disk 2 becomes unresponsive and monitoring results cannot be obtained within the timeout period.



Note

- The tuning described above impacts on the time taken from detection of a timeout until switching the primary server. Therefore, modify the values while taking into account the switch/disconnection time, using a design for which misdetection does not occur.
- Immediately selecting automatic degradation when a heartbeat abnormality occurs in operating system or server heartbeat monitoring risks causing split brain. Refer to "Appendix D Notes on Performing Automatic Degradation Immediately after a Heartbeat Abnormality" for details.

Information

Mirroring Controller uses connections to database instances and SQL access to monitor abnormality in some resources targeted for monitoring. The connection destination database names and connection user names used for abnormality monitoring conform to the parameters in the server configuration file. The application name is "mc_agent".

2.12 Setting Automatic Start and Stop of Mirroring Controller and Multiplexed Instances

Multiplexed instances and Mirroring Controller can be started and stopped automatically in line with the starting and stopping of the operating system of the database server.

Note

To guarantee the startup sequence of Mirroring Controller on the primary and standby servers, first confirm that the primary server has started, and then start the standby servers in sequence.

The startup sequence of the Mirroring Controller process on the database server and the Mirroring Controller arbitration process on the arbitration server is not guaranteed. If the arbitration server cannot be started first, execute the mc_ctl command in start mode with the --async-connect-arbiter option specified to start the Mirroring Controller process.

If you start the Mirroring Controller and multiplexed instances, wait for time correction, network setup, and so on.

Perform the following procedure:

1. Create a unit file

   Copy the unit file sample stored in the directory below, and revise it to match the target instance.

Sample file

```
/installDir/share/mcoi.service.sample
```

Example)

In the following example, the installation directory is "/opt/fsepv<x>server64", and the instance name is "inst1". Note that "<x>" indicates the product version.

```
# cp /opt/fsepv<x>server64/share/mcoi.service.sample /usr/lib/systemd/system/mcoi_inst1.service
```

Revise the underlined portions of the options below in the unit file.

Section	Option	Specified value	Description
Unit	Description	FUJITSU Enterprise Postgres MirroringController *instanceName*	Specifies the feature overview. Specifies the name of the target instance. (*1)
Service	ExecStart	/bin/bash -c '*installDir*/bin/mc_std start *installDir* *MirroringControllerManagementDir*' *mc_ctlOption*'	Command to be executed when the service is started. Specify the option you want to add when the mc_ctl command is executed without the -M option in the mc_ctl option. Note that the content specified in this mc_ctl option is carried over from the mc_std command to the mc_ctl command. (*2)
	ExecStop	/bin/bash -c '*installDir*/bin/mc_std stop *installDir* *MirroringControllerManagementDir*' *mc_ctlOption*'	Command to be executed when the service is stopped. Specify the option you want to add when the mc_ctl command is executed without the -M option in the mc_ctl option. However, to use the --mc-only option to stop only Mirroring Controller, you must use the --mc-only option at startup. Note that the content specified in this mc_ctl option is carried over from the mc_std command to the mc_ctl command.
	User	User	OS user account of the instance administrator user.
	Group	Group	Group to which the instance administrator user belongs.

*1: The instance name should be as nameThatIdentifiesTheInstance.
The naming conventions for identifying the instance are as follows:

- Up to 16 bytes
- The first character must be an ASCII alphabetic character
- The other characters must be ASCII alphanumeric characters

*2: When the arbitration server is used for automatic degradation, start the Mirroring Controller arbitration process on the arbitration server and then start the Mirroring Controller process on the database server. If the arbitration server cannot be started first, specify the --async-connect-arbiter option to start the Mirroring Controller process.

2. Enable automatic start and stop

   As the OS superuser, use the systemctl command to enable automatic start and stop.

   Example)

```
# systemctl enable mcoi_inst1.service
```

Note

If automatic start and stop of Mirroring Controller has been configured, to stop Mirroring Controller, do not use the mc_ctl command, but instead use the systemctl command as the OS superuser.

Example)

```
# systemctl stop mcoi_inst1.service
```

If the instance does not stop, refer to "Actions in Response to Failure to Stop an Instance" in the Operation Guide to stop the instance. Then, specify the -e option in the mc_ctl command to forcibly stop Mirroring Controller.

Example)

```
$ mc_ctl stop -M /mcdir/inst1 -e
```

If Mirroring Controller is stopped using the mc_ctl command, the message below is output to the system log, however there is no issue because automatic stop is executed by systemd.

Message

```
FATAL: failed to stop Mirroring Controller target server:"{0}" (MCA00043)
```

2.13 Setting Automatic Start and Stop of the Mirroring Controller Arbitration Process

You can automatically start or stop the Mirroring Controller arbitration process when the operating system on the arbitration server is started or stopped.

Note

If you start the Mirroring Controller arbitration process, wait for time correction, network setup, and so on.

Perform the following procedure:

1. Create a unit file.

   Copy the unit file sample stored in the directory below, and revise it to match the target instance.

   Sample file

   ```
   /installDir/share/mcarboi.service.sample
   ```

   Example)
   In the following example, the installation directory is "/opt/fsepv<x>assistant", and the identifier of the arbitration process is "arbiter1". Note that "<x>" indicates the product version.

   ```
   # cp /opt/fsepv<x>assistant/share/mcarboi.service.sample /usr/lib/systemd/system/
   mcarboi_arbiter1.service
   ```

   Revise the underlined portions of the options below in the unit file.

Section	Option	Specified value	Description
Unit	Description	FUJITSU Enterprise Postgres Mirroring Controller Arbiter <*arbitrationProcessId*>	Specifies the feature overview.

Section	Option	Specified value	Description
			Specifies the identifier of the targeted arbitration process. (*1)
Service	ExecStart	/bin/bash -c '*installDir*/bin/mc_arb_std start *installDir mirroringControllerArbitrationProcessMgmtDir mc_arbOption*'	Command to be executed when the service is started. Specify the option you want to add when the mc_arb command is executed without the -M option in the mc_arb option. Note that the content specified in this mc_arb option is carried over from the mc_arb_std command in "Specified value" to the mc_arb command.
	ExecStop	/bin/bash -c '*installDir*/bin/ mc_arb_std stop *installDir mirroringControllerArbitrationProcessMgmtDir mc_arbOption*'	Command to be executed when the service is stopped. Specify the option you want to add when the mc_arb command is executed without the -M option in the mc_arb option. Note that the content specified in this mc_arb option is carried over from the mc_arb_std command in "Specified value" to the mc_arb command.
	User	User	Specify the account of the operating system user.
	Group	Group	Specify the group to which the user belongs.

*1: The arbitration process identifier used here is a name for identifying the Mirroring Controller arbitration process.

The naming conventions for identifying the Mirroring Controller arbitration process are as follows:

- Up to 16 bytes
- The first character must be an ASCII alphabetic character
- The other characters must be ASCII alphanumeric characters

2. Enable automatic start and stop.

As the operating system superuser, use the systemctl command to enable automatic start and stop.

Example)

```
# systemctl enable mcarboi_arbiter1.service
```

2.14 Backup Operation

This section explains the backup operation for database multiplexing mode.

2.14.1 Backing up Database Multiplexing Mode Information

When changing the Mirroring Controller settings, in addition to backing up the database, back up the configuration file in the Mirroring Controller management directory so that the Mirroring Controller settings are not lost.

When the arbitration server is used for automatic degradation, also back up the configuration file in the Mirroring Controller arbitration process management directory.

2.14.2 Database Backup Operation

Using database multiplexing mode is the same as obtaining the backup data on the standby server as a safeguard against a disk failure. Note that all server disks may be corrupted due to some cause.

As a safeguard against this type of case, execute the pgx_dmpall command on the primary server to create the backup data.

However, it is not definite as to which server runs as the primary server, so ensure that the pgx_dmpall command is executed periodically on all servers, so that the backup data will be obtained. For example, create a script to obtain the backup data, and set it in the operation management software.

Point

When the pgx_dmpall command is executed on the standby server, it will not match the statuses, however the error message shown below will be output and return the value "1".

If a script that ignores only this type of error is executed on all servers, the backup data of the primary server can be obtained.

```
Error message
```

```
ERROR:recovery is in progress (10095)
```

Note

- Consider the possibility that the server that runs as the primary server may be destroyed alongside the backup data, so it is recommended to promote another server to become the primary server, and then back up the data on the new primary server without waiting for the next scheduled backup.
- Specify the same backup directory name for the primary and standby servers. If different backup directory names are specified, and recovery is performed using the backup data of the other server, the recovery cannot be performed correctly.

See

- Period backups allow shorter recovery time and reduction in disk usage. Refer to "Backing Up the Database" in the Operation Guide for details on the backup operation.
- Refer to "Chapter 4 Action Required when an Error Occurs in Database Multiplexing Mode" for details on recovery based on the backup data that was obtained using the pgx_dmpall command.

Chapter 3 Operations in Database Multiplexing Mode

This chapter describes the periodic operations that are performed when running database multiplexing mode.

The periodic operations are the same as the operations on a single server.

See

Refer to "Periodic Operations" in the Operation Guide for information on the periodic operations.

3.1 Starting and Stopping the Mirroring Controller Arbitration Process

This section describes how to start and stop the Mirroring Controller arbitration process.

3.1.1 Starting the Mirroring Controller Arbitration Process

While the Mirroring Controller arbitration process is in a stopped state, execute the mc_arb command in start mode to start the Mirroring Controller arbitration process.

Example)

```
$ mc_arb start -M /mcarb_dir/arbiter1
```

See

Refer to the Reference for information on how to specify the mc_arb command.

3.1.2 Stopping the Mirroring Controller Arbitration Process

While the Mirroring Controller arbitration process is running, execute the mc_arb command in stop mode to stop the Mirroring Controller arbitration process.

Example)

```
$ mc_arb stop -M /mcarb_dir/arbiter1
```

See

Refer to the Reference for information on how to specify the mc_arb command.

Note

- The arbitration server will be forcibly stopped when the service is stopped.
- Before shutting down the operating system on the arbitration server, either stop the Mirroring Controller on the primary server or standby server or shut down the operating system on the primary server or standby server.

3.2 Starting and Stopping Mirroring Controller

When database multiplexing mode is used, use the mc_ctl command to start and stop the instance and Mirroring Controller at the same time.

Do not start or stop the instance by itself.

Starting Mirroring Controller

While Mirroring Controller is in a stopped state, execute the mc_ctl command in start mode to start Mirroring Controller.

Enabling automatic switch/disconnection

Execute the mc_ctl command in start mode.

```
Example)
```

```
$ mc_ctl start -M /mcdir/inst1
```

When only the instance is started and stopped, the following will happen:

- When only the instance is started

  Features such as automatic switch and automatic disconnection will not work until Mirroring Controller is started.

- When only the instance is stopped

  Mirroring Controller determines that an error has occurred in the instance, and performs an unnecessary automatic switch.

  Automatic switch may also stop working correctly in some cases.

Disabling automatic switch/disconnection

Execute the mc_ctl command in start mode with the -F option specified.

```
Example)
```

```
$ mc_ctl start -M /mcdir/inst1 -F
```

When only the instance is started and stopped, the following will happen:

- When only the instance is started

  Errors indicated in "1.1 What is Database Multiplexing Mode" will not be detected until Mirroring Controller is started.

- When only the instance is stopped

  Mirroring Controller determines that an error has occurred in the instance, and outputs an error to the system log.

Point

- To start the Mirroring Controller process only, execute the mc_ctl command in start mode with the --mc-only option specified.
- After Mirroring Controller is started, automatic switch/disconnection can be enabled or disabled using the enable-failover or disable-failover mode of the mc_ctl command.
- When the arbitration server is used for automatic degradation, the Mirroring Controller process startup fails on the database server if the Mirroring Controller arbitration process has not been started on the arbitration server in advance. However, even if the Mirroring Controller arbitration process cannot be started in advance, the Mirroring Controller process can be started by specifying the --async-connect-arbiter option in the mc_ctl command.

Note

- When the arbitration server is used for automatic degradation, the database server must connect to the arbitration server, and as a result, Mirroring Controller startup may take longer.
- Mirroring Controller startup usually fails if the standby server is mistakenly started as the primary server or if the old primary server is not recovered after the switch and is then mistakenly started as the primary server. However, if the admin network is disconnected,

then startup does not fail, and both servers may become primary servers. Therefore, ensure that the admin network is connected before starting Mirroring Controller.

Stopping Mirroring Controller

While Mirroring Controller is running, execute the mc_ctl command in stop mode to stop Mirroring Controller process.

Example)

```
$ mc_ctl stop -M /mcdir/inst1
```

Point

To stop the Mirroring Controller process only, execute the mc_ctl command in stop mode with the --mc-only option specified.

Note

To prevent an unintended automatic switch, before shutting down the operating system on the primary server, you must stop the Mirroring Controller, or shut down the operating system on the standby server.

See

Refer to the Reference for information on how to specify the mc_ctl command.

3.3 Checking the Database Multiplexing Mode Status

3.3.1 Checking the Status of the Database Server

This section describes how to check the status of the database server.

Check the multiplexed database status by executing the mc_ctl command in status mode.

Additionally, errors can be detected by monitoring the Mirroring Controller messages. If the status or messages are monitored periodically, you can react quickly following an automatic switch failure.

Checking the status of the multiplexing database

When the mc_ctl command is executed, the details of the multiplexing configuration, information about whether switch is possible following the error, and location and details of the error that caused the switch or disconnection are displayed.

After starting database multiplexing mode, execute the mc_ctl command in status mode to check the multiplexing status.

An example of the status displayed when the mc_ctl command is executed is shown below.

Example)

```
$ mc_ctl status -M /mcdir/inst1

mirroring status
----------------
switchable
server_id  host_role       host            host_status  db_proc_status       disk_status
-------------------------------------------------------------------------------------------
----
server1    primary         192.0.2.100     normal       normal                 normal
server2    standby         192.0.2.110     normal       normal                 normal
```

Checking the status of connection to the Mirroring Controller arbitration process

When the arbitration server is used for automatic degradation, the status of the connection to the Mirroring Controller arbitration process can be checked by specifying the --arbiter option. If the output status is "online", it indicates that an arbitration request can be made from the database server to the arbitration server. When the arbitration server is used for automatic degradation, regularly execute the command in status mode with the --arbiter option specified and check that the output status is "online".

Example)
The mc_ctl command is executed with the --arbiter option specified, and the status is output.

```
$ mc_ctl status --arbiter -M /mcdir/inst1

arbiter_id   host            status
-------------------------------------
arbiter      192.0.3.120     online
```

Checking the status of data synchronization

Additionally, by referencing the pg_stat_replication statistics view on the primary server, the data synchronization status can be confirmed. However, when creating the monitoring program, note that the content of pg_stat_replication may be changed in the future.

The following example shows that the locations of the transaction log after it is sent and received (sent_lsn, replay_lsn) match, and that they are fully synchronized.

Example)

```
postgres=# select * from pg_stat_replication;
-[ RECORD 1 ]----+------------------------------
pid              | 10651
usesysid         | 10
usename          | fsep
application_name | standby
client_addr      | 192.0.2.210
client_hostname  |
client_port      | 55098
backend_start    | 2022-03-23 11:17:49.628793+09
backend_xmin     |
state            | streaming
sent_lsn         | 0/3000060
write_lsn        | 0/3000060
flush_lsn        | 0/3000060
replay_lsn       | 0/3000060
write_lag        |
flush_lag        |
replay_lag       |
sync_priority    | 1
sync_state       | sync
reply_time       | 2022-03-23 11:23:27.703366+09
```

See

- Refer to "mc_ctl" in Reference for information on the command.
- Refer to "Notes on Application Compatibility" in the Application Development Guide for information on retaining application compatibility.
- Refer to "The Statistics Collector" in "Server Administration" in the PostgreSQL Documentation for details on pg_stat_replication.

3.3.2 Checking the Status of the Arbitration Server

This section describes how to check the status of the arbitration server.

The status of the connection between the Mirroring Controller arbitration process and primary server/standby server can be checked by executing the mc_arb command in status mode.

The example below executes the mc_arb command, and shows the status.

Example)

```
$ mc_arb status -M /mcarb_dir/arbiter1

server_id    host            status
-------------------------------------
server1      192.0.3.100     online
server2      192.0.3.110     online
```

3.4 Manually Switching the Primary Server

The primary server cannot be switched automatically in the following case:

- If automatic switch/disconnection is disabled
- If output of messages is selected for heartbeat abnormalities during heartbeat monitoring of the operating system or server and the operating system/server crashes or becomes unresponsive

In this case, to manually switch the primary server, execute the mc_ctl command in switch mode on either the primary server or the standby server.

Example)

```
$ mc_ctl switch -M /mcdir/inst1
```

Point

If automatic switch/disconnection is enabled, it is possible to perform switch of primary server at any time.

3.5 Manually Disconnecting the Standby Server

The procedure to perform disconnection of the standby server differs depending on whether the automatic switch/disconnection is enabled or disabled.

If automatic switch/disconnection is enabled

Execute the mc_ctl command in stop mode on the standby server.

Example)

```
$ mc_ctl stop -M /mcdir/inst1
```

If automatic switch/disconnection is disabled

1. Execute the mc_ctl command in stop mode on the standby server.

   Example)

   ```
   $ mc_ctl stop -M /mcdir/inst1
   ```

2. Comment out the synchronous_standby_names parameter in the postgresql.conf file on the primary server.
3. Execute the pg_ctl command in reload mode on the primary server.

   Example)

   ```
   $ pg_ctl reload -D /database/inst1
   ```

Point

If automatic start and stop of Mirroring Controller has been configured using systemd, do not use the mc_ctl command, but instead use the systemctl command. Refer to "2.12 Setting Automatic Start and Stop of Mirroring Controller and Multiplexed Instances" for details.

3.6 Action Required when a Heartbeat Abnormality is Detected

The message below is output when a heartbeat abnormality is detected during heartbeat monitoring of operating systems or servers:

```
detected an error on the monitored object "server(server identifier name)": no response:ping timeout
(MCA00019)
```

If the heartbeat_error_action parameter in *serverIdentifier*.conf is set to "message", even if automatic switch/disconnection is enabled and Mirroring Controller is started, automatic switch/disconnection is not performed when a heartbeat abnormality is detected. Therefore, user action will be necessary.

This section explains the action required when the heartbeat_error_action parameter is set to "message" and a heartbeat abnormality is detected.

1. Identify the cause of the heartbeat abnormality. The possible causes are below:
   - The remote operating system or server crashed or is unresponsive
   - An admin network issue occurred
2. Address the cause identified in step 1.
   - The remote operating system or server crashed or is unresponsive

     Manually perform switch or disconnection using the mc_ctl command.
   - An admin network issue occurred

     Refer to "Chapter 4 Action Required when an Error Occurs in Database Multiplexing Mode", and recover the database multiplexing system.

3.7 Monitoring Mirroring Controller Messages

The messages that are output by Mirroring Controller are output to both the database server and the arbitration server. If the automatic switch fails, for example, an important message related to the continuation of the operation may be output, so ensure that the system log messages are monitored.

If the arbitration server is used for automatic degradation, monitor messages on both the database server and the arbitration server.

Message output destination on the database server

Messages are output to the system log.

Message output destination on the arbitration server

Messages are output to the system log.

Point

- To monitor message types considered to be important, an operating system setting must be configured beforehand. Refer to the operating system manuals, check if the message is of a message type that is monitored to be output to the system log, and configure the setting if required.
- If the heartbeat_error_action parameter in *serverIdentifier*.conf is set to "message", only message output is performed when a heartbeat abnormality is detected during heartbeat monitoring of operating systems and servers - automatic switch/disconnection is not performed. Therefore users need to monitor the messages. Refer to "3.6 Action Required when a Heartbeat Abnormality is Detected" for details.

Display format on the database server

```
programName[processId]: messageType:messageText (messageNumber)
```

Specify the program name in the syslog_ident parameter of the serverIdentifier.*conf* file of the database server.

The message types output by Mirroring Controller, their severity, and their corresponding value in the system log are shown in the table below.

Table 3.1 Message type, severity, and corresponding value in the system log

Message type	Severity	Meaning	System log
INFO	Information	Provides information that does not fall under LOG or NOTICE.	INFO
LOG		Provides information recognized as a particularly important event in tracing the operation history. (Example: Automatic switch is complete)	
NOTICE	Notice	Outputs information that takes into account the user instructions within the program in response to an executed or automatically executed process.	NOTICE
WARNING	Warning	Provides a warning, for example it will soon be impossible to maintain the multiplexing state.	WARNING
ERROR	Error	Reports that an error other than FATAL or PANIC has occurred.	ERROR
FATAL		Reports that an abnormality was detected in multiplexed database systems requiring recovery of the system, and also the content and cause of the abnormality.	CRIT
PANIC		Reports that an abnormality was detected in all multiplexed database systems requiring immediate recovery of the system, and also the content and cause of the abnormality.	ALERT

The message severity has the following meanings:

- Information

  Informational status. A message that was reported by the system is displayed. No action is required.

- Notice

  Informational status, but a message that should be noted is displayed. If necessary, take the actions described in the "Action" section of the message.

- Warning

  No error has occurred, but the user is requested to check, and take action. Take the actions described in the "Action" section of the message.

- Error

  An error has occurred. Take the actions described in the "Action" section of the message.

Display format on the arbitration server

```
programName[processId]: messageType: messageText (messageNumber)
```

Specify the program name in the syslog_ident parameter of the arbitration.conf file of the arbitration server.

The message types output by Mirroring Controller, their severity, and their corresponding value in the output destination log are shown in the table below.

Table 3.2 Message type, severity, and corresponding value in the output destination log

Message type	Severity	Meaning	System log
INFO	Information	Provides information not categorized as LOG or NOTICE.	INFO
LOG		Provides information recognized as a particularly important event in tracing the operation history. (Example: Automatic switch is complete)	
NOTICE	Notice	Outputs information that takes into account the user instructions within the program in response to an executed or automatically executed process.	NOTICE
WARNING	Warning	Provides a warning, for example it will soon be impossible to perform the arbitration process.	WARNING
ERROR	Error	Reports that an error other than FATAL or PANIC has occurred.	ERROR
FATAL		Reports that an abnormality was detected in the arbitration server requiring recovery of the system, and also the content and cause of the abnormality.	CRIT
PANIC		Reports that an abnormality was detected in the arbitration server requiring immediate recovery of the system, and also the content and cause of the abnormality.	ALERT

The message severity has the following meanings:

- Information

  Informational status. A message that was reported by the system is displayed. No action is required.

- Notice

  Informational status, but a message that should be noted is displayed. If necessary, take the actions described in the "Action" section of the message.

- Warning

  No error has occurred, but the user is requested to check, and take action. Take the actions described in the "Action" section of the message.

- Error

  An error has occurred. Take the actions described in the "Action" section of the message.

3.8 Server Maintenance

To perform maintenance tasks such as periodic server inspections and the application of updates for software products including the operating system, you must perform a planned stop of the server, and then perform the maintenance.

3.8.1 Rolling Updates

In database multiplexing mode, rolling updates, that perform the maintenance for the servers that comprise the cluster system, can be performed while jobs continue.

First, perform the maintenance for the standby server, and then switch the standby server to the primary server. Then, perform the maintenance for the original primary server that was switched to the standby server. This enables maintenance to be performed while jobs continue.

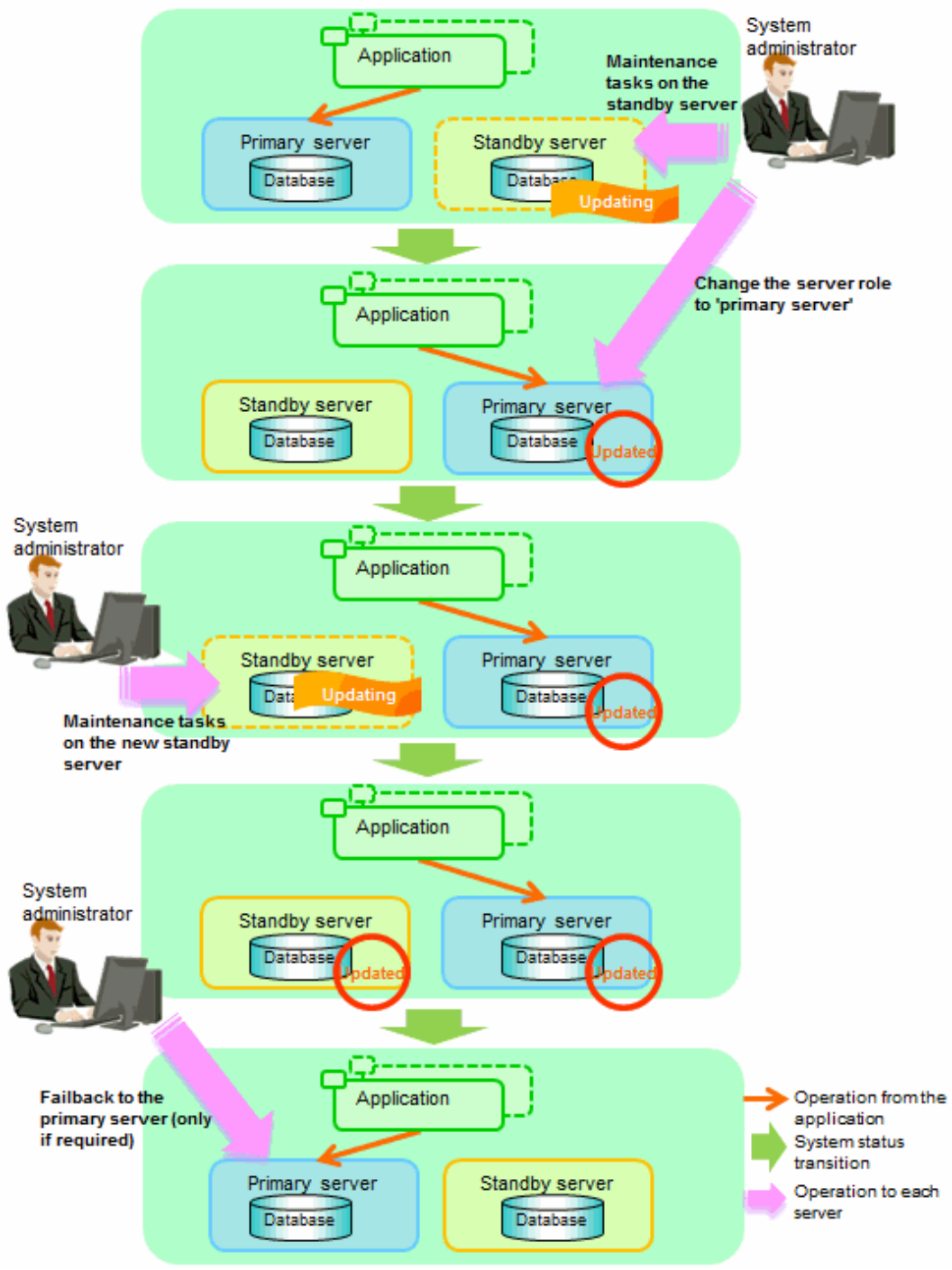
Note that arbitration server maintenance can be performed without affecting database server operation, so it is not necessary to consider rolling update.

See

If the downtime due to the maintenance of the standby server is expected to be long, refer to "Standby server downtime" in "3.9.1 Changes Required when the Standby Server is Stopped".

The flow of a rolling update is shown below.

Figure 3.1 Performing a Rolling Update



Perform the following procedure as shown in the above figure:

Standby server maintenance tasks

1. To perform the maintenance on the standby server, stop Mirroring Controller.

   Example)

   ```
   $ mc_ctl stop -M /mcdir/inst1
   ```

2. Ensure that Mirroring Controller has completely stopped.

   If the multiplexed instances and Mirroring Controller have been configured on the standby server to start and stop automatically when the operating system of the database server is started or stopped, cancel the setting to start and stop automatically.

   See

   Refer to "2.12 Setting Automatic Start and Stop of Mirroring Controller and Multiplexed Instances" for information on how to configure the multiplexed instances and Mirroring Controller to start and stop automatically when the operating system of the database server start and stops.

   As the OS superuser, execute the systemctl command to disable automatic start and stop.

   The example below disables automatic start and stop of "mcoi_inst1.service".

   Example)

   ```
   # systemctl disable mcoi_inst1.service
   ```

3. Perform maintenance tasks.

4. Create a copy of the primary server instance on the standby server.

   Execute the pg_basebackup command to create data in the standby server by synchronizing with the primary server.

   Example)

   ```
   $ pg_basebackup -D /database/inst1 -X fetch --waldir=/transaction/inst1 --progress --verbose -R
   --dbname='application_name=standbyServerName' -h primaryServerHostName -p
   primaryServerPortNumber
   ```

   See

   The procedure for copying the primary server instance to the standby server is the same as the procedure for setting up the standby server.

   Refer to "2.5.2 Creating, Setting, and Registering the Standby Server Instance", and then perform the recovery.

5. Check the settings for automatic start and stop of the multiplexed instances and Mirroring Controller.

   If the multiplexed instances and Mirroring Controller were configured in step 2 to not start and stop automatically when the operating system of the database server starts and stops, then change the settings back. This step can be skipped if automatic start and stop are not required.

   As the OS superuser, execute the systemctl command to enable automatic start and stop.

   The example below disables automatic start and stop of "mcoi_inst1.service".

   Example)

   ```
   # systemctl enable mcoi_inst1.service
   ```

6. Start (rebuild) Mirroring Controller on the standby server.

   This operation is required when determining the maintenance tasks on the standby server.

Enabling automatic switch/disconnection

As the instance administrator user, execute the mc_ctl command in start mode.

Example)

```
$ mc_ctl start -M /mcdir/inst1
```

Disabling automatic switch/disconnection

As the instance administrator user, execute the mc_ctl command in start mode with the -F option specified.

Example)

```
$ mc_ctl start -M /mcdir/inst1 -F
```

Point

After Mirroring Controller is started, automatic switch/disconnection can be enabled or disabled using the enable-failover or disable-failover mode of the mc_ctl command.

Switching to the primary server

To perform the maintenance on the primary server, execute the mc_ctl command in the switch mode on the primary server or the standby server.

Example)

```
$ mc_ctl switch -M /mcdir/inst1
```

When the switch is complete, the synchronous_standby_names parameter in the postgresql.conf file of the new primary server will be commented as follows:

Example)

```
#synchronous_standby_names = 'primary'
```

New standby server maintenance tasks

1. Stop the Mirroring Controller.

   On the new standby server (the primary server before the switch), execute the mc_ctl command in stop mode.

   If automatic start and stop of Mirroring Controller has been configured using systemd, do not use the mc_ctl command, but instead use the systemctl command. Refer to "2.12 Setting Automatic Start and Stop of Mirroring Controller and Multiplexed Instances" for details.

   Example)

   ```
   $ mc_ctl stop -M /mcdir/inst1
   ```

2. Ensure that Mirroring Controller has completely stopped.

   If the multiplexed instances and Mirroring Controller have been configured on the new standby server to start and stop automatically when the operating system of the database server is started or stopped, cancel the setting to start and stop automatically now.

See

Refer to "2.12 Setting Automatic Start and Stop of Mirroring Controller and Multiplexed Instances" for information on how to configure the multiplexed instances and Mirroring Controller to start and stop automatically when the operating system of the database server starts and stops.

As the OS superuser, execute the systemctl command to disable automatic start and stop.

The example below disables automatic start and stop of "mcoi_inst1.service".

Example)

```
# systemctl disable mcoi_inst1.service
```

3. Perform the maintenance on the new standby server that was stopped.
4. Create a copy of the new primary server instance on the new standby server.

   Execute the pg_basebackup command to create data in the new standby server by synchronizing with the new primary server.

   Example)

```
$ pg_basebackup -D /database/inst1 -X fetch --waldir=/transaction/inst1 --progress --verbose -R
--dbname='application_name=standbyServerName' -h primaryServerHostName -p
primaryServerPortNumber
```

See

The procedure for copying the primary server instance to the standby server is the same as the procedure for setting up the standby server.

Refer to "2.5.2 Creating, Setting, and Registering the Standby Server Instance", and then perform the recovery.

5. Check the settings for automatic start and stop of the multiplexed instances and Mirroring Controller.

   If the multiplexed instances and Mirroring Controller were configured in step 2 to not start and stop automatically when the operating system of the database server starts and stops, then change the settings back. This step can be skipped if automatic start and stop are not required.

   As the OS superuser, execute the systemctl command to enable automatic start and stop.

   The example below disables automatic start and stop of "mcoi_inst1.service".

   Example)

```
# systemctl enable mcoi_inst1.service
```

6. After the maintenance is complete, edit the following parameters in the postgresql.conf file of the standby server as required.

   Copying an instance results in the value of the synchronous_standby_names parameter becoming the specified value on the primary server. Therefore, correct it to the specified value on the standby server. If the parameter was commented out, then you must uncomment it.

7. On the standby server, start (rebuild) Mirroring Controller.

   Enabling automatic switch/disconnection

   As the instance administrator user, execute the mc_ctl command in start mode.

   Example)

```
$ mc_ctl start -M /mcdir/inst1
```

   Disabling automatic switch/disconnection

   As the instance administrator user, execute the mc_ctl command in start mode with the -F option specified.

   Example)

```
$ mc_ctl start -M /mcdir/inst1 -F
```

Point

After Mirroring Controller is started, automatic switch/disconnection can be enabled or disabled using the enable-failover or disable-failover mode of the mc_ctl command.

Failback of the Primary Server

Revert the primary server and standby server to the original server configuration. Do this to execute the main job on the previous primary server. Refer to "4.1.1.3 Failback of the Primary Server" for details.

Note

Obtain a backup as soon as this task is complete.

3.8.2 Stopping for Maintenance

Perform this procedure to stop all servers for periodic inspections, for example. On the server on which Mirroring Controller is running, execute the mc_ctl command in stop mode to stop the instance and Mirroring Controller.

If automatic start and stop of Mirroring Controller has been configured using systemd, do not use the mc_ctl command, but instead use the systemctl command. Refer to "2.12 Setting Automatic Start and Stop of Mirroring Controller and Multiplexed Instances" for details.

After that, on the server where the Mirroring Controller arbitration process is running, execute the mc_arb command in stop mode to stop the Mirroring Controller arbitration process.

Stopping Mirroring Controller

```
Example)
```

```
$ mc_ctl stop -M /mcdir/inst1 -a
```

Stopping the Mirroring Controller arbitration process

```
Example)
```

```
$ mc_arb stop -M /mcarb_dir/arbiter1
```

3.8.3 Arbitration Server Maintenance

Arbitration server maintenance can be performed without affecting database server operation.

Follow the procedure below to perform arbitration server maintenance.

1. Execute the mc_arb command in stop mode to forcibly stop the Mirroring Controller arbitration process.

   ```
   Example)
   ```

   ```
   $ mc_arb stop -M /mcarb_dir/arbiter1 -e
   ```

2. Perform maintenance tasks.
3. Execute the mc_arb command in start mode to restart the Mirroring Controller arbitration process.

   ```
   Example)
   ```

   ```
   $ mc_arb start -M /mcarb_dir/arbiter1
   ```

4. Execute the mc_arb command in status mode to check that the arbitration server is connected to the database server.

   The example below executes the mc_arb command, and shows the status.

   Example)

```
$ mc_arb status -M /mcarb_dir/arbiter1

server_id    host            status
-------------------------------------
server1      192.0.3.100     online
server2      192.0.3.110     online
```

5. Check the command output.

   Items to be checked

   Check that the output status is "online" on both lines.

3.9 Changes in Operation

The following changes in operation may be required:

- Changes required when the standby server is stopped
- Changing from single server mode to database multiplexing mode
- Changing from database multiplexing mode to single server mode
- Changing to database multiplexing mode when the arbitration server is used for automatic degradation
- Changing parameters
- Uninstalling in the database multiplexing mode

3.9.1 Changes Required when the Standby Server is Stopped

Operation when the standby server is stopped

Before performing maintenance for the primary server instance when the standby server has been stopped, stop Mirroring Controller on the primary server, comment out the synchronous_standby_names parameter in the postgresql.conf file of the primary server, and then execute the pg_ctl command in reload mode.

If this operation is not performed, operations performed on the primary server for the instance will remain in a wait state.

 See

Refer to "pg_ctl" in Reference for information on the command.

Standby server downtime

If you specified the synchronous_standby_names parameter of the postgresql.conf file and then the standby server instance is stopped, consider the points below.

- The wal_sender_timeout parameter in the postgresql.conf file

  If the standby server is stopped after the timeout set in this parameter was exceeded, an error stating that the transaction log could not be received may be output to the primary server system log, and all transaction logs that should be transferred to the standby server are accumulated.

- The wal_keep_size parameter in the postgresql.conf file

  If a transaction log that exceeds the value set in this parameter was generated while the standby server was stopped, the transaction log may be deleted.

Additionally, setting this parameter requires consideration regarding stabilization of the database multiplexing mode. Refer to "2.11.1 Tuning to Stabilize the Database Multiplexing Mode" for details.

Note

The standby server must be rebuilt if the pending transaction log to be transferred to the standby server is lost when the standby server is started after the maintenance task is complete.

Take the action advised in the recovery operation that starts from "4.1.1.1.3 Identify cause of error and perform recovery" through to "4.1.1.2 Rebuild the Standby Server".

3.9.2 Changing from Single Server Mode to Database Multiplexing Mode

The procedure for switching single server mode to database multiplexing mode for the purposes of high reliability and load distribution of the system is explained below.

This procedure is equivalent to the setup procedure explained in "Chapter 2 Setting Up Database Multiplexing Mode".

Note

If the data storage destination directory name is not comprised of ASCII characters

Stop the application job and then migrate to a directory with a name that uses only ASCII characters:

1. Stop the database instance on the primary server.
2. Change the name of the data storage destination directory to one that uses only ASCII characters.

See

When encrypting the storage data, refer to "Database Multiplexing Mode" in the Operation Guide, and then perform the setup for encryption on the primary and standby servers.

1. Install on the arbitration server

   Perform this step only if the arbitration server is used for automatic degradation.

   Install the Server Assistant on the server where the Mirroring Controller arbitration process is started.

   Refer to "Installation" in the Installation and Setup Guide for Server Assistant for information on how to install the Server Assistant.

2. Install on the standby server

   Install FUJITSU Enterprise Postgres on the server to be started as the standby server.

   Refer to "Installation" in the Installation and Setup Guide for Server for information on how to install FUJITSU Enterprise Postgres.

   Use ASCII characters in the data storage destination directory.

3. Stop the application jobs

   Stop the application jobs to be connected to the primary server.

4. Change the primary server settings

   To allow connections from the server to be started as the standby server, configure the settings in step 2 and thereafter of "2.4.2 Creating, Setting, and Registering the Primary Server Instance" on the primary server.

5. Set up the arbitration server

   Refer to "2.3 Setting Up the Arbitration Server" for details.

   Perform this step only if the arbitration server is used for automatic degradation.

6. Set up database multiplexing mode on the primary server

   Refer to "2.4.1 Setting Up Database Multiplexing Mode on the Primary Server" for details.

7. Set up database multiplexing mode on the standby server

   Refer to "2.5.1 Setting Up Database Multiplexing Mode on the Standby Server" for details.

8. Create the standby server instance and start it

   Refer to "2.5.2 Creating, Setting, and Registering the Standby Server Instance" for details.

After the above steps are completed, refer to the remaining explanations in "Chapter 2 Setting Up Database Multiplexing Mode" and ensure that the required settings and operations are completed.

3.9.3 Changing from Database Multiplexing Mode to Single Server Mode

The procedure for stopping database multiplexing mode and changing to single server mode is explained below.

Some tasks must be performed on the database server, and others must be performed on the arbitration server.

The tasks on the arbitration server are required only if the arbitration server is used for automatic degradation.

Tasks on the database server

1. Determine the server for which the instance is to be stopped, and switch this server

   Determine the server that is to be excluded as the database multiplexing mode target, and for which the instance is to be stopped.

   If the server for which the instance is to be stopped is the primary server, execute the mc_ctl command in the switch mode to switch the standby server to the primary server.

   The standby server after the switch is complete will be the server for which the instance is to be stopped.

   If the server for which the instance is to be stopped is the standby server, there is no need to perform the switch operation.

   Example)

```
$ mc_ctl switch -M /mcdir/inst1
```

2. Stop Mirroring Controller and the instance, and delete the file resources

   On the server that was determined in step 1, execute the mc_ctl command in stop mode to stop Mirroring Controller and the instance.

   If automatic start and stop of Mirroring Controller has been configured using systemd, do not use the mc_ctl command, but instead use the systemctl command. Refer to "2.12 Setting Automatic Start and Stop of Mirroring Controller and Multiplexed Instances" for details.

   Example)

```
$ mc_ctl stop -M /mcdir/inst1
```

   Then, delete the following file resources:

   - Data storage destination directory
   - Mirroring Controller management directory

   Example)

```
$ rm -rf /database/inst1
$ rm -rf /mcdir/inst1
```

See

Refer to "Security-Related Notes" in the Operation Guide for details on deleting the data securely.

3. Stop the application jobs

   Stop the application jobs to be connected to the primary server.

4. Stop Mirroring Controller and the instance on the primary server

   Execute the mc_ctl command in stop mode on the primary server.

   If automatic start and stop of Mirroring Controller has been configured using systemd, do not use the mc_ctl command, but instead use the systemctl command. Refer to "2.12 Setting Automatic Start and Stop of Mirroring Controller and Multiplexed Instances" for details.

   ```
   Example)
   ```

   ```
   $ mc_ctl stop -M /mcdir/inst1
   ```

5. Delete the database multiplexing mode settings that were configured for the primary server instance.

   Reset the postgresql.conf file parameters to their values before the database multiplexing operation was set.

   Delete the file resources from the Mirroring Controller management directory.

   If the backup operation was performed, delete the following resources:

   - Mirroring Controller management directory backup data obtained in database multiplexing mode
   - Instance backup data obtained in database multiplexing mode

   Additionally, if the primary_conninfo parameter is set in the postgresql.auto.conf file, execute the ALTER SYSTEM RESET statement to delete the setting.

   ```
   Example)
   An example execution of the psql command is shown below.
   ```

   ```
   postgres=# ALTER SYSTEM RESET primary_conninfo;
   ```

   After these actions are performed, ensure that the backup data is collected when starting the single operation.

See

- Refer to "Security-Related Notes" in the Operation Guide for details on deleting the data securely.
- Refer to "2.14 Backup Operation" for details on the backup operation.
- Refer to "Appendix A Parameters" for details on the postgresql.conf file parameters.

Point

In the above procedure, if the postgresql.conf file of the single primary server can be changed by reloading the file, the operation mode can be changed without stopping the application job.

In that case, execute the mc_ctl command in stop mode with the --mc-only option specified to stop only Mirroring Controller in relation to stopping the primary server.

Tasks on the arbitration server

1. Execute the mc_arb command in stop mode to stop the Mirroring Controller arbitration process.

   ```
   Example)
   ```

   ```
   $ mc_arb stop -M /mcarb_dir/arbiter1
   ```

2. Delete the Mirroring Controller arbitration process management directory.

   ```
   Example)
   ```

```
$ rm -rf /mcarb_dir/arbiter1
```

3.9.4 Changing to Database Multiplexing Mode when the Arbitration Server is Used for Automatic Degradation

This section provides the procedure to change to database multiplexing mode using the Mirroring Controller only on the database server when the arbitration server is used for automatic degradation.

Some tasks must be performed on the database server, and others must be performed on the arbitration server.

Tasks on the arbitration server

1. Set up the arbitration server.

   Refer to "2.3 Setting Up the Arbitration Server" for information on how to set up the arbitration server.

Tasks on the database server

1. On the server where Mirroring Controller is running, execute the mc_ctl command in stop mode to stop Mirroring Controller on the primary server and standby server.

   Example)

   ```
   $ mc_ctl stop -M /mcdir/inst1 -a --mc-only
   ```

2. Edit the network.conf file of the primary server and standby server to add the information of the arbitration server.

   Refer to "A.3 Network Configuration File" for details.

   The definition example of the network.conf file of the primary server is shown below:

   Example)

   The IDs of the primary server and standby server are set to "server1" and "server2", and their port numbers are set to "27540" and "27541". The ID of the server of the Mirroring Controller arbitration process is set to "arbiter", and its port number is set to "27541".

   ```
   server1 192.0.2.100,192.0.3.100 27540,27541 server
   server2 192.0.2.110,192.0.3.110 27540,27541 server
   arbiter 192.0.3.120 27541 arbiter
   ```

- Ensure that the port numbers set for the primary server, standby server, and arbitration server do not conflict with other software. Also do not configure the same segment for the admin network and arbitration network.
- If the server type is "server", two IP addresses or host names, and two port numbers need to be specified in the following order:
  - IP address or host name of the database server used as the admin network
  - IP address or host name of the database server used as the arbitration network
  - Port number of the database server used as the admin network
  - Port number of the database server used as the arbitration network
- If the server type is "arbiter", specify the IP address or host name set for the my_address parameter and the port number set for the port parameter in arbitration.conf.

3. Edit the *serverIdentifier*.conf file of the primary server and standby server to add parameters required for the operation where the arbitration server is used for automatic degradation.

   Refer to "A.4.1 Server Configuration File for the Database Servers" for information on the parameters required when the arbitration server is used for automatic degradation.

4. On the primary server and standby server, execute the mc_ctl command in start mode to start the Mirroring Controller process.

   Example)

```
$ mc_ctl start -M /mcdir/inst1 --mc-only
```

Common tasks

1. Check the connection status from the database server or arbitration server.

   Refer to "2.8 Checking the Connection Status" for details.

3.9.5 Changing Parameters

Stop Mirroring Controller before editing the Mirroring Controller server configuration file and network configuration file.

If the Mirroring Controller process crashes or becomes unresponsive, restart is performed automatically by the Mirroring Controller monitoring process, and the configuration file is reloaded. Therefore, if the configuration file was being edited, unintended behavior will occur.

3.9.6 Uninstalling in Database Multiplexing Mode

This section explains how to uninstall FUJITSU Enterprise Postgres on a server using database multiplexing mode.

Some tasks must be performed on the database server, and others must be performed on the arbitration server.

The tasks on the arbitration server are required only if the arbitration server is used for automatic degradation.

Tasks on the database server

1. Stop the multiplexed instances and Mirroring Controller

   Refer to "3.2 Starting and Stopping Mirroring Controller" for information on how to stop the instance.

2. Uninstall FUJITSU Enterprise Postgres

   Refer to "Uninstallation" in the Installation and Setup Guide for Server for information on how to uninstall FUJITSU Enterprise Postgres.

Tasks on the arbitration server

Refer to "Uninstallation" in the Installation and Setup Guide for Server Assistant, and uninstall the Server Assistant.

Chapter 4 Action Required when an Error Occurs in Database Multiplexing Mode

This chapter describes the action required if an error occurs in database multiplexing mode.

In database multiplexing mode, when an error is detected, the switch or disconnection of the standby server is performed automatically, so that only the primary server starts degrading. In this case, the recovery tasks will be required for the standby server on which the switch or disconnection was performed.

Other possible cases are as follows:

- When automatic switch fails
- When automatic disconnection fails
- When all servers or instances were stopped

4.1 Action Required when Server Degradation Occurs

If the server has started degrading, the recovery tasks will vary depending on whether the cause was the switch (failover or switchover), or the disconnection.

Execute the mc_ctl command in status mode, or refer to the system log, and check if the cause of the server degradation was the switch or the disconnection.

In the example below, the mc_ctl command is executed in status mode.

If a switch has occurred, "switched" (the switch is complete and the server is in a degrading state) is displayed for "mirroring status".

Example)

```
$ mc_ctl status -M /mcdir/inst1
mirroring status
----------------
switched

   :
```

If a disconnection has occurred, "not-switchable" (disconnection was performed so the server cannot be switched) is displayed for "mirroring status".

Example)

```
$ mc_ctl status -M /mcdir/inst1
mirroring status
----------------
not-switchable

  :
```

Note

If Mirroring Controller detects any errors on the server on which operations are continuing during recovery to database multiplexing mode from a degrading operation state, perform the procedure in "4.1.3 Addressing Errors During Degrading Operation", and then recover to database multiplexing mode.

4.1.1 Operations when the Server has Started Degrading after a Switch has Occurred

This section explains the operations when the server has started degrading after a switch has occurred.

Note

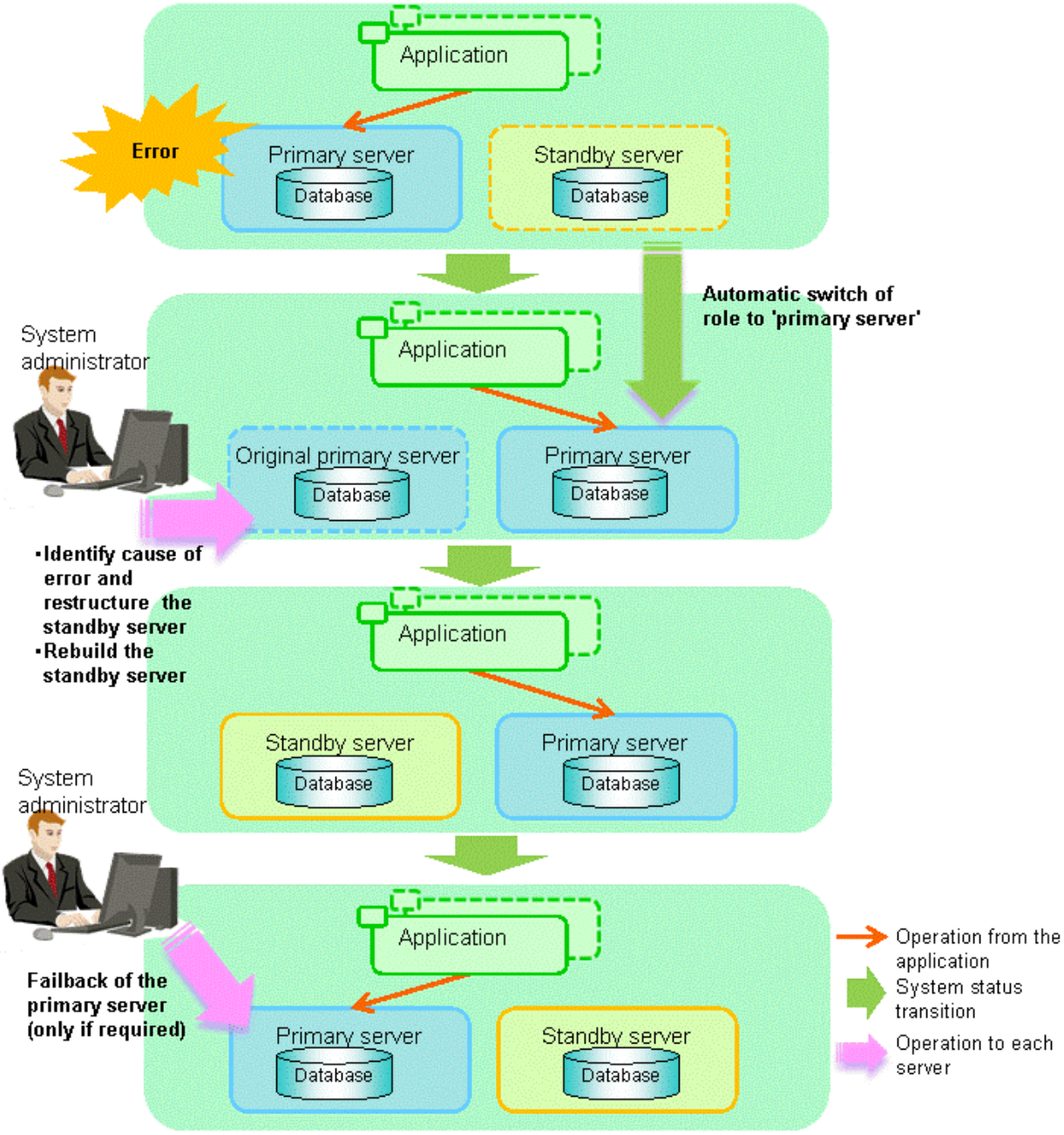
- After a switch has occurred as a result of an abnormality on the primary server, the database will not have a multiplexed configuration until the standby server is rebuilt. Remove the cause of the error as quickly as possible, and then rebuild the standby server.
- If the reference job was executed on the standby server, and the servers are switched because an error occurred on the primary server, the load is concentrated on the new primary server. Accordingly, pause the reference job on the original standby server, rebuild the original primary server as the new standby server, and then resume the reference job for the new standby server.
- If the instance on the new primary server is stopped before the original primary server where the error occurred is rebuilt as the new standby server, a split brain occurs at startup from the instance on the original primary server. Therefore, start the instance on the new primary server before rebuilding the standby server.

If the switch occurred and the server has started degrading, perform the following operations to recover the standby server and revert it to its original state:

- Identify Cause of Error and Restore the Standby Server
- Rebuild the Standby Server
- Failback of the Primary Server (only if required)

The flow of these operations is shown in the figure below.

Figure 4.1 Flow of operations



4.1.1.1 Identify Cause of Error and Restore the Standby Server

Perform the recovery according to the following procedure:

1. Stop Mirroring Controller
2. Recovery of the Mirroring Controller management directory
3. Identify cause of error and perform recovery

4.1.1.1.1 Stop Mirroring Controller

Execute the mc_ctl command in stop mode for the original primary server on which the error occurred.

If automatic start and stop of Mirroring Controller has been configured using systemd, do not use the mc_ctl command, but instead use the systemctl command. Refer to "2.12 Setting Automatic Start and Stop of Mirroring Controller and Multiplexed Instances" for details.

Example)

```
$ mc_ctl stop -M /mcdir/inst1
```

This also stops the instance that is required to perform the recovery.

Note

If the instance does not stop, refer to "Actions in Response to Failure to Stop an Instance" in the Operation Guide, and then stop the instance.

Then, specify the -e option in the above command to forcibly stop Mirroring Controller.

4.1.1.1.2 Recovery of the Mirroring Controller management directory

Copy the files in the Mirroring Controller management directory from the backup data, and then perform the recovery.

4.1.1.1.3 Identify cause of error and perform recovery

Refer to the system log of the primary server and the standby server to identify the cause of the error, and then perform recovery.

The following commands can be used to recover a standby server. Select depending on the recovery and the situation.

- pg_basebackup

  Creates a copy of all resources of the primary server instance.

- pg_rewind

  Creates a copy of only the updated files on the new primary server. For this reason, if this command is used to incorporate a new standby server, recovery time can be shortened. To use this command to build the original primary server as a new standby server, at least one of the following must be met:

  a. Checksums were enabled when an instance was created, or

  b. The wal_log_hints parameter of postgresql.conf was enabled when an instance was started.

  Additionally, full_page_writes must be enabled, which is its default value.

See

- Refer to "pg_basebackup" in "Reference" in the PostgreSQL Documentation for information on the pg_basebackup command.
- Refer to "pg_rewind" in "Reference" in the PostgreSQL Documentation for information on the pg_rewind command.

The example below executes the pg_rewind command to perform recovery by synchronizing data on the original primary server with the new primary server.

1. Wait for the application of unapplied update transaction logs on the new primary server.

   Execute the SQL below on the new primary server, and wait until the result is false.

   ```
   # select pg_is_in_recovery();
   ```

   Example)

   ```
   $ psql -h hostNameOfNewPrimaryServer -p portNumOfNewPrimaryServer -d dbName -c "select
   pg_is_in_recovery();"
   ```

   Any database can be connected to.

Note

If the pg_rewind command is executed immediately after promotion of the new primary server, the processing in steps 1 and 2 is required. If update-type SQL can be executed on the new primary server and checkpoint processing is executed after promotion, the processing in steps 1 and 2 will not be necessary.

2. Update the timeline ID.

   Execute checkpoint processing, and update the timeline ID.

   ```
   $ psql -h hostNameOfNewPrimaryServer -p portNumOfNewPrimaryServer -d dbName -c "checkpoint;"
   ```

   Any database can be connected to.

3. Create a copy of the new primary server instance in the original primary server (new standby server).

   Execute the pg_rewind command to synchronize the new standby server data with the new primary server.

   Example)

   ```
   $ pg_rewind -D /database/inst1 -R --source-server='user=userName host=newPrimaryServerHostName
   port=newPrimaryServerPortNumber dbname=dbName application_name=newStandbyServerName'
   ```

   ### Note

   - Use the pg_rewind command with the -R option to create a standby.signal file. If you do not create the standby.signal file, the Mirroring Controller cannot be started as a standby server.
   - If using a method that requires password authentication for connections to the primary server, you will need to ensure that authentication is performed automatically. If the -R option is specified for the pg_rewind command and the password parameter is specified for the --dbname option, the pg_rewind command will set the password in the primary_conninfo parameter in postgresql.auto.conf file, enabling connections to be performed automatically.

     If a password is not set in the primary_conninfo parameter in postgresql.auto.conf file, it will be necessary to create a .pgpass file in the home directory of the instance administrator user, and specify a password for the replication database.
   - If you need to set a connection string other than host, port and application_name, include it in the setting of the primary_conninfo parameter.
   - The primary_conninfo parameter should not be set in the postgresql.conf file, but only in the postgresql.auto.conf file using the pg_rewind command.

4. Specify parameters in the postgresql.conf file of the original primary server (new standby server).

   Set the parameters required for the standby server in postgresql.conf.

   Refer to "Table 2.4 Parameters" for information on the parameters to set in postgresql.conf.

See

- Refer to "Hot Standby" in the PostgreSQL Documentation for details on the standby.signal file.
- Refer to "Setting Up a Standby Server" in the PostgreSQL Documentation for details on the primary_conninfo.

Note

A new timeline is branched for the new primary server due to promotion, so 'latest' needs to be specified for the recovery_target_timeline parameter so that the old primary server (new standby server) follows the new primary server.

4.1.1.2 Rebuild the Standby Server

The starting of the recovered original primary server as the standby server is referred to as the "standby server rebuild".

On the original primary server, start Mirroring Controller and the instance.

Enabling automatic switch/disconnection

As the instance administrator user, execute the mc_ctl command in start mode.

Example)

```
$ mc_ctl start -M /mcdir/inst1
```

Disabling automatic switch/disconnection

As the instance administrator user, execute the mc_ctl command in start mode with the -F option specified.

Example)

```
$ mc_ctl start -M /mcdir/inst1 -F
```

Point

After Mirroring Controller is started, automatic switch/disconnection can be enabled or disabled using the enable-failover or disable-failover mode of the mc_ctl command.

4.1.1.3 Failback of the Primary Server

To revert the primary server and standby server to the original server configuration after rebuilding the standby server, perform failback for the primary server.

Do this to execute the main job on the previous primary server.

Perform the following procedure:

1. Failback of the primary server

   Execute the mc_ctl command in switch mode on the primary server or the standby server.

   Example)

   ```
   $ mc_ctl switch -M /mcdir/inst1
   ```

   After executing the mc_ctl command in switch mode, the status will be as follows:

   Example)

   ```
   $ mc_ctl status -M /mcdir/inst1
   mirroring status
   ----------------
   switched
   server_id  host_role                  host         host_status  db_proc_status       disk_status
   ------------------------------------------------------------------------------------------------
   server1    primary                  192.0.2.100 normal        abnormal(postmaster) normal
   server2    none(inactivated primary) 192.0.2.110 normal        abnormal(postmaster) normal
   ```

2. Stop the original primary server

   On the original primary server, execute the mc_ctl command in stop mode to stop Mirroring Controller and the instance.

   If automatic start and stop of Mirroring Controller has been configured using systemd, do not use the mc_ctl command, but instead use the systemctl command. Refer to "2.12 Setting Automatic Start and Stop of Mirroring Controller and Multiplexed Instances" for details.

   Example)

```
$ mc_ctl stop -M /mcdir/inst1
```

3. Create a copy of the new primary server instance in the original primary server (new standby server)

   Execute the pg_basebackup command to create data in the new standby server by synchronizing with the new primary server.

   Example)

```
$ pg_basebackup -D /database/inst1 -X fetch --waldir=/transaction/inst1 --progress --verbose -R
--dbname='application_name=standbyServerName' -h primaryServerHostName -p
primaryServerPortNumber
```

See

The procedure for copying the new primary server instance to the new standby server is the same as the procedure for setting up the new standby server.

Refer to "2.5.2 Creating, Setting, and Registering the Standby Server Instance", and then perform the recovery.

4. Rebuild the standby server

   On the standby server, start Mirroring Controller and the instance.

   Enabling automatic switch/disconnection

   As the instance administrator user, execute the mc_ctl command in start mode.

   Example)

```
$ mc_ctl start -M /mcdir/inst1
```

   Disabling automatic switch/disconnection

   As the instance administrator user, execute the mc_ctl command in start mode with the -F option specified.

   Example)

```
$ mc_ctl start -M /mcdir/inst1 -F
```

Point

After Mirroring Controller is started, automatic switch/disconnection can be enabled or disabled using the enable-failover or disable-failover mode of the mc_ctl command.

4.1.2 Operations when the Server has Started Degrading after a Disconnection has Occurred

This section explains the operations when the server has started degrading after a disconnection has occurred.

Note

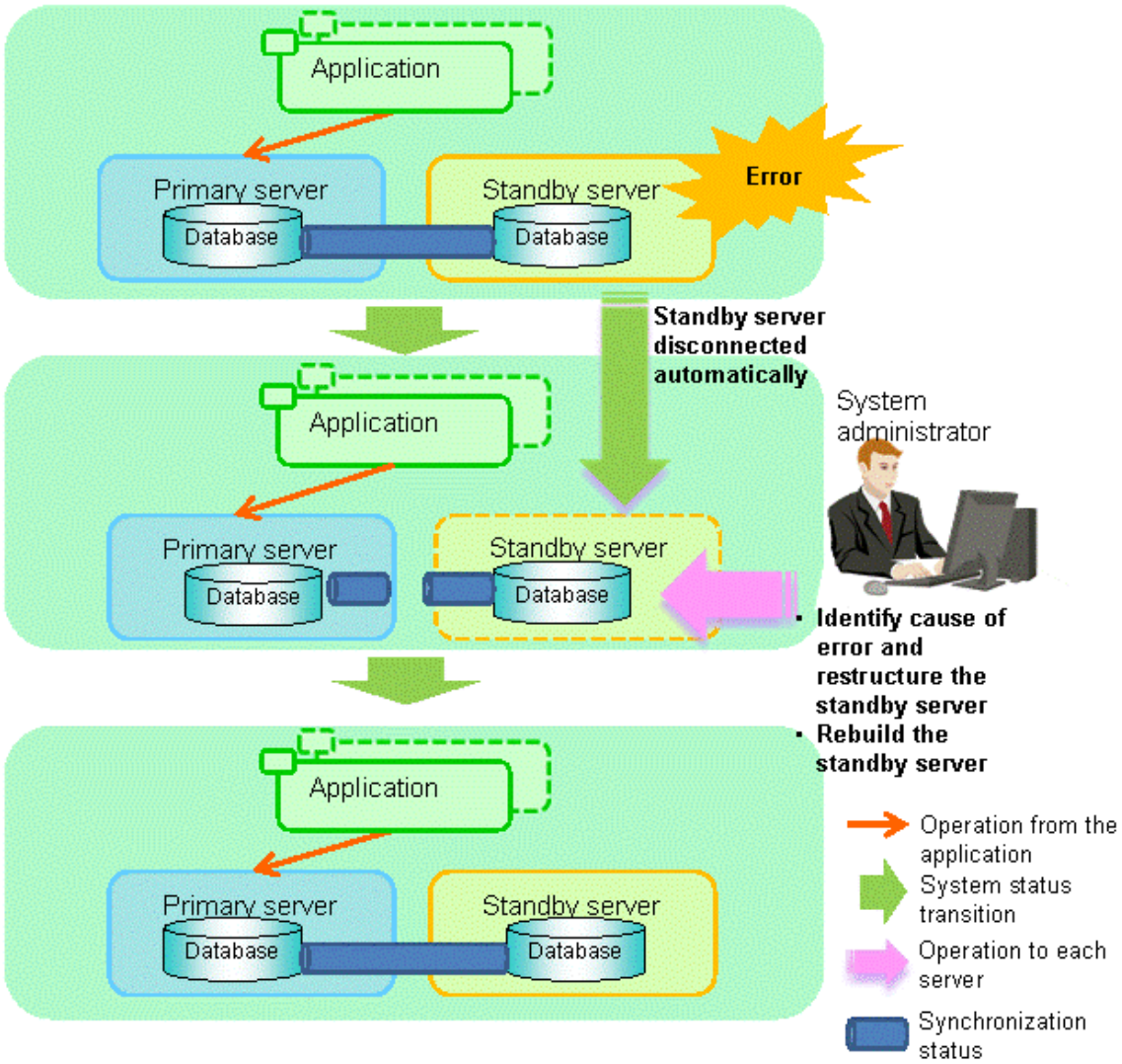
After a disconnection has occurred as a result of an abnormality on the standby server, the database will not have a multiplexed configuration until the standby server is rebuilt. Remove the cause of the error as quickly as possible, and then rebuild the standby server.

If the disconnection occurred and the server has started degrading, perform the following operations to recover the standby server and revert it to its original state:

- Identify Cause of Error and Restore the Standby Server
- Rebuild the Standby Server

The flow of these operations is shown in the figure below.

Figure 4.2 Flow of operations



4.1.2.1 Identify Cause of Error and Restore the Standby Server

Perform the recovery according to the following procedure:

1. Stop Mirroring Controller
2. Recovery of the Mirroring Controller management directory
3. Identify cause of error and perform recovery

4.1.2.1.1 Stop Mirroring Controller

Execute the mc_ctl command in stop mode for the standby server on which the error occurred.

If automatic start and stop of Mirroring Controller has been configured using systemd, do not use the mc_ctl command, but instead use the systemctl command. Refer to "2.12 Setting Automatic Start and Stop of Mirroring Controller and Multiplexed Instances" for details.

Example)

```
$ mc_ctl stop -M /mcdir/inst1
```

This also stops the instance that is required to perform the recovery.

Note

If the instance does not stop, refer to "Actions in Response to Failure to Stop an Instance" in the Operation Guide, and then stop the instance.

Then, specify the -e option in the above command to forcibly stop Mirroring Controller.

4.1.2.1.2 Recovery of the Mirroring Controller management directory

Copy the files in the Mirroring Controller management directory from the backup data, and then perform the recovery.

4.1.2.1.3 Identify cause of error and perform recovery

Refer to the system logs of the primary server and the standby server to identify the cause of the error, and then perform recovery.

Execute the pg_basebackup command to perform recovery by synchronizing data in the primary server with the standby server.

```
Example)
```

```
$ pg_basebackup -D /database/inst1 -X fetch --waldir=/transaction/inst1 --progress --verbose -R --
dbname='application_name=standbyServerName' -h primaryServerHostName -p primaryServerPortNumber
```

See

This recovery procedure is the same as the procedure for setting up the standby server.

Refer to "2.5.2 Creating, Setting, and Registering the Standby Server Instance", and then perform the recovery.

4.1.2.2 Rebuild the Standby Server

Start the Mirroring Controller and the instance of the standby server, and rebuild the standby server.

Enabling automatic switch/disconnection

As the instance administrator user, execute the mc_ctl command in start mode.

```
Example)
```

```
$ mc_ctl start -M /mcdir/inst1
```

Disabling automatic switch/disconnection

As the instance administrator user, execute the mc_ctl command in start mode with the -F option specified.

```
Example)
```

```
$ mc_ctl start -M /mcdir/inst1 -F
```

Point

After Mirroring Controller is started, automatic switch/disconnection can be enabled or disabled using the enable-failover or disable-failover mode of the mc_ctl command.

4.1.3 Addressing Errors During Degrading Operation

This section explains how to address errors that may occur on the server on which operation is continuing during degrading operation triggered by a switch or disconnection.

If needing to recover from backup data

If it is necessary to recover the database using backup data due to data becoming corrupted from disk failure or user operation error, refer to the following for information on recovery to database multiplexing mode:

- Action Required when All Database Servers or Instances Stopped
- Recovering from an Incorrect User Operation

If a temporary error occurs

If a temporary error occurs, such as due to a high load on the server or insufficient system resources, remove the cause of the error and restart Mirroring Controller, and then refer to the following for details on recovery to database multiplexing mode:

- Operations when the Server has Started Degrading after a Switch has Occurred
- Operations when the Server has Started Degrading after a Disconnection has Occurred

See

Refer to "3.2 Starting and Stopping Mirroring Controller" for information on restarting Mirroring Controller.

4.2 Action Required when Automatic Switch Fails

If the system behavior is unstable, for example there are insufficient temporary system resources, the Mirroring Controller automatic switch may fail.

Perform the switch manually using one of the following methods:

- Refer to the procedures in "3.4 Manually Switching the Primary Server".
- In the standby server, execute the mc_ctl command in switch mode with the -force option specified to forcibly perform the switch.

  Example)

```
$ mc_ctl switch -M /mcdir/inst1 --force
```

Point

- Even if connection cannot be established between database servers, it is possible to fence the primary server and forcibly switch by executing the mc_ctl command in switch mode with the --force option specified.
- The primary server is not fenced in the cases below, so stop Mirroring Controller and instances of the primary server database in advance:
  - The --no-fencing option is specified when performing forced switch.
  - The heartbeat_error_action parameter in *serverIdentifier*.conf is set to "message" and the fencing command is not configured to be used (the fencing_command parameter is omitted in *serverIdentifier*.conf).
  - The heartbeat_error_action parameter in *serverIdentifier*.conf is set to "fallback".

See

Recovery to database multiplexing mode

Refer to "4.1.1.2 Rebuild the Standby Server" and "4.1.1.3 Failback of the Primary Server" for information on recovery to database multiplexing mode.

4.3 Action Required when Automatic Disconnection Fails

If the system behavior is unstable, for example there are insufficient system resources such as available memory or free disk space, automatic disconnection using Mirroring Controller may not be possible.

Perform the disconnection manually using one of the following methods:

- Refer to the procedures in "3.5 Manually Disconnecting the Standby Server".
- In the primary server, execute the mc_ctl command in detach mode to perform forced disconnection.

  Example)

```
$ mc_ctl detach -M /mcdir/inst1
```

Point

- Even if connection cannot be established between database servers, it is possible to fence the standby server and forcibly disconnect by executing the mc_ctl command in detach mode.
- In the cases below, stop Mirroring Controller and instances of the standby server database in advance so that the standby server is not fenced:
  - The --no-fencing option is specified when performing forced disconnection.
  - The heartbeat_error_action parameter in *serverIdentifier*.conf is set to "message" and the fencing command is not configured to be used (the fencing_command parameter is omitted in *serverIdentifier.conf*).
  - The heartbeat_error_action parameter in *serverIdentifier*.conf is set to "fallback".

See

Recovery to database multiplexing mode

Refer to "4.1.2.2 Rebuild the Standby Server" for information on recovery to database multiplexing mode.

4.4 Action Required when All Database Servers or Instances Stopped

This section explains what happens when all database servers or instances on the database server have stopped, so jobs cannot continue.

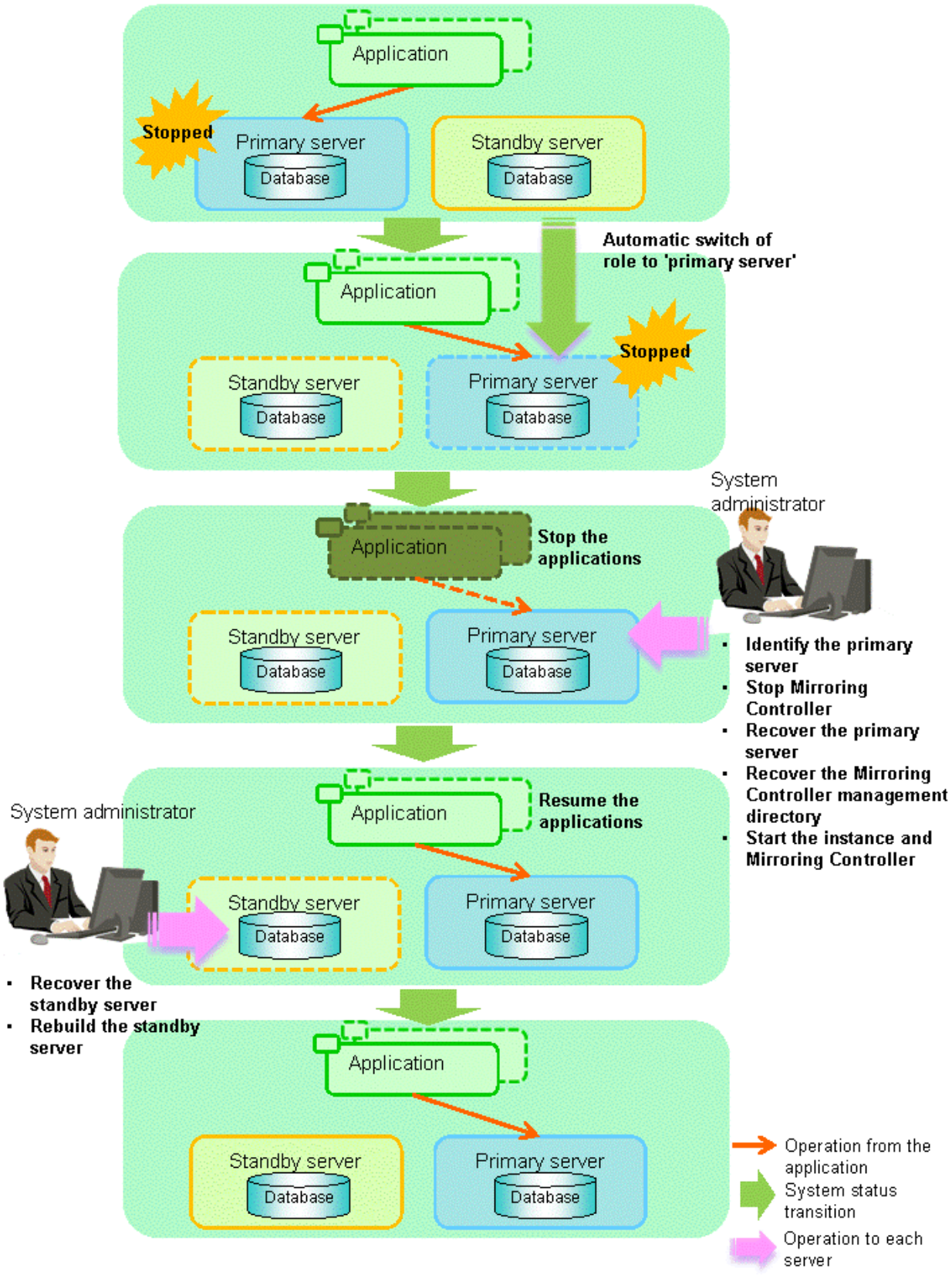
See

Recovery to database multiplexing mode

Refer to "4.1.1.2 Rebuild the Standby Server" and "4.1.1.3 Failback of the Primary Server" for information on recovery to database multiplexing mode.

The flow of these recovery operations is shown in the figure below.

Figure 4.3 Flow of operations



Perform the following procedure:

1. Stop the applications

   Stop the applications from running.

2. Identify the primary server

   Use one of the following methods to identify the primary server that was running before the servers or instances stopped:

   - Refer to the system log on each server and identify the server where the following message was output.

     Message:

     ```
     MirroringControllerOpen[30017]: LOG:  promotion processing completed (MCA00062)
     ```

   - On each server, execute the mc_ctl command in status mode to search the servers for which "none(inactivated primary)" is displayed.

3. Stop Mirroring Controller on the primary server

   Execute the mc_ctl command in stop mode on the primary server.

   If automatic start and stop of Mirroring Controller has been configured using systemd, do not use the mc_ctl command, but instead use the systemctl command. Refer to "2.12 Setting Automatic Start and Stop of Mirroring Controller and Multiplexed Instances" for details.

   Example)

   ```
   $ mc_ctl stop -M /mcdir/inst1
   ```

   Note

   Forcibly stopping Mirroring Controller

   If Mirroring Controller does not stop, specify the -e option in the stop mode of the mc_ctl command and then execute the command.

   Example)

   ```
   $ mc_ctl stop -M /mcdir/inst1 -e
   ```

4. Recover the primary server

   First, refer to "Actions when an Error Occurs" in the Operation Guide, and then identify the cause of the error and perform recovery.

   Next, recover the primary server using the recovery method that uses the pgx_rcvall command based on the backup data.

   If the backup operation was performed using the pgx_dmpall command based on the instructions in "2.14.2 Database Backup Operation", perform the following procedure for the recovery:

   a. Perform the following operations on both the primary server and the standby server, and check the server containing the backup data and the archive log that show the latest date.

      - Execute the pgx_rcvall command with the -l option specified and identify the backup data that shows the latest date.
      - Identify the archive log that shows the latest date, as shown below.

        Example)

        ```
        $ ls -ltr backupDataStorageDir/*_wal
        ```

   b. If the latest backup data exists on the standby server, copy (*1) the backup data and overwrite (*2) it to each backup storage destination directory on the primary server.

   c. If the latest archive log and transaction log file exist on the standby server, copy (*1) the archive log and overwrite (*2) it to the backup storage destination directory on the primary server.

   d. Execute the pgx_rcvall command on the primary server, specifying the backup storage destination directory of the primary server.

Note

*1: The backup data may contain a symbolic link, so copy the backup data so that the symbolic link is not converted to an ordinary file (with the tar command, for example).

*2: If you can save a copy of the backup storage destination directory, do so without overwriting it.

See

Refer to "Actions when an Error Occurs" in the Operation Guide for information on the pgx_rcvall command.

5. Recover the Mirroring Controller management directory

   Copy the files in the Mirroring Controller management directory from the backup data, and then perform the recovery.

6. Start the primary server instance and Mirroring Controller

   Enabling automatic switch/disconnection

   As the instance administrator user, execute the mc_ctl command in start mode.

   Example)

   ```
   $ mc_ctl start -M /mcdir/inst1
   ```

   Disabling automatic switch/disconnection

   As the instance administrator user, execute the mc_ctl command in start mode with the -F option specified.

   Example)

   ```
   $ mc_ctl start -M /mcdir/inst1 -F
   ```

Point

After Mirroring Controller is started, automatic switch/disconnection can be enabled or disabled using the enable-failover or disable-failover mode of the mc_ctl command.

7. Resume applications

   Resume the applications.

8. Stop Mirroring Controller on the standby server

   Execute the mc_ctl command in stop mode on the standby server.

   If automatic start and stop of Mirroring Controller has been configured using systemd, do not use the mc_ctl command, but instead use the systemctl command. Refer to "2.12 Setting Automatic Start and Stop of Mirroring Controller and Multiplexed Instances" for details.

   Example)

   ```
   $ mc_ctl stop -M /mcdir/inst1
   ```

9. Recover the standby server

   Refer to "2.5.2 Creating, Setting, and Registering the Standby Server Instance", and then recover (set up) the standby server from the primary server.

10. Rebuild the standby server

    On the standby server, start Mirroring Controller and the instance.

Enabling automatic switch/disconnection

As the instance administrator user, execute the mc_ctl command in start mode.

Example)

```
$ mc_ctl start -M /mcdir/inst1
```

Disabling automatic switch/disconnection

As the instance administrator user, execute the mc_ctl command in start mode with the -F option specified.

Example)

```
$ mc_ctl start -M /mcdir/inst1 -F
```

Point

After Mirroring Controller is started, automatic switch/disconnection can be enabled or disabled using the enable-failover or disable-failover mode of the mc_ctl command.

4.5 Recovering from an Incorrect User Operation

This section describes how to recover an instance when data has been corrupted due to incorrect user operation.

For example, when data has been corrupted due to incorrect user operation, such as data being unintentionally changed or deleted by an application or command, it is necessary to restore the original data on the primary server and resynchronize with the standby server.

Use the following procedure to perform recovery.

1. Identify the primary server

   Execute the mc_ctl command in status mode on each server, and search for a server for which "primary" or "none(inactivated primary)" is displayed.

2. Stop the applications and commands that caused the incorrect operation to occur

   Stop applications and commands that are running on the primary server. This will minimize the impact caused by the incorrect data.

   Also, if any applications used for reference by the standby server are running, stop them too.

3. Stop the instance and Mirroring Controller

   Stop the instance and Mirroring Controller on both the primary server and standby server.

   Example)

   ```
   $ mc_ctl stop -a -M /mcdir/inst1
   ```

4. Recover the database on the primary server

   Recover the database using the recovery method in which the pgx_rcvall command uses the backup data to recover the database to a restore point prior to the time when the incorrect operation was performed.

   See

   Refer to "Recovering from an Incorrect User Operation" in the Operation Guide for information on using the pgx_rcvall command to recover the database to a restore point, and then perform only the database recovery procedure while the instance is in a stop state.

5. Start the instance and Mirroring Controller

   Start the instance and Mirroring Controller on the primary server.

   Enabling automatic switch/disconnection

   As the instance administrator user, execute the mc_ctl command in start mode.

Example)

```
$ mc_ctl start -M /mcdir/inst1
```

Disabling automatic switch/disconnection

As the instance administrator user, execute the mc_ctl command in start mode with the -F option specified.

Example)

```
$ mc_ctl start -M /mcdir/inst1 -F
```

Point

After Mirroring Controller is started, automatic switch/disconnection can be enabled or disabled using the enable-failover or disable-failover mode of the mc_ctl command.

6. Build the new standby server

   Refer to "2.5 Setting Up the Standby Server" for information on building (setting up) a standby server from the primary server.

Chapter 5 Managing Mirroring Controller Using WebAdmin

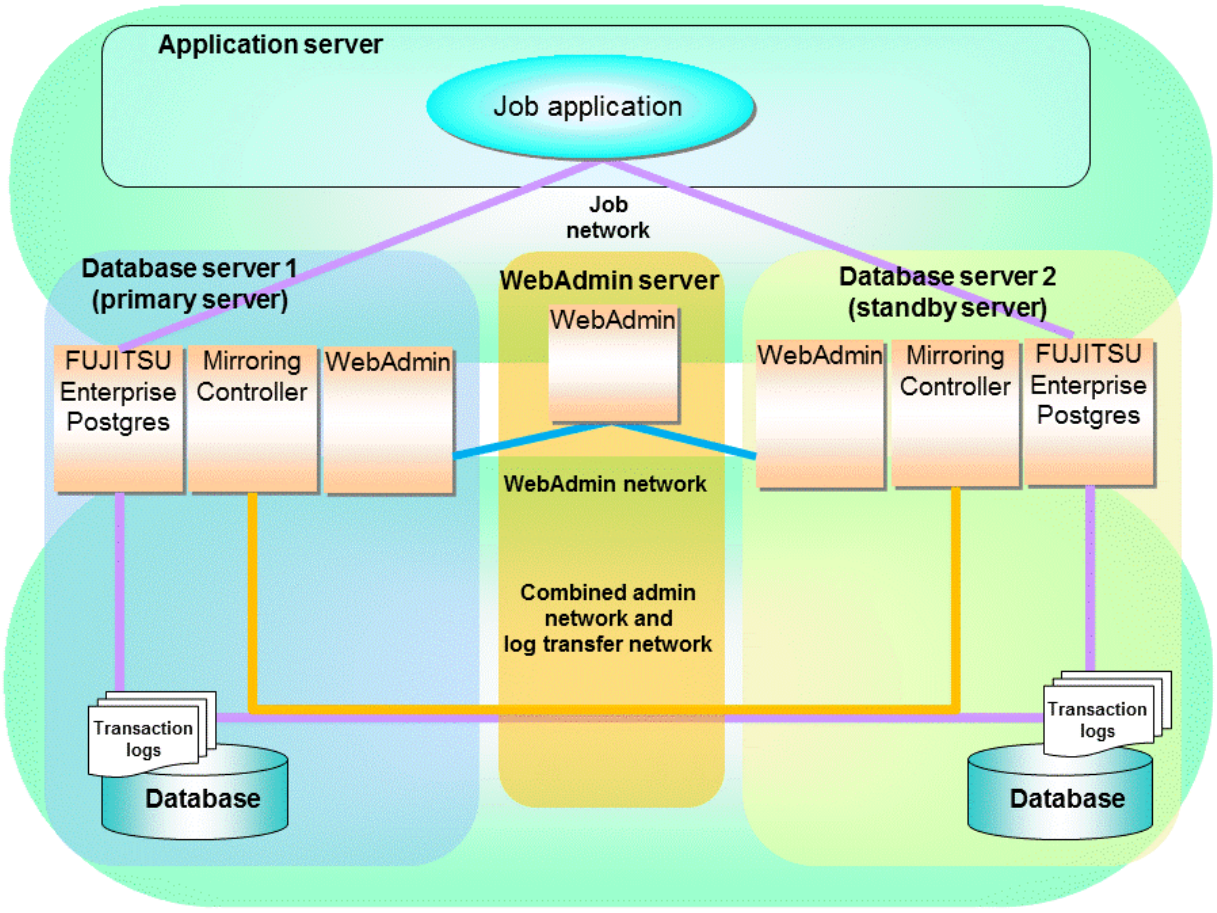
This chapter describes how to set up and manage Mirroring Controller in a streaming replication cluster using WebAdmin.

Mirroring Controller can be used to monitor a streaming replication cluster and perform automatic switching or disconnect synchronous replication when there is an error.

WebAdmin can be used to set up Mirroring Controller in an existing replication cluster. Mirroring Controller can be set up for either synchronous standby instances or asynchronous standby instances.

The configuration of the database multiplexing system built using WebAdmin is shown below:

Figure 5.1 Configuration of database multiplexing operation system using WebAdmin



Point

- If Mirroring Controller is set up to the replication cluster using WebAdmin, the network with the host name (or IP address) specified in [Host name] will be used as the admin network and the log transfer network.
- To use a network other than the job network as the log transfer network, before building the replication cluster specify a host name other than the job network one in [Host name].

Note

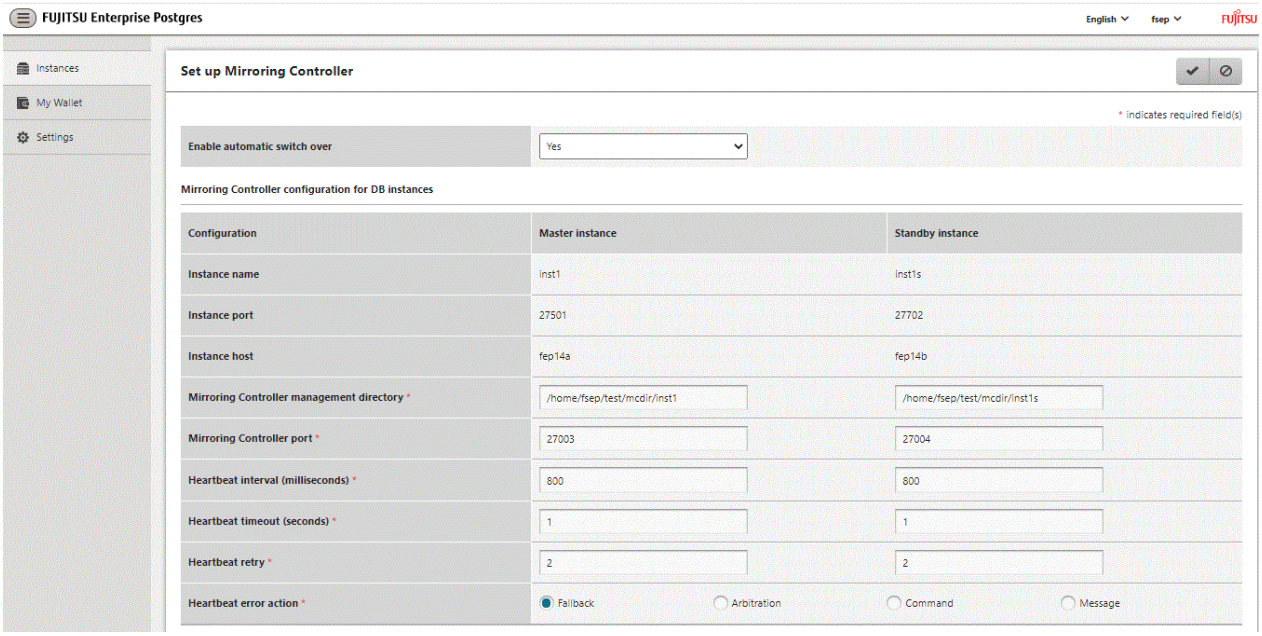
If you set up the arbitration server using WebAdmin, install WebAdmin on the arbitration server.

5.1 Mirroring Controller Setup

Perform the following procedure to set up Mirroring Controller in a streaming replication cluster.

1. In the [Instances] tab, select the standby instance on which Mirroring Controller needs to be set up.
2. Click  .
3. Enter the information for the Mirroring Controller to be set up.

   In the example below, Mirroring Controller is being set up for the replication cluster having master instance "inst1" and standby instance "inst1s".



The instance name, host address and port of the master and standby instances are displayed for easy reference.

Enter the following items on master instance and on standby instance fields for Mirroring Controller setup, as shown in the above screenshot:

- [Enable automatic switch over]: Toggles the automatic switch/disconnection functionality. Select "Yes". The default is "No".
- [Mirroring Controller management directory]: Directory where the Mirroring Controller configuration files will be stored. When the [Mirroring Controller management directory] is entered, WebAdmin will search the Mirroring Controller configuration files in the entered directory based on the [Data storage path] of the corresponding DB instance. If Mirroring Controller configuration files are found, the Mirroring Controller fields will be auto filled.
- [Mirroring Controller port]: Port number of Mirroring Controller.
- [Heartbeat interval (milliseconds)]: Number of milliseconds between two consecutive heartbeat checks. The default is "800".
- [Heartbeat timeout (seconds)]: Number of seconds for the heartbeat timeout. The default is "1".
- [Heartbeat retry]: Number of retries for heartbeat monitoring, before failover occurs. The default is "2".
- [Heartbeat error action]: Operation when a heartbeat abnormality is detected. The default is "Fallback".

  When using FUJITSU Enterprise Postgres 11,12 and 13 instance created with previous versions, the instances will be in compatibility mode, and the "Fallback" is preselected and cannot be changed in the [Heartbeat error action] for Mirroring Controller setup.

When the [Heartbeat error action] is set to "Arbitration", the following extra items are displayed:

- [Arbitration network IP address]: IP address of the arbitration network.

- [Mirroring Controller Arbitration port]: Port number of Mirroring Controller for communicating with the arbitration server.

The [Arbitration server configuration] section is also displayed with the following items. The [Arbitration server configuration] will not be auto filled.

- [Location]: Location of the arbitration server. "Local" or "Remote" can be selected depending on your configuration.

  If the arbitration server and WebAdmin server are located on the same server, you can select "Local" and the following items are displayed:

  - [Arbitration management directory]: Directory where the arbitration server configuration files will be stored.
  - [Arbitration server host or IP address]: Host name or IP address of the arbitration server.
  - [Arbitration process port]: Port number for the arbitration process.
  - [Fencing command]: Full path of the fencing command that fences a database server when an abnormality is detected.

  If "Remote" is set for the item, the items below are displayed in addition to the above items.

  - In the [Arbitration server configuration] section, [Operating system credential] is displayed where you can enter the following information:

    [User name]: User name to access the arbitration server.

    [Password]: Password to access the arbitration server.

  - In the [Remote WebAdmin for Arbitration server] section, the following items are displayed:

    [Remote WebAdmin address]: IP address of the remote WebAdmin installed on the arbitration server.

    [Remote WebAdmin port]: Port number for the WebAdmin installed on the arbitration server.

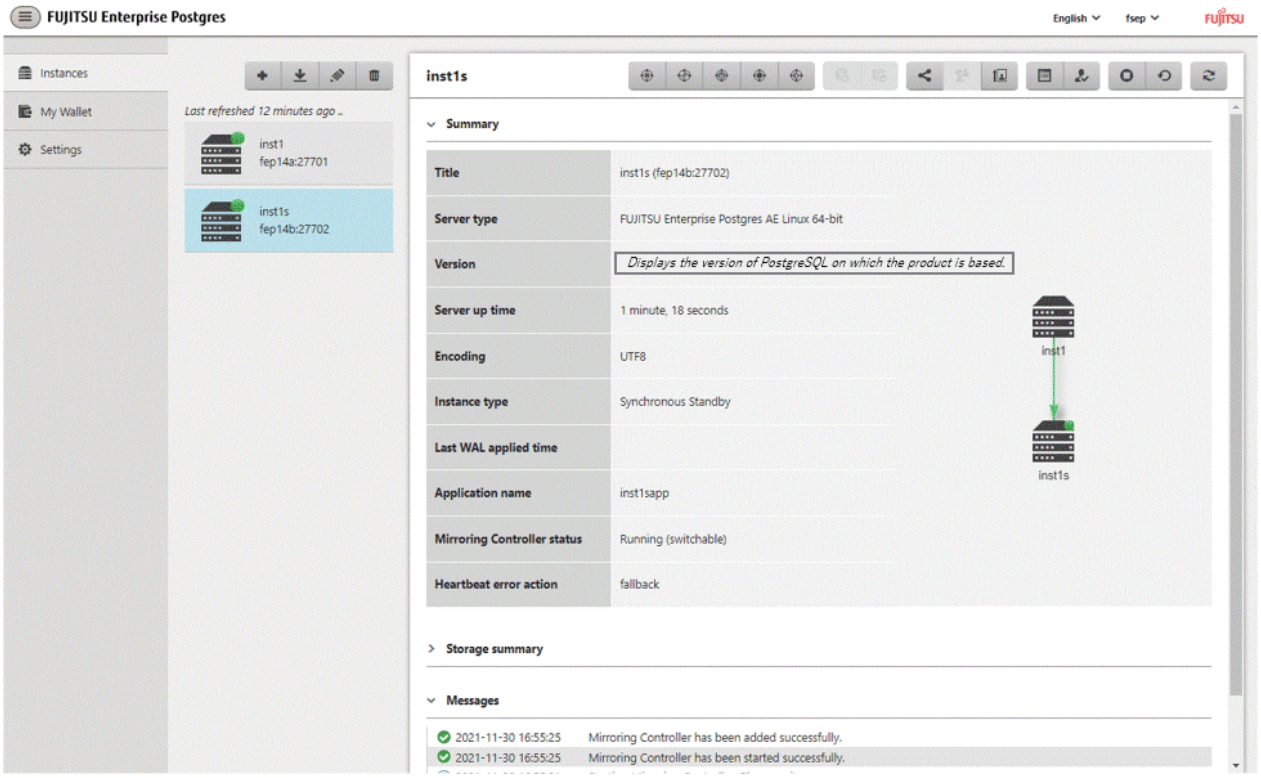
When the [Heartbeat error action] is set to "Command", the following extra items are displayed:

- [Arbitration command]: Full path of the arbitration command to be executed when an abnormality is detected.
- [Fencing command]: Full path of the fencing command that fences a database server when an abnormality is detected.

4. Click  to set up Mirroring Controller.

5. Upon successful completion, Mirroring Controller will be started on master and standby instances.

   In the [Instances] tab, select standby instance. The page below is displayed, in which you can check the Mirroring Controller status. In the example below, standby instance "inst1s" is used.



After the Mirroring Controller has been set up,  ([Edit Mirroring Controller] button) and  ([Mirroring Controller Configuration] button) are available.

When the [Heartbeat error action] is "Arbitration", the following information is displayed: whether the arbitration status is "online" or "offline", the arbitration server IP address and the arbitration process port.

 Note

Operating system credential (User name, Password) should not contain hazardous characters. Refer to "Appendix E WebAdmin Disallow User Inputs Containing Hazardous Characters".

5.2 Edit Mirroring Controller Setup

Settings made in "5.1 Mirroring Controller Setup" can be updated in either the master instance or a standby instance using WebAdmin.

Perform the following procedure to edit Mirroring Controller configuration:

1. In the [Instances] tab, select the instance for which the Mirroring Controller configuration is to be edited.
2. Click  .
3. Enter the information for the Mirroring Controller to be updated. Refer to "5.1 Mirroring Controller Setup".
4. Click  to update the Mirroring Controller.
5. Upon successful completion, Mirroring Controller will be started on master and standby instances.

Editing and saving the [Edit Mirroring Controller] page will reset all other settings that are not listed on this page to default values.

5.3 Mirroring Controller Configuration

The information related to Mirroring Controller monitoring and control (refer to "A.4.1 Server Configuration File for the Database Servers") and the information related to arbitration and control of the Mirroring Controller arbitration process (refer to "A.4.2 Arbitration Configuration File") can be set using WebAdmin. You can view and update the configuration on either the master instance or the standby instance.

Perform the following procedure:

1. In the [Instances] tab, select the instance for the Mirroring Controller configuration you want to view.
2. Click  to view the Mirroring Controller configuration.
3. Click  to show the editing page for the Mirroring Controller configuration. The Mirroring Controller configurations defined during [Mirroring Controller Setup] are read-only on this page. Refer to "5.1 Mirroring Controller Setup".

   Additionally, refer to the "Appendix A Parameters" for information about the settings and the corresponding parameter names.

   The items common to all [Heartbeat error action] are:

   - Target DB
   - Core file path
   - Syslog facility
   - Syslog identity
   - Remote call timeout (milliseconds)
   - Agent alive timeout (seconds)
   - DB instance check interval (milliseconds)
   - DB instance check timeout (seconds)
   - DB instance check retry
   - DB instance timeout action
   - Disk check interval (milliseconds)
   - Disk check retry
   - Tablespace directory error action
   - Post-switch command
   - Post-promote command
     (Post-promote command is replaced in FUJITSU Enterprise Postgres 12. The Post-promote command is still valid and will be displayed when it is used in the server configuration file of Mirroring Controller.)
   - Post-attach command
   - Pre-detach command
   - State transition command timeout (seconds)
   - Check synchronous standby names validation

   When the [Heartbeat error action] is set to "Arbitration", the following extra items are displayed:

   - Arbitration timeout (seconds)
   - Arbiter alive interval (milliseconds)
   - Arbiter alive retry
   - Arbiter alive timeout (seconds)
   - Arbiter connect interval (milliseconds)

- Arbiter connect timeout (seconds)
- Fencing command
- Fencing command timeout (seconds)
- Shutdown detached synchronous standby

When the [Heartbeat error action] is set to "Arbitration", the [Arbitration server configuration] section is displayed with the following items:

- Core file path
- Syslog facility
- Syslog identity
- Fencing command timeout (seconds)
- Heartbeat interval (milliseconds)
- Heartbeat timeout (seconds)
- Heartbeat retry

When the [Heartbeat error action] is set to "Command", the following extra items are available:

- Fencing command timeout (seconds)
- Arbitration command timeout (seconds)
- Shutdown detached synchronous standby

When the [Heartbeat error action] is set to "Message", the following extra items are available:

- Fencing command
- Fencing command timeout (seconds)

In addition, the following configurations are provided:

- DB instance JDBC connection SSL parameters
- DB instance libpq connection SSL parameters

4. Click  to update the Mirroring Controller configurations.

5.4 Stopping Mirroring Controller

Mirroring Controller can be stopped either in master instance or in standby instance using WebAdmin.

Perform the following procedure to stop Mirroring Controller.

1. In the [Instances] tab, select the instance where to stop Mirroring Controller.
2. Click  .
3. In the confirmation dialog box, click [Yes].

Mirroring Controller will be stopped on the selected instance. The Mirroring Controller status will be updated, and a confirmation message entry will be displayed in the [Message] section.

5.5 Starting Mirroring Controller

Mirroring Controller can be started either in master instance or in standby instance using WebAdmin.

Perform the following procedure to start Mirroring Controller.

1. In the [Instances] tab, select the instance where to start Mirroring Controller.
2. Click  .
3. In the confirmation dialog box, select the desired failover mode, and then click [Yes].

Mirroring Controller will be started on the selected instance. The Mirroring Controller status will be updated, and a confirmation message entry will be displayed in the [Message] section.

5.6 Disabling Failover Mode

Disabling failover mode in Mirroring Controller disables automatic switch/disconnection between master and standby instances.

Perform the following procedure to disable failover mode.

1. In the [Instances] tab, select the instance.
2. Click  .
3. In the confirmation dialog box, click [Yes].

Failover mode will be disabled in Mirroring Controller. The Mirroring Controller status will be updated and a confirmation message entry will be displayed in the [Message] section.

5.7 Enabling Failover Mode

Enabling failover mode in Mirroring Controller enables automatic switch/disconnection between master and standby instances.

Perform the following procedure to enable failover.

1. In the [Instances] tab, select the instance.
2. Click  .
3. In the confirmation dialog box, click [Yes].

Failover mode will be enabled in Mirroring Controller. The Mirroring Controller status will be updated and a confirmation message entry will be displayed in the [Message] section.

5.8 Deleting Mirroring Controller Setup

Deleting Mirroring Controller setup removes its setup from master and standby instances.

1. In the [Instances] tab, select the instance.
2. Click  .
3. In the confirmation dialog box, click [Yes].

Mirroring Controller setup will be removed from the cluster. The cluster status will be updated and a confirmation message entry will be displayed in the [Message] section.

For the instances in FUJITSU Enterprise Postgres 12 or later, WebAdmin does not delete the Mirroring Controller management directory and the configuration files.

5.9 Status Update after Failover

When Mirroring Controller performs a failover, standby instance will be promoted to standalone instance. The Mirroring Controller setup will be removed from both standby and master instances.

The following scenario describes one of the ways in which failover can be triggered, and the results achieved by the use of Mirroring Controller in WebAdmin.

1. In the [Instances] tab, select the master instance "inst1".
2. Click  .
3. In the confirmation dialog box, the warning "This instance is being monitored by Mirroring Controller. Stopping the instance may result in cluster failover." is displayed.
4. Choose the stop mode and click [Yes].

   In the server, the following takes place:

   a. The master instance is stopped.
   b. Failover is triggered in Mirroring Controller.
   c. The Mirroring Controller setup is removed from both master and standby instances
   d. Standby instance is promoted to standalone.
5. When the instance is refreshed in WebAdmin, the latest status of the instances will be displayed.

When failover is performed, the Mirroring Controller setup is removed from both master and standby instances. Therefore, to manage the Mirroring Controller using WebAdmin again, create the standby instance and set up Mirroring Controller.

Refer to "Creating a Standby Instance" in the Operation Guide for details.

Refer to "5.1 Mirroring Controller Setup" for details.

5.10 Action Required when an Error Occurs in the Combined Admin Network and Log Transfer Network

Communication errors may temporarily occur in the network used as the admin network and log transfer network due to reasons such as high load on the server or insufficient system resources. Because of this, there is a risk of causing a split-brain situation by mistake even though the server has no issues.

Split brain is a phenomenon in which both servers temporarily operate as primary servers, causing data updates to be performed on both servers.

How to detect split brain using WebAdmin

If the conditions below are met, split brain may occur. Refer to "Split-brain detection method" and "How to recover from a split-brain" in "Appendix D Notes on Performing Automatic Degradation Immediately after a Heartbeat Abnormality" and take the actions described.

1. A standby instance is selected in the [Instances] tab, and
2. "Standalone" is displayed in [Instance type], and
3. A master instance is selected in the [Instances] tab, and
4. "Standalone" is displayed in [Instance type].

The admin network is important because Mirroring Controllers use it to confirm the status of each server.

The log transfer network is also important to maintain the data freshness.

Therefore, use network configurations resistant to faults for these networks by using the network redundancy channel bonding feature provided by the operating system or network driver vendor.

5.11 Performing Automatic Degradation Using the Arbitration Server

If database multiplexing is performed using WebAdmin, it is also possible to perform automatic degradation using the arbitration server. In such cases, it is necessary to perform tasks on the database server and the arbitration server after setting up Mirroring Controller in WebAdmin.

Tasks on the arbitration server

Perform setup of the arbitration server using Mirroring Controller commands.

1. Set up the arbitration server.

   Refer to "2.3 Setting Up the Arbitration Server" in "Chapter 2 Setting Up Database Multiplexing Mode" for information on how to set up the arbitration server.

Tasks on the database server

Change some of the settings after setting up Mirroring Controller in WebAdmin.

1. Set up Mirroring Controller in WebAdmin.

   Refer to "5.1 Mirroring Controller Setup" for details.

2. Use WebAdmin to stop Mirroring Controller on the master and standby instances.

   Refer to "5.4 Stopping Mirroring Controller" for details.

3. Edit the network configuration file of the master and standby instances, and add the arbitration server information.

   The network configuration file is network.conf, which exists in the Mirroring Controller management directory specified during Mirroring Controller setup. Refer to "A.3 Network Configuration File" for details.

   A definition example of network.conf is shown below.

   ```
   Example:
   The port number of the database server to be used as the arbitration network is set to "27541".
   The ID of the server of the Mirroring Controller arbitration process is set to "arbiter", and its
   port number is set to "27541".
   ```

   ```
   dbsvm27500 192.0.2.100,192.0.3.100 27540,27541 server
   dbsvs27500 192.0.2.110,192.0.3.110 27540,27541 server
   arbiter 192.0.3.120 27541 arbiter
   ```

   Note

   - Ensure that the port numbers set for the database server and the arbitration server do not conflict with other software. In addition, do not configure the same segment for the admin network and the arbitration network.
   - If the server type is "server", two IP addresses or host names, and two port numbers need to be specified in the following order:
     - IP address or host name of the database server used as the admin network
     - IP address or host name of the database server used as the arbitration network
     - Port number of the database server used as the admin network
     - Port number of the database server used as the arbitration network

- If the server type is "arbiter", specify the IP address or host name set for the my_address parameter and the port number set for the port parameter in arbitration.conf of the arbitration server.
- WebAdmin also support editing mirroring controller configuration via Use WebAdmin to edit Mirroring Controller configurations.
  Refer to "5.2 Edit Mirroring Controller Setup" for detailes.

4. Edit the server configuration file of the master and standby instances, and add the parameters required for automatic degradation using the arbitration server.

   The server configuration file is *instanceName*.conf or *instancePort*.conf, which exists in the Mirroring Controller management directory specified during Mirroring Controller setup.

   To perform automatic degradation using the arbitration server, set the heartbeat_error_action parameter to "arbitration".

   Refer to "A.4.1 Server Configuration File for the Database Servers" for information on other parameters.

5. Use WebAdmin to start Mirroring Controller on the master and standby instances.

   Refer to "5.5 Starting Mirroring Controller" for details.

Common tasks

1. Use the Mirroring Controller command to check the connection status from the database server or the arbitration server.

   Refer to "2.8 Checking the Connection Status" for information on how to check the connection status.

Appendix A Parameters

This appendix describes the configuration files and parameters required by the database multiplexing mode.

See

Refer to "Server Configuration" in the PostgreSQL Documentation for information on the postgresql.conf file.

A.1 Parameters Set on the Primary Server

The content for the parameters set in the postgresql.conf file of the primary server is shown in the table below.

Table A.1 postgresql.conf file

Parameter	Value set	Explanation
wal_level	replica or logical	Specify the output level for the transaction log. Specify "logical" when logical decoding is also to be used.
max_wal_senders	2 or more	Specify "2" when building a Mirroring Controller cluster system. When additionally connecting asynchronous standby servers to the cluster system, add the number of simultaneous connections from these standby servers.
synchronous_standby_names	'*standbyServerName*'	Use single quotation marks (') to enclose the name that will identify the standby server. Any name can be specified. Do not change this parameter while Mirroring Controller is running. Do not specify multiple names to this parameter as the Mirroring Controller can manage only one standby server.
hot_standby	on	Specify whether queries can be run on the standby server. Specify "on".
wal_keep_size	WAL save size (megabytes)	If a delay exceeding the value set in this parameter occurs, the WAL segment required later by the primary server may be deleted. Additionally, if you stop a standby server (for maintenance, for example), consider the stop time and set a value that will not cause the WAL segment to be deleted. Refer to "Estimating Transaction Log Space Requirements" in the Installation and Setup Guide for Server for information on estimating the WAL save size.
wal_log_hints	on	When using the pg_rewind command to recover a standby server, specify this parameter or enable checksums when executing the initdb command.
wal_sender_timeout	Timeout (milliseconds)	Specify the time period after which it is determined that the receiver process (walreceiver) of the transaction log is in an abnormal state on the primary server. The specified value must be larger than the value set for the wal_receiver_status_interval parameter set in the postgresql.conf file of the standby server.

Parameter	Value set	Explanation
		By aligning this value with the value for the database process heartbeat monitoring time, you can unify the time after which it is determined that an error has occurred.
wal_receiver_timeout	Timeout (milliseconds)	Specify the time period after which it is determined that an error has occurred when the transaction log was received on the standby server. By aligning this value with the value for the database process heartbeat monitoring time, you can unify the time after which it is determined that an error has occurred.
archive_mode	on	Specify the archive log mode.
archive_command	'*installDir*/bin/pgx_walcopy.cmd "%p" "*backupDataStorageDestinationDirectory*/archived_wal/%f"'	Specify the command and storage destination to save the transaction log.
backup_destination	Backup data storage destination directory	Specify the name of directory where to store the backup data. Set the permissions so that only the instance administrator user can access the specified directory. Specify the same full path on all servers, so that the backup data of other servers can be used to perform recovery.
listen_addresses	Primary server IP address, host name, or "*"	Specify the IP address or host name of the primary server. Specify the IP address or corresponding host name that will be used to connect to the log transfer network. The content specified is also used to allow connections from client applications. To receive the connection and the transaction log from any client or standby server, specify "*". Refer to "Connections and Authentication" in the PostgreSQL Documentation for details.
max_connections	Number of simultaneous client connections to the instance + superuser_reserved_connections value	The value specified is also used to restrict the number of connections from client applications and the number of connections for the management of instances. Refer to "When an Instance was Created with the initdb Command" in the Installation and Setup Guide for Server, and "Connections and Authentication" in the PostgreSQL Documentation, for details.
superuser_reserved_connections	Add the number of simultaneous executions of mc_ctl status (*1) + 2	Specify the number of connections reserved for connections from database superusers. Add the number of connections from Mirroring Controller processes. Also reflect the added value in the max_connections parameter.
restart_after_crash	off	If "on" is specified, or the default value is used for this parameter, behavior equivalent to restarting FUJITSU Enterprise Postgres, including crash recovery, will be performed when some server processes end abnormally. However, when database multiplexing monitoring is used, a failover will occur after an error is detected when some server processes end abnormally, and the restart of those server processes is forcibly stopped. Specify "off" to

Parameter	Value set	Explanation
		prevent behavior such as this from occurring for no apparent reason.
synchronous_commit	on or remote_apply	Specify up to what position WAL send is to be performed before transaction commit processing returns a normal termination response to a client. The recommended value is "on" or "remote_apply" to prevent data loss caused by operating system or server down immediately after a switch or switch.
recovery_target_timeline	latest	Specify "latest" so that the new standby server (original primary server) will follow the new primary server when a switch occurs. This parameter is required when the original primary server is incorporated as a new standby server after the primary server is switched.

*1: Number of simultaneous executions of the mc_ctl command in the status mode.

A.2 Parameters Set on the Standby Server

This section explains the content of the file and parameters set on the standby server. After editing postgresql.conf file, start the instance.

The content for the parameters specified in postgresql.conf file is shown in the table below.

Table A.2 postgresql.conf file

Parameter	Value set	Explanation
wal_level	replica or logical	Specify the output level for the transaction log. Specify "logical" when logical decoding is also to be used.
max_wal_senders	2 or more	Specify "2" when building a Mirroring Controller cluster system. When additionally connecting asynchronous standby servers to the cluster system, add the number of simultaneous connections from these standby servers.
synchronous_standby_names	'*primaryServerName*'	Use single quotation marks (') to enclose the name that will identify the primary server. Any name can be specified. This name will be required to rebuild the original primary server as the new standby server after the primary server was switched. Do not change this parameter while Mirroring Controller is running. Do not specify multiple names to this parameter as the Mirroring Controller can manage only one standby server.
hot_standby	on	Specify whether queries can be run on the standby server. Specify "on".
wal_keep_size	WAL save size (megabytes)	If a delay exceeding the value set in this parameter occurs, the WAL segment required later by the standby server may be deleted by the primary server.

Parameter	Value set	Explanation
		Additionally, if you stop a standby server (for maintenance, for example), consider the stop time and set a value that will not cause the WAL segment to be deleted. Refer to "Estimating Transaction Log Space Requirements" in the Installation and Setup Guide for Server for information on estimating the WALsave size.
wal_log_hints	on	When using the pg_rewind command to recover a standby server, specify this parameter or enable checksums when executing the initdb command.
wal_sender_timeout	Timeout (milliseconds)	Specify the time period after which it is determined that the receiver process (walreceiver) of the transaction log is in an abnormal state on the primary server. The specified value must be larger than the value set for the wal_receiver_status_interval parameter set in the postgresql.conf file of the standby server. By aligning this value with the value for the database process heartbeat monitoring time, you can unify the time after which it is determined that an error has occurred.
wal_receiver_timeout	Timeout (milliseconds)	Specify the time period after which it is determined that an error has occurred when the transaction log was received on the standby server. By aligning this value with the value for the database process heartbeat monitoring time, you can unify the time after which it is determined that an error has occurred.
backup_destination	Backup data storage destination directory	Specify the name of the backup data storage directory. Set the permissions so that only the instance administrator user can access the specified directory. Specify the same full path on all servers so that the backup data of other servers can be used to perform recovery.
archive_mode	on	Specify the archive log mode.
archive_command	'*installDir*/bin/pgx_walcopy.cmd "%p" "*backupDataStorageDestinationDirectory*/archived_wal/%f"'	Specify the command and storage destination to save the transaction log.
listen_addresses	Standby server IP address, host name, or "*"	Specify the IP address or host name of the standby server. Specify the IP address or corresponding host name that will be used to connect to the log transfer network. The content specified is also used to allow connections from client applications. To receive the connection and the transaction log from any client or standby server, specify "*". Refer to "Connections and Authentication" in the PostgreSQL Documentation for details.

Parameter	Value set	Explanation
max_connections	Number of simultaneous client connections to the instance + superuser_reserved_connections value	The value specified is also used to restrict the number of connections from client applications and the number of connections for the management of instances. Refer to "When an Instance was Created with the initdb Command" in the Installation and Setup Guide for Server, and "Connections and Authentication" in the PostgreSQL Documentation, for details.
superuser_reserved_connections	Add the number of simultaneous executions of mc_ctl status (*1) + 2	Specify the number of connections reserved for connections from database superusers. Add the number of connections from Mirroring Controller processes. Also reflect the added value in the max_connections parameter.
restart_after_crash	off	If "on" is specified, or the default value is used for this parameter, behavior equivalent to restarting FUJITSU Enterprise Postgres, including crash recovery, will be performed when some server processes end abnormally. However, when database multiplexing monitoring is used, a failover will occur after an error is detected when some server processes end abnormally, and the restart of those server processes is forcibly stopped. Specify "off" to prevent behavior such as this from occurring for no apparent reason.
synchronous_commit	on or remote_apply	Specify up to what position WAL send is to be performed before transaction commit processing returns a normal termination response to a client. The recommended value is "on" or "remote_apply" to prevent data loss caused by operating system or server down immediately after a switch or switch.
primary_conninfo	'*streamingReplication ConnectionDestinationInfo*'	Use single quotation marks (') to enclose the connection destination information of the streaming replication. The default value of this parameter is automatically set to postgresql.auto.conf in the procedure to run pg _ basebackup for instance setup.
recovery_target_timeline	latest	Specify "latest" so that the new standby server (original primary server) will follow the new primary server when a switch occurs. This parameter is required when the original primary server is incorporated as a new standby server after the primary server is switched.
streaming_wal_compression	Any number from -1 to 9	Specifies that you want to send a compressed WAL by streaming replication. -1: Compress at zlib's default compression level 0: Uncompressed 1-9: Compress at specified compression level, 9 is high compression Default is uncompressed.

A.3 Network Configuration File

This section explains the network configuration file (network.conf) to be defined individually for the database servers and the arbitration server. Define the same content on the primary server and standby server.

For database multiplexing mode, define the network configuration for the following in network.conf.

- Integration between Mirroring Controller processes
- Integration between a Mirroring Controller process and the Mirroring Controller arbitration process

Items to be defined in network.conf

Format:

```
serverIdentifier hostName[,hostName] portNum[,portNum] [serverType]
Or,
serverIdentifier ipAddr[,ipAddr] portNum[,portNum] [serverType]
```

Specify the server identifier, IP address or host name, port number, and server type, using a space as the delimiter.

The items are explained in the table below.

Table A.3 network.conf file

Item	Description
serverIdentifier	Specify any identifier for the server. The maximum length is 64 bytes. Use ASCII characters excluding spaces and number signs (#) to specify this parameter.
ipAddrOrHostName	Specify the IP address or its corresponding host name that will connect to the admin network that performs communication between the database servers, and to the arbitration network that performs communication between a database server and the arbitration server. When specifying two IP addresses or host names delimited by a comma, do not insert a space after the comma. Use ASCII characters excluding spaces to specify the host name.
portNum	A port number cannot be specified if it exceeds the range 0 to 65535. Ensure that the port number does not conflict with other software. Do not specify an ephemeral port that may temporarily be assigned by another program. Note that the value specified in this parameter must also be set in the services file. When specifying two port numbers delimited by a comma, do not insert a space after the comma.
serverType	Specify "server" for a database server ("server" can be omitted), or "arbiter" for the arbitration server.

Content to be defined on the database servers

This section explains the network.conf content to be defined on the database servers.

The content to be defined depends on the operation settings at the time a heartbeat abnormality is detected.

When automatic degradation by the arbitration server is selected

- Specify definitions related to the admin network and arbitration network.
- Specify the IP address or host name and port number according to the server type (database server or arbitration server) as shown in the table below.

Server type	IP address or host name		Port number	
	First	Second	First	Second
server	IP address or host name used as the admin network	IP address or host name used as the arbitration network (*1)	Port number used as the admin network	Port number used as the arbitration network (*1)

Server type	IP address or host name		Port number	
	First	Second	First	Second
arbiter	IP address or host name of the arbitration server Specify the same value as that specified in the my_address parameter of arbitration.conf on the arbitration server.	Not required	Port number on the arbitration server Specify the same value as that specified in the port parameter of arbitration.conf on the arbitration server.	Not required

*1: This value can be omitted from definitions not related to the local server. If it is omitted, network.conf must be created on both the primary server and standby server.

Example)

IPv4

```
server1 192.0.2.100,192.0.3.100 27540,27541 server
server2 192.0.2.110,192.0.3.110 27540,27541 server
arbiter 192.0.3.120 27541 arbiter
```

IPv6

```
server1 2001:258:8404:1217:250:56ff:fea7:559f,2001:258:8404:1217:250:56ff:fea8:559f
27540,27541 server
server2 2001:258:8404:1217:250:56ff:fea7:55a0,2001:258:8404:1217:250:56ff:fea8:55a0
27540,27541 server
arbiter 2001:258:8404:1217:250:56ff:fea8:55a0 27541 arbiter
```

When operation other than automatic degradation by the arbitration server is selected

- Specify definitions related to the admin network.
- Define the same content on the primary server and standby server.
- Define lines for database servers only.
- Specify only one IP address or host name and port number.

IP address or host name		Port number	
First	Second	First	Second
IP address or host name to be used as the admin network	Not required	Port number used as the admin network	Not required

Example)

The literal space represents a space.

IPv4

```
server1 192.0.2.100 27540
server2 192.0.2.110 27540
```

IPv6

```
server1 2001:258:8404:1217:250:56ff:fea7:559f 27540
server2 2001:258:8404:1217:250:56ff:fea7:55a0 27540
```

Content to be defined on the arbitration server

This section explains the network.conf content to be defined on the arbitration server.

- Specify definitions related to the arbitration network.
- Define lines for database servers only.
- For the IP address or host name, specify the same value as the second IP address or host name specified in the database server line in network.conf of the database server.
- For the port number, specify the same value as the second port number specified in the database server line in network.conf of the database server.

Example)

The literal space represents a space.

IPv4

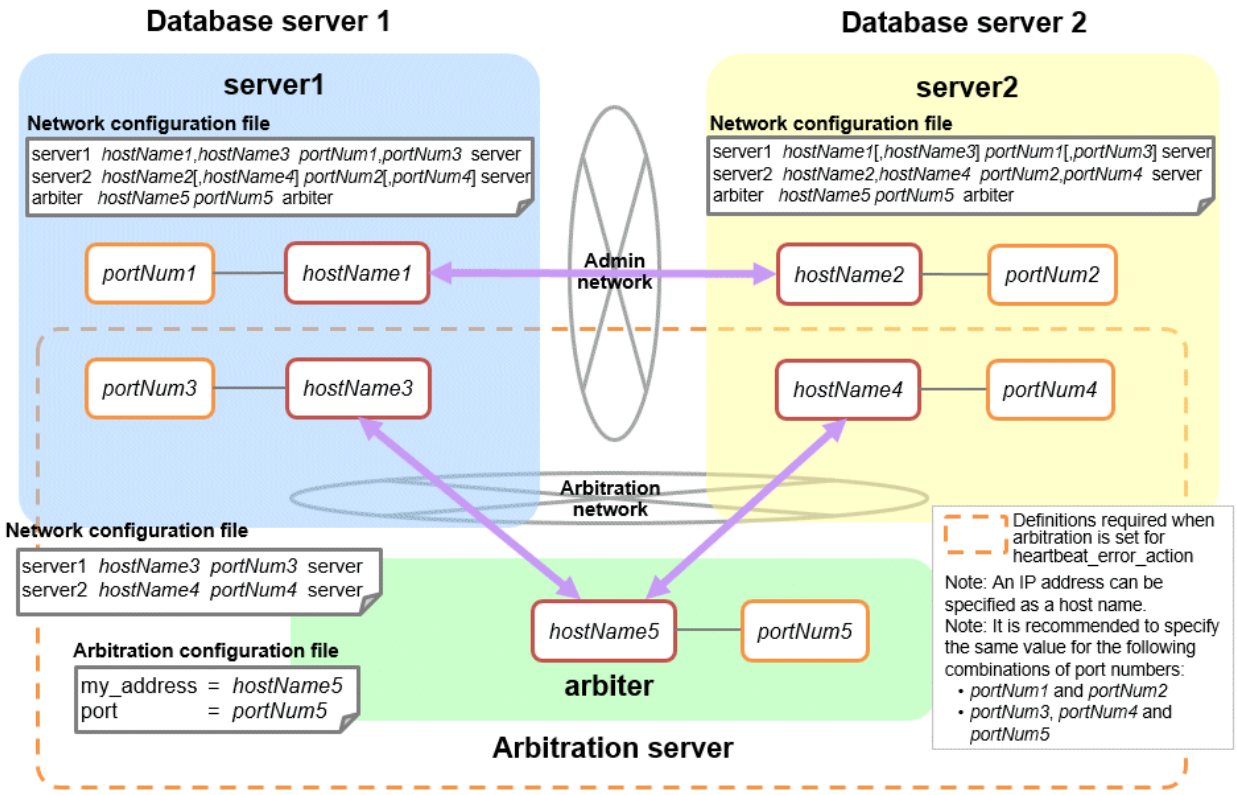
```
server1 192.0.3.100 27541
server2 192.0.3.110 27541
```

IPv6

```
server1 2001:258:8404:1217:250:56ff:fea8:559f 27541
server2 2001:258:8404:1217:250:56ff:fea8:55a0 27541
```

Relationship between network-related definitions

Refer to the diagram below for the relationship between the host names and IP addresses or port numbers specified in the network configuration file (network.conf) and arbitration configuration file (arbitration.conf).



A.4 Server Configuration File

A.4.1 Server Configuration File for the Database Servers

Define the information related to Mirroring Controller monitoring and control in the serverIdentifier.conf file. The maximum length of the server identifier is 64 bytes. Use ASCII characters excluding spaces to specify this parameter.

If the primary server and standby server environments are different, define content that is different, according to the environment.

Table A.4 serverIdentifier.conf file

Parameter	Value set	Explanation
db_instance	'*dataStorageDestinationDir*' [Example] db_instance = '/database1/inst1'	Specify using single quotation marks (') to enclose the data storage destination directory used to identify the monitoring target instance. Use ASCII characters to specify this parameter.
target_db	postgres or template1	Specify the name of the database to be connected to the database instance. The default is "postgres".
db_instance_username	'*usernameToConnectToDbInstance*'	Specify the username to connect to the database instance. Use ASCII characters to specify this parameter. Specify this parameter if the database administrator user is different from the operating system user who starts Mirroring Controller. Enclose the username of the database superuser in single quotation marks ('). The maximum length of the username is 63 bytes.

Parameter	Value set	Explanation
		The default is the operating system user who starts Mirroring Controller.
db_instance_password	'*passwordOfInstanceAdminUser*'	Specify the password used when Mirroring Controller connects to a database instance, enclosed in single quotation marks ('). Use ASCII characters to specify this parameter. If password authentication is performed, you must specify this parameter in the settings used when Mirroring Controller connects to a database instance. If you specify this parameter when password authentication is not performed, the parameter will be ignored. If the specified value of this parameter includes ' or \, write \' or \\, respectively.
enable_hash_in_password	on or off	Specify on to treat the # in the db_instance_password specification as a password character, or off to treat it as a comment. The default is "off".
core_file_path	*'coreFileOutputDir'*	Specify the directory to which the core file is to be output, enclosed in single quotation marks ('). Use ASCII characters to specify this parameter. If this parameter is omitted, it will be assumed that the Mirroring Controller management directory was specified.
syslog_facility	Specify LOCAL0, LOCAL1, LOCAL2, LOCAL3, LOCAL4, LOCAL5, LOCAL6, or LOCAL7.	When the import of logs to the syslog is enabled, the value of this parameter will be used for "facility" of the syslog. The default is "LOCAL0".
syslog_ident (*1)	'*programName*'	Specify using single quotation marks (') to enclose the program name used to identify the Mirroring Controller message in the system log. Use ASCII characters excluding spaces to specify this parameter. The default is 'MirroringControllerOpen'.
remote_call_timeout	Admin communication timeout	Specify the timeout value (milliseconds) of the Mirroring Controller agent process for communication between servers. Specify a value between 0 and 2147483647 to be less than the operation system TCP connection timeout (*2). The value 0 indicates that there is no timeout limit. The default is 70000 milliseconds (70 seconds).
agent_alive_timeout	Timeout for Mirroring Controller process heartbeat monitoring (seconds)	If there is no response for at least the number of seconds specified, the Mirroring Controller process is restarted. Specify 0 or a value between 2 and 2147483647. The value 0 indicates that there is no timeout limit. The default is 0 seconds.
heartbeat_error_action	Operation when a heartbeat abnormality is detected using	arbitration: Perform automatic degradation using the arbitration server.

Parameter	Value set	Explanation
	operating system or server heartbeat monitoring	command: Call a user command to determine degradation, and perform automatic degradation if required. message: Notify messages. fallback: Perform automatic degradation unconditionally. The default is "arbitration". Set the same value on the primary server and standby server.
heartbeat_interval	Interval time for abnormality monitoring during heartbeat monitoring of the operating system or server (milliseconds)	Abnormality monitoring of the operating system or server is performed at the interval specified in heartbeat_interval. If an error is detected, operation will conform to the value specified for heartbeat_error_action. If "arbitration" is specified in heartbeat_error_action, the error detection time during monitoring of the operating system or server becomes longer than when the arbitration server is not used, by up to the value specified for arbitration_timeout. Specify a value between 1 and 2147483647. The specified value is used as the default for db_instance_check_interval and disk_check_interval. The default is 800 milliseconds.
heartbeat_timeout	Timeout for abnormality monitoring during heartbeat monitoring of the operating system or server (seconds)	If there is no response for at least the number of seconds specified, it will be assumed that an error has occurred that requires the primary server to be switched, or the standby server to be disconnected. If an error is detected, operation will conform to the value specified for heartbeat_error_action. If "arbitration" is specified in heartbeat_error_action, the error detection time during monitoring of the operating system or server becomes longer than when the arbitration server is not used, by up to the value specified for arbitration_timeout. Specify a value between 1 and 2147483647. The specified value is used as the default for db_instance_check_timeout. The default is 1 second.
heartbeat_retry	Number of retries for abnormality monitoring during heartbeat monitoring of the operating system or server (number of times)	Specify the number of retries to be performed when an error has been detected that requires the primary server to be switched, or the standby server to be disconnected. If an error is detected in succession more than the specified number of times, switch or disconnection will be performed. If an error is detected, operation will conform to the value specified for heartbeat_error_action. If "arbitration" is specified in heartbeat_error_action, the error detection time during monitoring of the operating system or server becomes longer than when the arbitration server is not used, by up to the value specified for arbitration_timeout. Specify a value between 0 and 2147483647. The specified value is used as the default for db_instance_check_retry and disk_check_retry.

Parameter	Value set	Explanation
		The default is 2 times.
db_instance_check_interval	Database process heartbeat monitoring interval (milliseconds)	Heartbeat monitoring of the database process is performed at the interval specified in db_instance_check_interval. This parameter setting is also used for abnormality monitoring of streaming replication. Specify a value between 1 and 2147483647. The default is the value set for heartbeat_interval.
db_instance_check_timeout	Database process heartbeat monitoring timeout (seconds)	If there is no response for at least the number of seconds specified, it will be assumed that an error has occurred that requires the primary server to be switched, or the standby server to be disconnected. Specify a value between 1 and 2147483647. The default is the value set for heartbeat_timeout.
db_instance_check_retry	Number of retries for database process heartbeat monitoring (number of times)	Specify the number of retries to be performed when an error has been detected that requires the primary server to be switched, or the standby server to be disconnected. If an error is detected in succession more than the specified number of times, switch or disconnection will be performed. However, if it detects that the database process is down, it will immediately switch or disconnect regardless of the setting of this parameter. This parameter setting is also used for abnormality monitoring of streaming replication. Specify a value between 0 and 2147483647. The default number of retries is the value set for heartbeat_retry.
db_instance_timeout_action	none, message, or failover	Specify the behavior for no-response monitoring of the instance. none: Do not perform no-response monitoring. message: Notify messages if an error is detected during no-response monitoring. failover: Perform automatic degradation if an error is detected during no-response monitoring. The default is "failover".
disk_check_interval	Interval time for disk abnormality monitoring (milliseconds)	Abnormality monitoring of disk failure is performed at the interval specified in disk_check_interval. If the file cannot be created, it will be assumed that an error has occurred that requires the primary server to be switched, or the standby server to be disconnected. Specify a value between 1 and 2147483647. Set a value larger than the disk access time. The default is the value set for heartbeat_interval.
disk_check_retry	Number of retries for disk abnormality monitoring (number of times)	Specify the number of retries to be performed when an error has been detected that requires the primary server to be switched, or the standby server to be disconnected.

Parameter	Value set	Explanation
		If an error is detected in succession more than the specified number of times, switch or disconnection will be performed. Specify a value between 0 and 2147483647. The default number of retries is the value set for heartbeat_retry.
disk_check_timeout (*3)	Abnormality monitoring timeout time (seconds)	The time allowed from the start time of the next disk_check_interval after a disk error occurs until the error is determined to be due to timeout. To disconnect the standby server when a disk error due to this timeout is detected on the standby server, set shutdown_detached_synchronous_standby to on. The default is 2147483. Specify an integer between 0 and 2147483.
disk_check_max_threads (*3)	Upper limit on the number of threads used for abnormality monitoring	Upper limit on the number of threads for disk monitoring. The default is the number of processors available to the JVM) Specify an integer between 1 and 2147483647, but setting a value greater than the threads available on the machine may result in a system error. When you run the mc_ctl status command separately from the monitoring process, each mc_ctl status temporarily uses the same number of threads as the monitoring process. When setting disk_check_max_threads, consider the machine's thread limit, the number of table spaces you plan to use, and the number of mc_ctl status commands that may be executed at the same time.
tablespace_directory_error_action	message or failover	Specify the behavior to be implemented if an error is detected in the tablespace storage directory. message: Notify messages. failover: Perform automatic degradation. The default is "failover".
arbiter_alive_interval	Interval time for monitoring connection to the Mirroring Controller arbitration process (milliseconds)	A heartbeat is sent to the Mirroring Controller arbitration process at the specified interval. Specify a value between 1 and 2147483647. The default is 16000 milliseconds. This parameter does not need to be set for operation that does not use the arbitration server.
arbiter_alive_timeout	Timeout for monitoring connection to the Mirroring Controller arbitration process (seconds)	If the heartbeat does not respond within the specified number of seconds, the Mirroring Controller arbitration process is determined to have been disconnected, a message is output, and reconnection is attempted. Specify a value between 1 and 2147483647. The default is 20 seconds. This parameter does not need to be set for operation that does not use the arbitration server.

Parameter	Value set	Explanation
arbiter_alive_retry	Number of retries for monitoring connection to the Mirroring Controller arbitration process (number of times)	Specify the number of heartbeat retries to be performed if an error is detected in the heartbeat to the Mirroring Controller arbitration process. If the heartbeat does not respond within the specified number of retries, the Mirroring Controller arbitration process is determined to have been disconnected. Specify a value between 0 and 2147483647. The default is 0 times. This parameter does not need to be set for operation that does not use the arbitration server.
arbiter_connect_interval	Attempt interval for connection to the Mirroring Controller arbitration process (milliseconds)	Reconnection is attempted at the specified interval if connection fails at startup of the Mirroring Controller process or if the Mirroring Controller arbitration process is disconnected. Specify a value between 1 and 2147483647. The default is 16000 milliseconds. This parameter does not need to be set for operation that does not use the arbitration server.
arbiter_connect_timeout	Timeout for connection to the Mirroring Controller arbitration process (seconds)	If reconnection at startup of the Mirroring Controller process or after disconnection of the Mirroring Controller arbitration process does not succeed within the specified number of seconds, connection to the Mirroring Controller arbitration process is determined to have failed and reconnection is attempted. Specify a value between 1 and 2147483647. The default is 20 seconds. This parameter does not need to be set for operation that does not use the arbitration server.
fencing_command	'*fencingCmdFilePath*' [Setting example] fencing_command = '/mc/fencing_dir/execute_fencing.sh'	Specify the full path of the fencing command that fences a database server where an error is determined to have occurred. Enclose the path in single quotation marks ('). Specify the path using less than 1024 bytes. This parameter must be specified when "command" is set for heartbeat_error_action.
fencing_command_timeout	Fencing command timeout (seconds)	If the command does not respond within the specified number of seconds, fencing is determined to have failed and a signal (SIGTERM) is sent to the fencing command execution process. Specify a value between 1 and 2147483647. The default is 20 seconds.
arbitration_timeout	Arbitration processing timeout in the Mirroring Controller arbitration process (seconds)	The specified value must be at least equal to the value of fencing_command_timeout in the arbitration configuration file, which is the heartbeat monitoring time of the operating system or server. If there is no response for at least the number of seconds specified, the primary server will not be switched and the

Parameter	Value set	Explanation
		standby server will not be disconnected. Therefore, perform degradation manually. If the heartbeat_interval, heartbeat_timeout, and heartbeat_retry values are specified in arbitration.conf for the arbitration server, use the arbitration server values to design arbitration_timeout. Specify a value between 1 and 2147483647. The default is 30 seconds. This parameter does not need to be set for operation that does not use the arbitration server.
arbitration_command	'*arbitrationCmdFilePath*' [Setting example] arbitration_command = '/mc/arbitration_dir/execute_arbitration_command.sh'	Specify the full path of the arbitration command to be executed when an abnormality is detected during heartbeat monitoring of the operating system or server. Enclose the path in single quotation marks ('). Specify the path using less than 1024 bytes. This parameter must be specified when "command" is set for heartbeat_error_action.
arbitration_command_timeout	Arbitration command timeout (seconds)	If the arbitration command does not respond within the specified number of seconds, it is determined that execution of the arbitration command has failed and a signal (SIGTERM) is sent to the arbitration command execution process. Specify a value between 1 and 2147483647. The default is 30 seconds. This parameter can be specified only when "command" is set for heartbeat_error_action.
shutdown_detached_synchronous_standby	on or off	Specify whether to forcibly stop the instance on the standby server when the standby server is disconnected. on: Stop the instance. off: Do not stop the instance. If "on" is specified and the pre-detach command was created, the pre-detach command is executed and then the instance is stopped. The default is "off".
post_switch_command	'*postSwitchCmdFilePath*' [Setting example] post_switch_command = '/mc/status_change/execute_post_switch.sh'	Specify the full path of the command to be called by Mirroring Controller after a new primary server is promoted during a failover of the primary server. Enclose the path in single quotation marks ('). Specify the path using less than 1024 bytes.
post_attach_command	'*postAttachCmdFilePath*' [Setting example] post_attach_command = '/mc/status_change/execute_post_attach.sh'	Specify the full path of the command to be called by Mirroring Controller after the standby server is attached to the cluster system. Enclose the path in single quotation marks ('). Specify the path using less than 1024 bytes.

Parameter	Value set	Explanation
pre_detach_command	'*preDetachCmdFilePath*' [Setting example] pre_detach_command = '/mc/status_change/execute_pre_detach.sh'	Specify the full path of the command to be called by Mirroring Controller before the standby server is disconnected from the cluster system. Enclose the path in single quotation marks ('). Specify the path using less than 1024 bytes.
status_change_command_timeout	State transition command timeout (seconds)	Specify the timeout value of the post-switch command, post-attach command, and pre-detach command. If the command does not respond within the specified number of seconds, a signal (SIGTERM) is sent to the execution process of the status change command. Specify a timeout between 1 and 2147483647. The default is 20 seconds.
enable_promote_on_os_and_admin_network_error (*4)	on or off	If on is specified, if a admin network error occurs and replication is further lost, the system will ask the arbitration server to verify that the primary server and databases are running, and if they are down, promote the standby server. The default is "off".
check_synchronous_standby_names_validation	on or off	Specify whether Mirroring Controller is to periodically check during operations whether the synchronous_standby_names parameter in postgresql.conf was changed by an incorrect user operation. However, it is not recommended to enable this parameter, because performing this check causes Mirroring Controller to use the CPU of the database server redundantly and execute SQL statements at high frequency. The default is "off".
db_instance_ext_pq_conninfo	*'libpqConnectionSSLParmToConnectToDbinstance'*	Specify, in key-value form, the connection parameter for libpq that Mirroring Controller adds when connecting to a database. The connection parameters you can specify are those related to SSL. Use ASCII characters to specify this parameter. The connection parameter specified in this parameter must also be specified in the db_instance_ext_jdbc_conninfo.
db_instance_ext_jdbc_conninfo	*'JDBCConnectionSSLParmToConnectToDbinstance'*	Specify, in URI form, the connection parameter for JDBC that Mirroring Controller adds when connecting to a database. The connection parameters you can specify are those related to SSL. Use ASCII characters to specify this parameter. The connection parameter specified in this parameter must also be specified in the db_instance_ext_pq_conninfo.

*1: By specifying the syslog_ident parameter of the postgresql.conf file, the Mirroring Controller output content can be referenced transparently, so log reference is easy.

*2: The operating system TCP connection timeout period is determined by the kernel parameter tcp_syn_retries. The remote_call_timeout parameter must be set to a value that is shorter than the timeout period for the operating system TCP connection timeout, so change either parameter as necessary.

*3: Parameters available by applying bug fixes including PH23295.

*4: Parameters available by applying bug fixes including PH23520.

The availability of some parameters depends on the value set for the heartbeat_error_action parameter that sets the operation to be performed if heartbeat monitoring of the operating system or server detects a heartbeat abnormality.

Table A.5 Parameter availability depending on the value set for the heartbeat_error_action parameter

Parameter	Value set			
	arbitration	command	message	fallback
arbiter_alive_interval	Y	N	N	N
arbiter_alive_timeout	Y	N	N	N
arbiter_alive_retry	Y	N	N	N
arbiter_connect_interval	Y	N	N	N
arbiter_connect_timeout	Y	N	N	N
arbitration_timeout	Y	N	N	N
arbitration_command	N	R	N	N
arbitration_command_timeout	N	Y	N	N
fencing_command	Y	R	Y	N
fencing_command_timeout	Y	Y	Y	N
shutdown_detached_synchronous_standby	Y	Y	N	N

R: Required

Y: Can be specified

N: Cannot be specified

A.4.2 Arbitration Configuration File

In arbitration.conf, define the information related to arbitration and control of the Mirroring Controller arbitration process.

Table A.6 arbitration.conf file

Parameter	Value set	Description
port	Port number of the Mirroring Controller arbitration process	The specified value must not exceed the range 0 to 65535. Ensure that the port number does not conflict with other software. Do not specify an ephemeral port that may temporarily be assigned by another program. For the port number of the arbitration server to be specified in network.conf on the database server, specify the same value as the port number specified in this parameter.
my_address	'*ipAddrOrHostNameThatAcceptsConnectionFromMirroringControllerProcessOnDbServer*' [Setting example] my_address = '192.0.3.120'	For the IP address or host name of the arbitration server to be specified in network.conf on the database server, specify the same value as the IP address or host name specified in this parameter. IPv4 and IPv6 addresses can be specified. Specify the IP address or host name, enclosed in single quotation marks (').
core_file_path	'*coreFileOutputDir*'	Specify the directory to which the core file is to be output, enclosed in single quotation marks ('). Use ASCII characters to specify this parameter.

Parameter	Value set	Description
		If this parameter is omitted, it will be assumed that the Mirroring Controller arbitration process management directory was specified.
syslog_facility	Specify LOCAL0, LOCAL1, LOCAL2, LOCAL3, LOCAL4, LOCAL5, LOCAL6, or LOCAL7.	When the import of logs to the syslog is enabled, the value of this parameter will be used for "facility" of the syslog. The default is "LOCAL0".
syslog_ident	'*programName*'	Specify using single quotation marks (') to enclose the program name used to identify the Mirroring Controller arbitration process message in the system log. Use ASCII characters excluding spaces to specify this parameter. The default is 'MirroringControllerArbiter'.
fencing_command	'*fencingCmdFilePath*' [Setting example] fencing_command = '/arbiter/fencing_dir/execute_fencing.sh'	Specify the full path of the fencing command that fences a database server where an error is determined to have occurred. Enclose the path in single quotation marks ('). Specify the path using less than 1024 bytes.
fencing_command_timeout	Fencing command timeout (seconds)	If the command does not respond within the specified number of seconds, fencing is determined to have failed and a signal (SIGTERM) is sent to the fencing command execution process. Specify a value between 1 and 2147483647. The default is 20 seconds.
heartbeat_interval(*1)	Interval time for heartbeat monitoring of the operating system or server (milliseconds)	The heartbeat monitoring of the database server is checked at the specified interval and arbitration is performed. Specify a value between 1 and 2147483647. The default is the value specified in *serverIdentifier*.conf of the database server. Specify this parameter to perform optimization taking into account differences in the line load to the admin network and the reduction in the time it takes to degrade.
heartbeat_timeout	Timeout for heartbeat monitoring of the operating system or server (seconds)	If there is no response for at least the number of seconds specified, it will be assumed that an error has occurred that requires the primary server or standby server to be fenced. Specify a value between 1 and 2147483647. The default is the value specified in *serverIdentifier*.conf of the database server. Specify this parameter to perform optimization taking into account differences in the line load to the admin network and the reduction in the time it takes to degrade.
heartbeat_retry	Number of retries for heartbeat monitoring of the operating system or server (number of times)	Specify the number of retries to be performed when an error has been detected that requires the primary server or standby server to be fenced.

Parameter	Value set	Description
		If an error is detected in succession more than the specified number of times, fencing will be performed. Specify a value between 0 and 2147483647. The default is the value specified in *serverIdentifier*.conf of the database server. Specify this parameter to perform optimization taking into account differences in the line load to the admin network and the reduction in the time it takes to degrade.

*1:Refer to "2.11.4 Tuning for Optimization of Degradation Using Abnormality Monitoring" for information on the tuning parameters for operating system or server abnormality monitoring when using an arbitration server.

Appendix B Supplementary Information on Building the Primary Server and Standby Server on the Same Server

The primary server and standby server can be pseudo-configured on the same server for system testing, for example. Out of consideration for performance and reliability, do not use this type of configuration for any other purposes. For this reason, do not use this type of configuration in a production environment.

Note that the setup and operations is the same as if the primary and standby servers are built on different servers.

This appendix provides supplementary information explaining how to configure the primary server and standby server on the same server.

Note

Even if automatic degradation by an arbitration server is set when the primary server and standby server are configured on the same server, there will be no effect of it.

B.1 Backup Data Storage Destination Directory

It is not a problem if the same backup data storage destination directory is used on the primary server and standby server.

B.2 How to Execute the mc_ctl Command

When executing the mc_ctl command, specify the server identifier in the --local-server option in order to identify the operation destination server.

Below is an example of starting Mirroring Controller of the server "server1" defined in the network.conf file. For mc_ctl command operations using another mode, also specify the --local-server option.

Define two server identifiers for the same IP address with different port numbers in the network.conf file.

```
Example)
```

```
server1 192.0.2.100 27540
server2 192.0.2.100 27541
```

Ensure that the port numbers of both primary server and standby server do not conflict with any other software.

Enabling automatic switch/disconnection

Start Mirroring Controller of the server "server1":

```
Example)
```

```
$ mc_ctl start -M /mcdir/inst1 --local-server server1
```

Stop Mirroring Controller of the server "server1":

```
Example)
```

```
$ mc_ctl stop -M /mcdir/inst1 --local-server server1
```

Disabling automatic switch/disconnection

Start Mirroring Controller of the server "server1":

```
Example)
```

```
$ mc_ctl start -M /mcdir/inst1 -F --local-server server1
```

Stop Mirroring Controller of the server "server1":

Example)

```
$ mc_ctl stop -M /mcdir/inst1 --local-server server1
```

Note

Add the --local-server option to the mc_ctl option specification for ExecStart and ExecStop of the unit file for systemd.

Refer to "2.12 Setting Automatic Start and Stop of Mirroring Controller and Multiplexed Instances" for details.

Appendix C User Commands

This appendix describes three categories of commands:

- Fencing command
- Arbitration command
- State transition commands

This appendix describes each category of user command.

C.1 Fencing Command

Format

The syntax for calling the fencing command from the Mirroring Controller process or the Mirroring Controller arbitration process is described below.

Fencing command of the database server

```
fencingCmd executionMode mcDegradationOper cmdServerId targetServerId primarycenter
```

Fencing command of the arbitration server

```
fencingCmd executionMode mcDegradationOper targetServerId
```

Input

Fencing command of the database server

Execution mode

monitor: Detect issues via automatic monitoring of the Mirroring Controller process

command: Mirroring Controller command execution (switch mode or detach mode of the mc_ctl command)

Degradation operation to be performed by Mirroring Controller

switch: Switch

detach: Disconnect

cmdServerId

ID of the database server that called the command

targetServerId

ID of the database server to be fenced

primarycenter

Fixed value

Fencing command of the arbitration server

Execution mode

monitor: Detect issues via automatic monitoring of the Mirroring Controller process

command: Mirroring Controller command execution (switch mode or detach mode of the mc_ctl command)

Degradation operation to be performed by Mirroring Controller

switch: Switch

detach: Disconnect

targetServerId

ID of the database server to be fenced

Output

Return value

0: Mirroring Controller will continue the degradation process.

Other than 0: Mirroring Controller will cancel the degradation process.

Description

Identifies the database server targeted for fencing based on the input server identifier, and implements the process that isolates it from the cluster system.

Notes

- The command is executed by the operating system user who started Mirroring Controller or the Mirroring Controller arbitration process. Therefore, if the command is to be executed by a specific operating system user, change the executing user of the command accordingly.
- The operating system user who started Mirroring Controller or the Mirroring Controller arbitration process must have execution privileges to the command. Otherwise, the degradation process will be canceled.
- From a security point of view, set the access privileges as necessary so that the fencing command is not overwritten and unauthorized operations are not performed by unintended operating system users.
- If the fencing command returns a value other than 0, Mirroring Controller will cancel the degradation process, so it is necessary for the user to check the status of the server, and switch or disconnect it manually.
- Before executing the fencing command, check if the server is already fenced, to avoid the command terminating abnormally.
- If the command times out, Mirroring Controller will stop the command, output an error message, and cancel the degradation process.

Information

The fencing command can be implemented by simply stopping the operating system or server. For example, if stopping the power for the database server, it is possible to use a utility to control the hardware control board in environments equipped with boards compatible with IPMI hardware standard.

Below is a sample script of a fencing command that powers off the database server using the IPMI tool.

Sample shell script

```
/installDir/share/mcarb_execute_fencing.sh.sample
```

C.2 Arbitration Command

Format

The syntax for calling the arbitration command from the Mirroring Controller process is described below.

```
arbitrationCmd cmdServerId targetServerId primarycenter
```

Input

cmdServerId

ID of the database server that called the command

targetServerId

ID of the database server to arbitrate

primarycenter

Fixed value

Output

Return value

0: The database server to arbitrate has an issue, and Mirroring Controller will continue the degradation process.

Other than 0: The database server to arbitrate is normal, and Mirroring Controller will cancel the degradation process.

Description

Identifies the database server to arbitrate based on the input server identifier, and checks the status of the server.

Notes

- The command is executed by the operating system user who started Mirroring Controller.
- The operating system user who started Mirroring Controller must have execution privileges to the command. Otherwise, the command will not be called, and the degradation process will be canceled.
- If the command times out, Mirroring Controller will stop the command, output an error message, and cancel the degradation process.

C.3 State Transition Commands

State transition commands include the three types of user commands below. Any of the commands can be implemented by Mirroring Controller in conjunction with database server status transitions.

- Post-switch command
- Pre-detach command
- Post-attach command

C.3.1 Post-switch Command

Format

The syntax for calling the post-switch command from the Mirroring Controller process is described below.

```
postswitchCmd serverIdentifier primarycenter
```

Input

serverIdentifier

ID of the database server (new primary server) that was switched

primarycenter

Fixed value

Output

Return value

None

Notes

- The command is executed by the operating system user who started Mirroring Controller.
- The operating system user who started Mirroring Controller must have execution privileges to the command. Otherwise, the command will not be called.
- If the command times out, Mirroring Controller will stop the command, output an error message, and cancel the process.

C.3.2 Pre-detach Command

Format

The syntax for calling the pre-detach command from the Mirroring Controller process is described below.

```
predetachCmd cmdServerId serverRole targetServerId primarycenter
```

Input

cmdServerId

ID of the database server that called the command

Server role

Role of the database server that called the command

primary: Primary

standby: Standby

targetServerId

ID of the standby server to be disconnected from the cluster system

primarycenter

Fixed value

Output

Return value

None

Notes

- The command is executed by the operating system user who started Mirroring Controller.
- The operating system user who started Mirroring Controller must have execution privileges to the command. Otherwise, the command will not be called, however, Mirroring Controller will output an error message and continue the process.
- If the command times out, Mirroring Controller will stop the command, output an error message, and cancel the process.

C.3.3 Post-attach Command

Format

The syntax for calling the post-attach command from the Mirroring Controller process is described below.

```
postattachCmd cmdServerId serverRole targetServerId primarycenter
```

Input

cmdServerId

ID of the database server that called the command

Server role

Role of the database server that called the command

primary: Primary

standby: Standby

targetServerId

ID of the standby server to be attached to the cluster system

primarycenter

Fixed value

Output

Return value

None

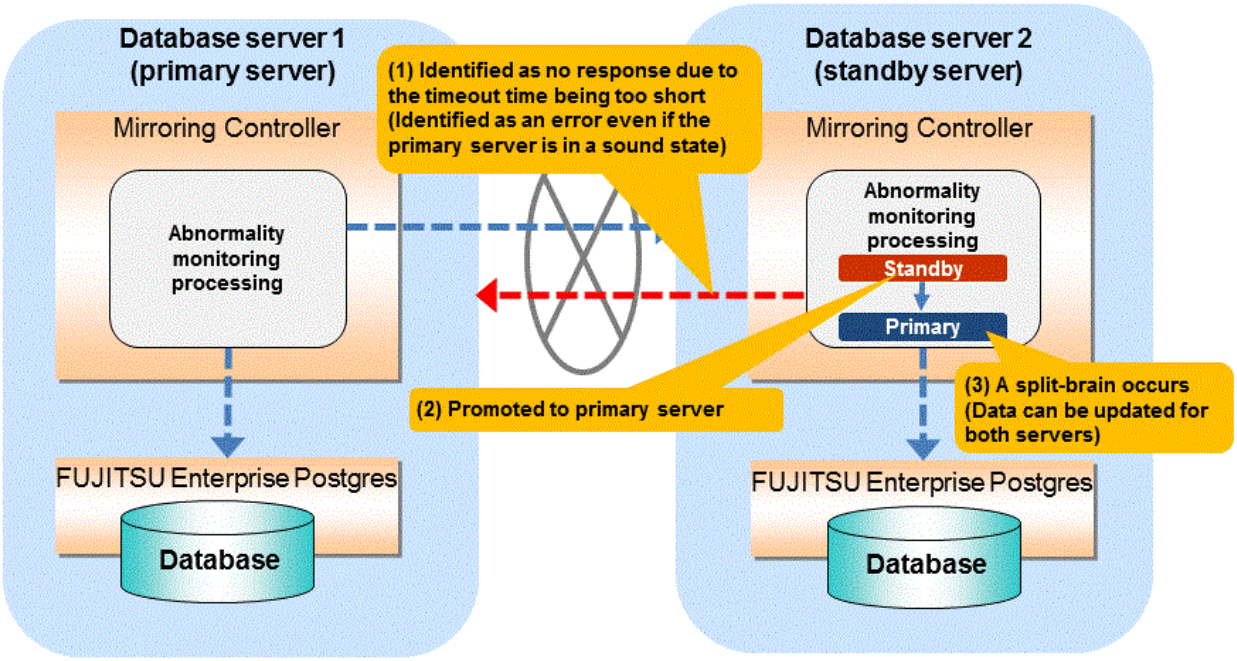
Notes

- The command is executed by the operating system user who started Mirroring Controller.
- The operating system user who started Mirroring Controller must have execution privileges to the command. Otherwise, the command will not be called.
- If the command times out, Mirroring Controller will stop the command, output an error message, and cancel the process.

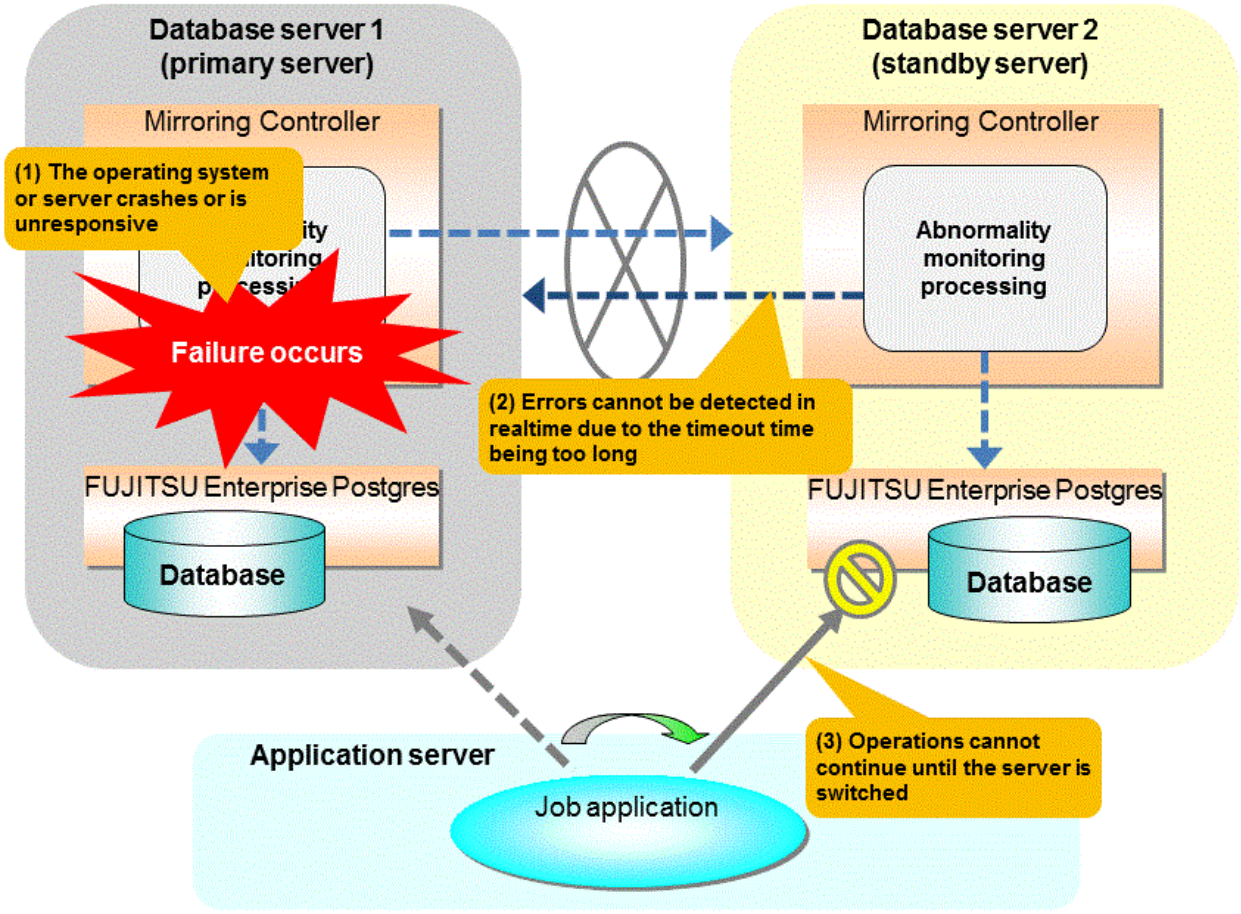
Appendix D Notes on Performing Automatic Degradation Immediately after a Heartbeat Abnormality

The type of issue below occurs if automatic degradation is performed unconditionally after an issue is detected during heartbeat monitoring of an operating system or server, and heartbeat monitoring was not properly tuned.

● If the timeout time is too short



● If the timeout time is too long



Notes on monitoring when the operating system or server crashes or is unresponsive

As illustrated in the diagram above, timeout is used to monitor whether the operating system or server crashes or is unresponsive. Therefore, if tuning has not been performed correctly, there is a risk of a split-brain mistakenly occurring even if the server is in a sound state.

Split-brain is a phenomenon in which both servers temporarily operate as primary servers, causing data updates to be performed on both servers.

Split-brain detection method

It can be confirmed that split-brain occurs under the following conditions:

1. When the mc_ctl command is executed in status mode on both servers, the "host_role" of both servers is output as "primary", and
2. The following message is output to the system log of one of the servers:

```
promotion processing completed (MCA00062)
```

How to recover from a split-brain

Use the procedure described below. Note that the new primary server is the server that was confirmed in step 2 of the aforementioned detection method.

1. Stop all applications that are running on the old and new primary servers.
2. Investigate and recover the database.
   Investigate the update results that have not been reflected to the new primary server from the database of the old primary server, and apply to the new primary server as necessary.
3. Stop the old primary server instance and the Mirroring Controller.

4. Resume the applications that were stopped in step 1.

5. Recover the old primary server.
   While referring to "2.5 Setting Up the Standby Server", build (set up) the old primary server as the new standby server, from the new primary server.

Appendix E WebAdmin Disallow User Inputs Containing Hazardous Characters

WebAdmin considers the following as hazardous characters, which are not allowed in user inputs.

```
| (pipe sign)

& (ampersand sign)

; (semicolon sign)

$ (dollar sign)

% (percent sign)

@ (at sign)

' (single apostrophe)

" (quotation mark)

\' (backslash-escaped apostrophe)

\" (backslash-escaped quotation mark)

<> (triangular parenthesis)

() (parenthesis)

+ (plus sign)

CR (Carriage return, ASCII 0x0d)

LF (Line feed, ASCII 0x0a)

, (comma sign)

\ (backslash)
```

Appendix F Collecting Failure Investigation Data

If the cause of an error that occurs while building the environment or during operations is unclear, data must be collected for initial investigation.

This appendix describes how to collect data for initial investigation.

Use the pgx_fjqssinf command to collect data for initial investigation.

See

Refer to the Reference for information on the pgx_fjqssinf command.

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[S]

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Fujitsu Enterprise Postgres 14 SP1 on IBM LinuxONE

Connection Manager User's Guide

SP1

Linux

FUJITSU

J2UL-2753-02ZLZ0(00)
September-2022

Preface

Purpose of this document

This document describes the Connection Manager features of FUJITSU Enterprise Postgres.

Intended readers

This document is aimed at people who use the Connection Manager features.

Readers of this document are also assumed to have general knowledge of:

- FUJITSU Enterprise Postgres
- PostgreSQL
- Linux

Structure of this document

This document is structured as follows:

Chapter 1 Connection Manager Features

Explains the features and Mechanisms of the Connection Manager.

Chapter 2 Setting Up

Explains setting up the Connection Manager.

Chapter 3 Using from an Application

Explains how to use the Connection Manager from an application.

Appendix A System Views

Explains the system view of Connection Manager.

Export restrictions

If this document is to be exported or provided overseas, confirm legal requirements for the Foreign Exchange and Foreign Trade Act as well as other laws and regulations, including U.S. Export Administration Regulations, and follow the required procedures.

Issue date and version

```
Edition 2.0: September 2022
Edition 1.0: February 2022
```

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Contents

Chapter 1 Connection Manager Features

The Connection Manager provides the following features:

Heartbeat monitoring feature

Detects kernel panics between the server running the client and the server running the PostgreSQL instance(hereinafter referred to as instance), physical server failures, and inter-server network link downs, and notifies the client or instance. The client is notified as an error event through the SQL connection, and the instance will be notified in the form of a force collection of SQL connections with clients that are out of service.

Transparent connection support feature

When an application wants to connect to an instance of an attribute in a set of instances configured for replication, it can connect to that instance without being aware of which server it is running on.

Information

The available client drivers for Connection Manager are libpq (C language library), ECPG (embedded SQL in C), JDBC driver and ODBC driver.

Each function is described below.

1.1 Heartbeat Monitoring Feature

Describes the Connection Manager's heartbeat monitoring feature.

Note

The Connection Manager does not monitor for delays, such as CPU busy occurring in the postmaster process or in the backend processes to which the application connects directly, or for no response, such as due to a software bugs. It also does not monitor application downtime or unresponsiveness. To detect these, use various timeout features provided by PostgreSQL or the client drivers.

1.1.1 Difference from TCP keepalive

A peer of TCP connections cannot automatically detect a link down or server down.

There are two main methods to detect it. One is the operating system (Not all operating systems support it) TCP keepalive feature, and the other is the keepalive-equivalent timeout function implemented at the application layer. Connection Manager's heartbeat monitoring capabilities are categorized as the latter.

The operating system TCP keepalive feature has the following disadvantages, but the Connection Manager's heartbeat monitoring feature does not:

- The keepalive does not work when the TCP layer cannot receive an acknowledgement (ACK) and retransmits the packet repeatedly. This means that it is not possible to detect a down (For example, if a network goes down,) before sending some data and receiving ACK from the other side. There is also a parameter to interrupt retransmissions, which is not supported by some operating systems. The Connection Manager's heartbeat monitoring feature does not have this disadvantage because it is timeout monitoring at the application layer.
- The periodic packets for keepalive are sent per-TCP socket. If a instance accepts too many (For example, a few thousand clients) SQL connections, the load on the instance side cannot be ignored. The Connection Manager's heartbeat monitoring feature greatly reduces the load by allowing packets to be sent to the instance on a per-server basis on which the client runs.

1.1.2 Mechanism of Heartbeat Monitoring Feature

On the client side, the user must start one monitoring process using the cm_ctl command for the set of the instances to be monitored. This process, called the "conmgr process", can only be started by a user who is not an administrator (e.g. superuser(root) on Linux). An instance set is a collection of one or more instances that make up replication. One configuration file (conmgr.conf) for each conmgr process is used to set the information about the set of the instances being monitored and the parameters for monitoring.

On the server side, by installing PostgreSQL's EXTENSION that is called "watchdog", the postmaster will start two processes as background workers at instance startup.

One is the process for sending and receiving packets to and from the conmgr process for heartbeat monitoring. It is called "watchdog process". The other is the process for forcibly terminating SQL connections of the clients for which the watchdog process detects a failure on heartbeat monitorting. It is called "terminator process". SQL connections that do not use Connection Manager is also terminated, because the terminator process terminates them by IP address as key.

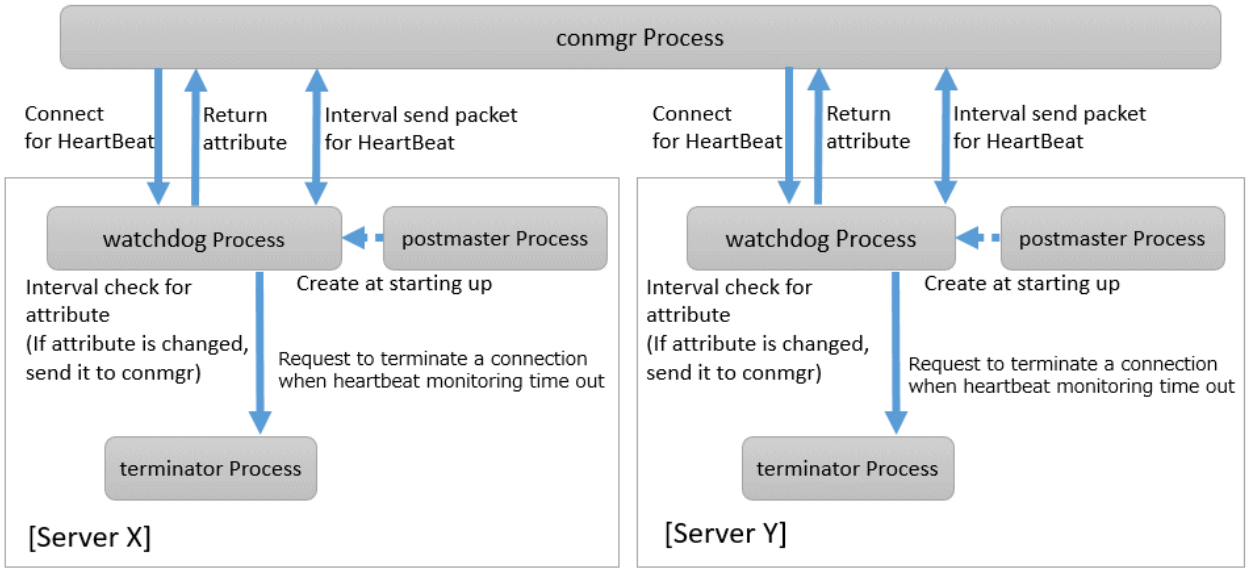
Note

System Configuration Notes

For replication, it is recommended that the instance that connects to the upstream instance of replication and the conmgr process that regards the upstream instance as an instance to be monitored for heartbeart (specified in backend_host parameter or backend_hostaddr parameter that is a configuration parameter of conmgr process) be not placed on the same server. This is because if the conmgr process stops normally or abnormally, the terminator process in the upstream instance will also kill the replication connection. The replication connection will reconnect automatically even if it is forcibly disconnected, so replication will continue without any problems. However, this can be a problem when the replication load is high or on systems that are sensitive to replication delays.

Note that the replication connection have different monitoring feature than the Connection Manager, so there is no need to monitor the Connection Manager for heartbeat. Refer to PostgreSQL documentation for details.

The process relationship is as follows:



See

Refer to "cm_ctl" in the Reference for information on cm_ctl command.

1.2 Transparent Connection Support Feature

The features similar to Connection Manager's transparent connection support feature can be found in PostgreSQL's libpq and other client drivers.

Using libpq as an example, the connection parameter to use that feature is target_session_attrs parameter. If this parameter is used not through Connection Manager, libpq will attempt to find the required instance by connecting sequentially to all instances of the set of instance requested by the host parameter or hostaddr parameter. In the worst case, libpq may find the promoted primary at the connection to the last instance of instance set. This means that you cannot predict how long it will take to complete the switch.

However, when conmbined with the Connection Manager, the conmgr process obtains its attributes via the watchdog process from all servers in a set of servers in advance, so that the connections to that server can be initiated as soon as the application requests it.

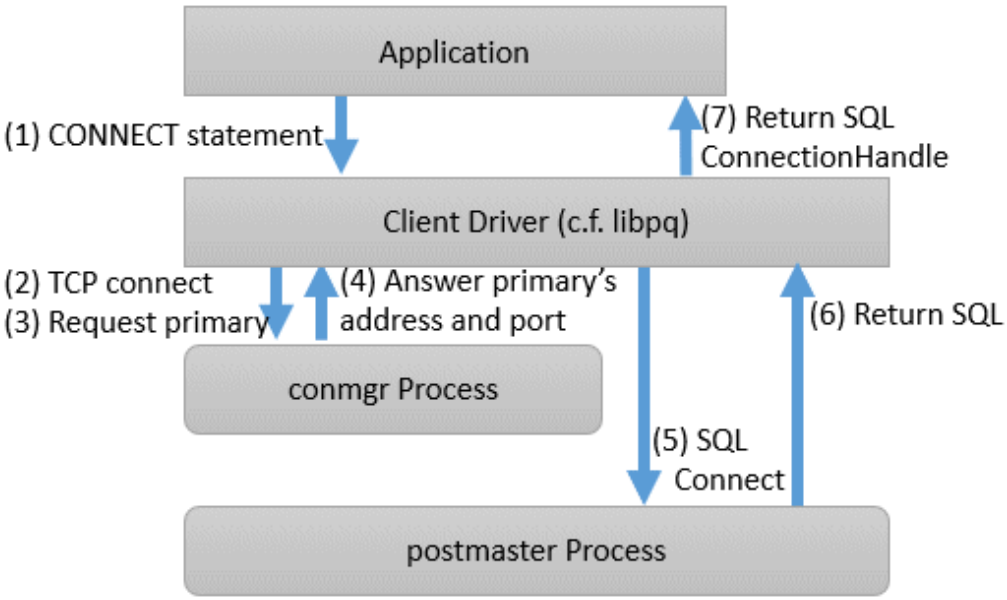
1.2.1 Mechanism of Connections using Transparent Connection Support Feature

A connection using this mechanism actually consists of two steps, but from the perspective of the application, it looks like a single SQL connection. In the application's connection string, specify the IP address or host name (In most cases it is "localhost") and port number where the conmgr process listens, and target_session_attrs parameter. You do not need to explicitly state that the connection is to the conmgr process. This is because the client driver can automatically determine whether the connection is to a instance or a conmgr process.

In the first phase of the connection, the client driver receives a connection request from the application and connects to the location specified in the connection string. Initially, it uses the protocol PostgreSQL requests, and if it learns in the middle that the connection is to a conmgr process, it asks the conmgr process for the IP address and port number that the instance with the attributes specified in the connection parameter target_session_attrs is listening for. If the destination is a backend process rather than a conmgr process, the connection process completes immediately and continues to send and receive data for normal SQL execution. The first stage of processing falls within the scope of timeout monitoring for SQL connection processing by each client driver. For example, the connection_timeout parameter of libpq.

In the second phase of the connection, the client driver connects to the instance using the IP address and port number from the conmgr process.Thereafter, the client driver and the instance directly send and receive the data for SQL execution. This ensures that the Connection Manager does not affect the performance of the SQL execution.

When the client driver is waiting to receive data after the second stage is completed, it monitors the reception of data to the two sockets obtained at each stage of the connection. This allows the client driver to know when, for example, the conmgr process notifies the client of a network link down.



Chapter 2 Setting Up

Describes setting up the Connection Manager.

2.1 Setting Up the Client Side

On the client side, configure settings for the conmgr process.

2.1.1 Creating a Directory for the conmgr Process

You need one conmgr process for each set of instances that you want to configure for replication. Assign a dedicated directory to each conmgr process. This directory must assign read, execute, and write permissions for the user who starts the conmgr process.

This directory is specified when you run the cm_ctl command, which starts and stops the conmgr process. To specify a directory in the cm_ctl command, set it in the environment variable CMDATA or specify it in the -D option.

See

Refer to "cm_ctl" in the Reference for information on cm_ctl.

2.1.2 Configuring conmgr.conf

Place the configuration file conmgr.conf in the directory for the conmgr process.

Syntax for conmgr.conf

- In conmgr.conf, after the symbol(#) are considered comments.
- The parameter name = value" is a set of settings and must be written on one line.
- Set the value in a format that matches the type of each parameter. The types and formats are:
  - integer: Numeric type. Express as a sequence of numbers in decimal number.
  - string: String type. You can also include spaces by enclosing them in quotation marks('). If you include quotation marks, escape them.
  - enum: Enumeration type. Possible values are determined.

Parameters to Set

port (integer)

Specify the port number on which the conmgr process listens for connections from the applications.

The value must be greater than or equal to 1 and less than or equal to 65535. The default is 27546. You must restart conmgr process for this parameter change to take effect.

backend_host* (string)

Specify the host name or IP address of the instance.

You can also use IPv6 address. If you specify the IP address directly, you can save time by using backend_hostaddr parameter. If backend_host parameter and backend_hostaddr parameter are both specified, backend_hostaddr parameter is used. You must restart conmgr process for this parameter change to take effect.

To distinguish multiple instances, append a zero-based number immediately after the parameter name, such as backend_host0, backend_host1,... This number is called the instance number. A parameter identified by the same instance number configures the settings of a single instance. If you want to exclude some instances from your replication configuration, you can simply remove the settings for that instance.

Note

Refer to "System Configuration Notes" in "1.1.2 Mechanism of Heartbeat Monitoring Feature" for details.

Note

If the primary is not included in the instances configured in conmgr.conf, use the -W option when starting Connection Manager with the cm_ctl command. Without the -W option, the cm_ctl command will not return until the primary connection is complete.

For example, if two instances are listening on "host name:host0, port number:5432" and "host name:host1, port number:2345", write as follows.

```
backend_host0='host0'
backend_port0=5432
backend_host1='host1'
backend_port1=2345
```

You can also mix different instance number settings:

```
backend_host0='host0'
backend_host1='host1'
backend_port0=5432
backend_port1=2345
```

It does not matter if the instance number is missing as in the following (instance number 1):

```
backend_host0='host0'
backend_host2='host2'
backend_port0=5432
backend_port2=2345
```

If the host name is omitted, as in instance number 1 below, an error will occur when loading the configuration file.

```
backend_host0='host0'
backend_host2='host2'
backend_port0=5432
backend_port1=5555
backend_port2=2345
```

backend_hostaddr*(string)

Same as backend_host parameter except no name resolution is used.

backend_port* (integer)

Specify the port number the postmaster of the instance will listen on.

The value must be greater than or equal to 1 and less than or equal to 65535. The default is 27500. Append the instance number as you would for backend_host parameter. You must restart conmgr process for this parameter change to take effect.

watchdog_port* (integer)

Specify the port number on which the watchdog process listens.

The conmgr process connects to this port, but the user application does not. you must set it to the same value as watchdog.port parameter in postgresql.conf. The value must be greater than or equal to 1 and less than or equal to 65535. The default is 27545. Append the instance number as you would for backend_host parameter. You must restart conmgr process for this parameter change to take effect.

heartbeat_interval (integer)

Specify the interval at which heartbeat packets are sent for heartbeat monitoring.

Used in conjunction with heartbeat_timeout parameter. Connection Manager heartbeat monitoring always continues to send packets periodically from both ends of the connection. If a packet is not received from the other side within a certain period of time, the link is considered down.

Note that this method is different from TCP keepalive. TCP keepalive send a keepalive packet only when there is a certain amount of inactivity (idle), and expects to receive an ACK for that packet. If TCP keepalive does not receive an ACK, it repeats this a specified number of times and then assumes that the link is down.

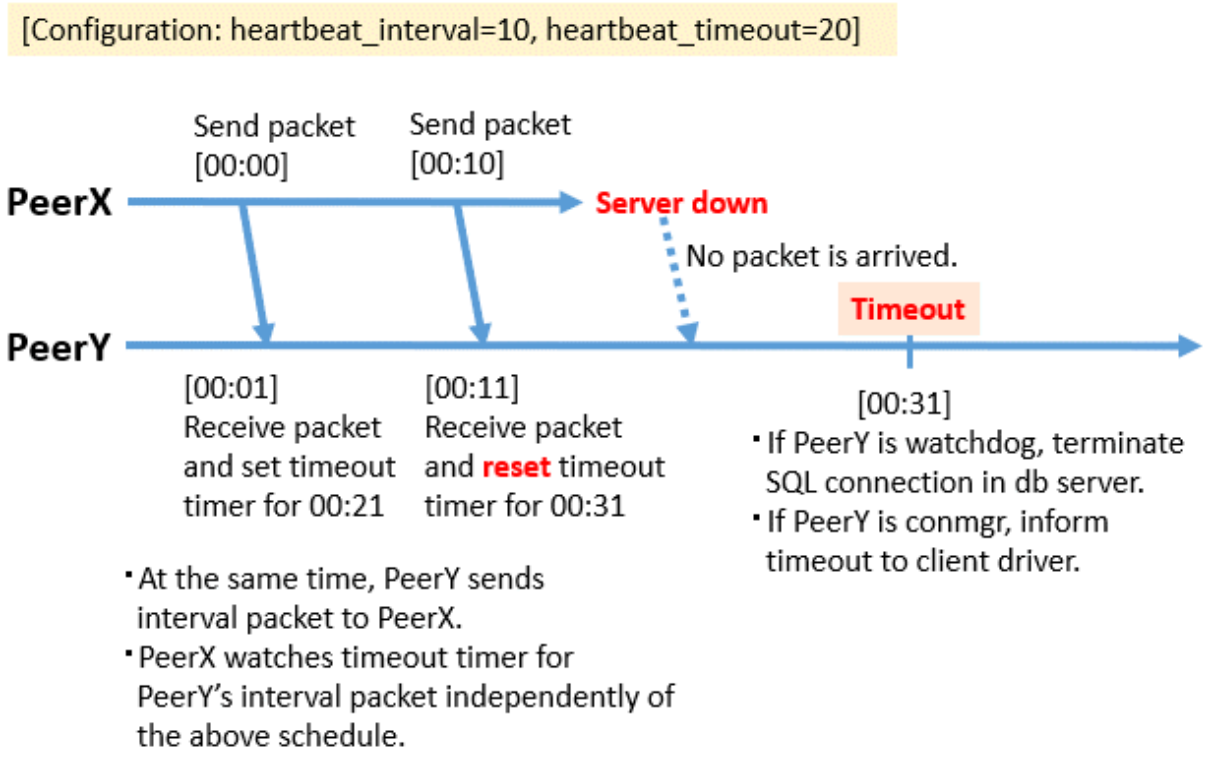
The heartbeat_interval parameter and heartbeat_timeout parameter are propagated from the conmgr process to the watchdog process, and also apply to the interval between the transmissions of heartbeat packets from the watchdog process. If a watchdog process is connected from both a conmgr process with a heartbeat_interval parameter of 3 seconds and a conmgr process with a heartbeat_interval of 5 seconds, it sends heartbeat packets every 3 seconds to the former process and every 5 seconds to the latter process. The unit is seconds. Specify a value equal to or more than 1 second. The default is 10 seconds. You must restart conmgr process for this parameter change to take effect.

heartbeat_timeout (integer)

If a heartbeat packet for heartbeat monitoring cannot be received for more than the time specified by this parameter, an error is assumed to have occurred and the application is notified of the error.

This parameter should be decide of heartbeat_interval parameter as the basis. No error is occured when the configuration file is loaded, but is always considered abnormal by heartbeat monitoring if it is at least not greater than heartbeat_interval parameter. The unit is seconds. Specify a value equal to or more than 1 second. The default is 20 seconds. You must restart conmgr process for this parameter change to take effect.

Refer to the following figure for the relationship between the heartbeat_interval parameter and heartbeat_timeout parameter settings and the heartbeat timeout.



heartbeat_connect_interval (integer)

Specify the interval between attempts to establish heartbeat monitoring again after detecting an abnormality.

This parameter is useful when only the database server is started, but not the instance. In such a situation, the TCP connection fails immediately, and retries cannot be attempted without an interval. If you specify an excessively long value, you may delay noticing the start of the instance. If a connection attempt fails for a long time, it will attempt the next connection after the time specified by heartbeat_connect_interval parameter has elapsed. The unit is seconds. Specify a value equal to or more than 1 second. The default is 1 second. You must restart conmgr for this parameter change to take effect.

heartbeat_connect_timeout (integer)

Specify the connection timeout for establishing heartbeat monitoring.

The connection includes the time it takes to send the TCP connection and the first heartbeat packet to the watchdog process and receive a reply from the watchdog process. This parameter is particularly needed when the other server is down or the network is disconnected. This is because TCP connections are attempted over a long period of time, depending on the operating system configuration, and the connection takes a long time to fail. The unit is seconds. Specify a value equal to or more than 1 second. The default is 10 seconds. You must restart conmgr process for this parameter change to take effect.

log_destination (string)

Specify the destination of the message.

You can specify multiple destinations. Use commas to separate multiple entries and enclose all in single quotation marks.

"stderr" and "syslog" can be specified. The default is to print only to stderr. You must restart conmgr process for this parameter change to take effect.

syslog_facility (enum)

Specify the syslog facility.

Valid only if log_destination parameter includes "syslog".

LOCAL0, LOCAL1, LOCAL2, LOCAL3, LOCAL4, LOCAL5, LOCAL6, or LOCAL7 can be specified. The default is "LOCAL0". You must restart conmgr process for this parameter change to take effect.

syslog_ident (string)

Specify the program name used to identify the output from the conmgr process.

The default is "conmgr". You must restart conmgr process for this parameter change to take effect.

log_min_messages (enum)

Specifies the level of messages to output.

It can be DEBUG, INFO, NOTICE, WARNING, ERROR, LOG, FATAL, or PANIC. Messages below the specified level are not output. The default is "WARNING". You must restart conmgr process for this parameter change to take effect.

max_connections (integer)

Specifies the maximum number of simultaneous connections to the conmgr process.

If there are more than this maximum number of client connections, it forces the connection to be closed without sending an error message to the client.

The conmgr process also outputs this fact at level "LOG" to the destination specified by log_destination. Specify a value equal to or more than 0.

If 0 is specified, there is no limit. The default is 0. You must restart conmgr process for this parameter change to take effect.

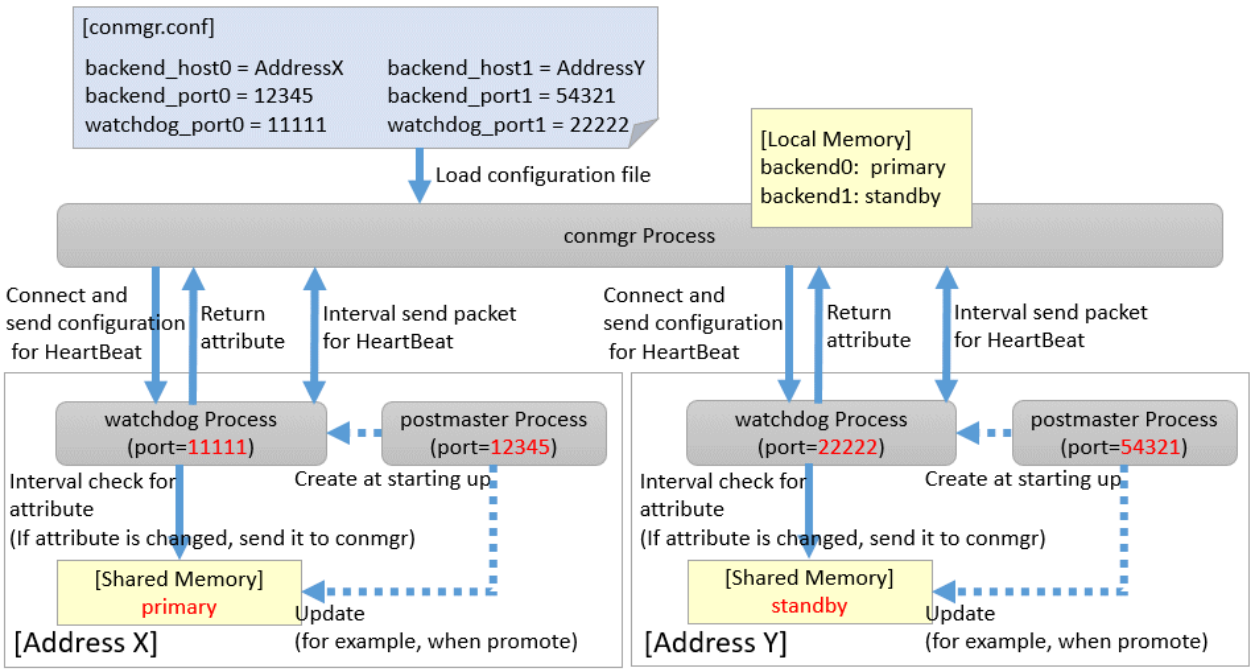
Note

The maximum number of file descriptors that can be opened simultaneously (You can check it with -n of the ulimit command.) imposed on a conmgr process by the OS user limit should be greater than the value derived from the following equation:. Otherwise, the conmgr process will abort if the user limit is violated.

```
9 + Number of database instances specified in conmgr.conf x 2  + max_connections specified in
conmgr.conf
```

Overview of connections definitions

The following figure shows the relationship between the IP address or host name and the port number set in conmgr.conf and the processes.



2.2 Setting Up the Server Side

On the server side, configure settings for the watchdog process.

2.2.1 Configuring postgresql.conf

Describes the postgresql.conf parameters that must be set when using the Connection Manager.

Parameters to Set

max_connections

An existing PostgreSQL parameter. Add 2 to the value already set.

Connection to the instance is maintained from the time the instance is started to do the following:

- The watchdog process checks the state of the instance.
- The terminator process forces the client to terminate the SQL connection.

shared_preload_libraries

An existing PostgreSQL parameter. Add a watchdog.

The watchdog process and terminator process start when you add watchdog and restart the instance.

watchdog.port (integer)

Specify the port number on which the watchdog process accepts connections for heartbeat monitoring from the conmgr process.

The value must be greater than or equal to 1 and less than or equal to 65535. The default is 27545. The instance must be restarted for this parameter change to take effect.

watchdog.check_attr_interval (integer)

Specify the interval between checking the attributes of a instance.

watchdog process immediately notifies the conmgr process if the attribute changes.

The unit is milliseconds. Specify a value equal to or more than 1 millisecond. The default is 1000 milliseconds. The instance must be restarted for this parameter change to take effect.

watchdog.max_heartbeat_connections (integer)

Specify the maximum number of conmgr processes that connect to watchdog process.

The default is the value specified in max_connections of postgresql.conf.

There is no upper limit, but about 200 bytes of memory are consumed for 1 connection when PostgreSQL is started.

Note

Normally you do not need to consider, but if you have a heartbeat connection with a very large number of conmgr processes, it may violate on the maximum number of file descriptors (You can check it with -n of the ulimit command.) of the OS user limit. This is because the socket for the heartbeat connection consumes the file descriptor. Set the maximum number of file descriptors of the OS user limit to a value larger than the value calculated below from the max_files_per_process parameter value and watchdog.max_heartbeat_connections parameter value in postgresql.conf.

```
max_files_per_process + watchdog.max_heartbeat_connections x 2
```

2.2.2 Introducing the watchdog extension

Execute the CREATE EXTENSION statement with watchdog.

Example)

```
postgres=# CREATE EXTENSION watchdog;
CREATE EXTENSION
```

This allows you to see the pgx_stat_watchdog view for information about the watchdog process.

2.3 Removing Setup

Describes how to removing setup the Connection Manager.

No work is required on the client side.

On the server side, drop watchdog extension by DROP EXTENSION statement and remove it from shared_preload_libraries.

Example)

```
postgres=# DROP EXTENSION watchdog;
DROP EXTENSION
```

Chapter 3 Using from an Application

Describes how to use the Connection Manager from an application.

3.1 Connection Method

When connecting to the instance using ConnectionManager, specify the following values in the connection parameters of the application. Application connection parameters are parameters that specify the database IP address, host name, port number, etc., which are originally specified when connecting to the database from the application. For example, when using libpq, specify "localhost" for the host parameter and specify the port number on which the conmgr process listens for the port parameter.

Connection parameters not shown here are used directly by the instance in the second stage of the connection, connecting to the instance (connecting to an instance without the Connection Manager), and the conmgr process does not check or use it.

Connection destination address

Specify "localhost". Unix domain sockets are not allowed.

It is possible to connect to a remote conmgr process, but it should not be used for other purposes expect such as testing. This is because there is no mechanism between the application and the conmgr process to detect the remote server down or the network link down, making the Connection Manager meaningless.

Port number

Specify the value specified for the port parameter in conmgr.conf.

Connection destination instance attributes

Follow the "Target server" in the application connection switch feature. Refer to "Taget server" in "Connection Information for the Application Connection Switch Feature" in the "Application Development Guide" for information on the target server in the application connection switch feature.

3.2 How to Detect Instance Errors

Only special if you are using libpq's asynchronous communication method. For additional discovery methods, refer to "Errors when an Application Connection Switch Occurs and Corresponding Actions" of the for each client driver in the "Application Development Guide" . If the conmgr process goes down while accessing it, or if the conmgr process tries to establish a SQL connection while it is down, the same error is returned as if the instance went down.

3.3 How to Use in libpq

libpq provides very detailed communication control. Therefore, to detect a heartbeat error through the conmgr process, you may need to modify the existing application logic.

 See

Refer to "libpq - C Library" in the PostgreSQL Documentation on functions described below.

3.3.1 How to Specify Multiple Connection Destinations

The host parameter or hostaddr parameter in the connection string not only specifies the destination of one conmgr process, but can also be a mixture of destinations of other conmgr processes and postmaster. In this case, the connections are tried in the order listed.

For example, if the connection string specifies conmgr1, conmgr2 in that order, and if conmgr1 does not know the server for the attribute specified in target_session_attrs parameter, it queries conmgr2 for the destination. And, for example, if postmaster1, conmgr1 is specified, it will attempt to connect directly to the database instance pointed to by postmaster1. If this fails, query conmgr1 for a connection.

3.3.2 Using the Asynchronous Connection Method

An asynchronous connection method is to use a function like PQconnectStart() instead of a function like PQconnectdb (). PQconnectStart() returns without synchronizing the completion of the connection to the database. The user application must then monitor the sockets returned by PQsocket() to be readable or writable, for example by using the poll() system call, according to the values required by the return value of PQconnectPoll().

With the Connection Manager, the socket returned by PQsocket() may change after a call to PQconnectPoll(), so be sure to reacquire the socket that you want to give to the poll() system call using PQsocket(). This behavior is similar to simply specifying multiple hosts in the connection string without using the Connection Manager.

3.3.3 Using an Asynchronous Communication Method

An asynchronous communication method is one in which the application returns control without waiting for a response from the database, and PQsetnonblocking() is used to asynchronize completion of transmission or completion of receipt of all results. Instead of using a function like PQexec(), use a function like PQsendQuery(). In this method, the user application monitors the socket that connects to the database returned by PQsocket(), for example, by using the poll() system call.

For example, if the link to the database goes down, simply monitoring the socket returned by PQsocket with the poll() system call will not detect it.

However, it is possible to detect the reception of database anomaly detection packets sent from the conmgr process, for example, by monitoring the reception of data on the socket (POLLIN) connecting to the conmgr process returned by PQcmSocket(). Once a reception is detected, the user application need not directly manipulate the packet. By calling something like PQgetResult() or PQcosumeInput() according to the existing application logic, it behaves as if the connection were disconnected. Refer to "Errors when an Application Connection Switch Occurs and Corresponding Actions" in the Application Development Guide on SQLSTATE returned,etc. If you are not using the Connection Manager, PQcmSocket() returns -1.

3.3.4 Behavior of PQhost() or PQhostaddr() or PQport()

PQhost(), PQhostaddr() or PQport() typically return a host parameter or hostaddr parameter or port parameter specified in the connection string by the user application. However, if you specify a connection destination for the conmgr process, the destination for the conmgr process you specify will be changed to the database connection destination information provided by the conmgr process before the connection is completed. This behavior is similar to simply specifying multiple hosts in the connection string without using the Connection Manager.

3.3.5 Behavior of PQstatus()

If you are using an asynchronous connection method, you can monitor the intermediate state of the connection to the database with PQstatus(). If you are using the Connection Manager, the enum value returned by PQstatus() is appended with the following:

```
CONNECTION_AWAITING_CMRESPONSE
/ * Waiting for a response from the conmgr process * /
```

3.3.6 PQcmSocket()

You can get a socket that leads to the conmgr process. It returns a value equal to or more than 0 for a valid socket, or -1 if you are not connected to the conmgr process.

```
int PQcmSocket(const PGconn *conn);
```

3.4 How to Use in ODBC Driver

Describes points to note when using the Connection Manager using the ODBC driver.

3.4.1 Behavior of SQLGetInfo()

When SQL_SERVER_NAME is specified in the argument InfoType, SQLGetInfo () normally returns the contents set in Servername or Server of the data source. However, if you specify a connection destination for the conmgr process, the destination for the conmgr process you specify will be changed to the database connection destination information provided by the conmgr process before the connection is completed. This behavior is similar to simply specifying multiple hosts in the connection string without using the Connection Manager.

3.5 How to Use in JDBC Driver

Describes points to note when using the Connection Manager using the JDBC driver.

3.5.1 Behavior of loadBalanceHosts Parameter

The loadBalanceHosts parameter is a connection parameter for the JDBC driver to use the load balancing feature. You can specify whether to use the load balancing feature by setting this parameter. However, Connection Manager provides a unique load balancing feature that users cannot specify whether to use or not. Therefore, even if the user sets the loadBalanceHosts parameter to disable the JDBC driver load balancing feature, the Connection Manager load balancing feature is always enabled when connecting to the database via the Connection Manager.

Appendix A System Views

A.1 pgx_stat_watchdog

A row in this view corresponds to conmgr process, which is connected to watchdog process. Additional columns may be added in future versions versions.

Column	Type	Description
conmgr_addr	inet	IP address of conmgr process.
conmgr_port	integer	The conmgr (ephemeral) port number that conmgr process is using to communicate with watchdog process. This is not the port number to be set in conmgr.conf.
heartbeat_interval	integer	The interval at which heartbeat packets are sent to and from this conmgr process. The unit is seconds.
heartbeat_timeout	integer	The timeout value for the heartbeat to and from this conmgr process. The unit is seconds.

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Fujitsu Enterprise Postgres 14 SP1 on IBM LinuxONE

Glossary

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FUJITSU

J2UL-2757-02ZLZ0(00)
September-2022

Preface

Purpose of this document

This document explains FUJITSU Enterprise Postgres terminology.

Intended readers

This document is aimed at all users of FUJITSU Enterprise Postgres.

Export restrictions

Exportation/release of this document may require necessary procedures in accordance with the regulations of your resident country and/or US export control laws.

Issue date and version

```
Edition 2.0: September 2022
Edition 1.0: February 2022
```

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Contents

Glossary

Arbitration command

A user command called when an abnormality is detected using operating system/server heartbeat monitoring in database multiplexing mode.

Arbitration server

A dedicated server on which the Server Assistant program is installed.

Archive log

Contains the history of updates made to the database, and is used during recovery.

Backup data storage destination

The directory that stores the backup data.

Client command

A command that is executed from the client machine and used. Also known as a client application.

Connection Manager

The replication operation to continue without knowing where the application is connected.

The Connection Manager feature improves the availability.

Data storage destination

The directory that stores the database clusters.

Database cluster

The database storage area on the database storage disk. Database clusters are a collection of databases managed by an instance.

Data masking

A feature that can change the returned data for queries generated by applications, to prevent exposing actual data.

Database multiplexing

Mechanism in which a database is made redundant on multiple servers, by transferring transaction logs (WAL) via the network to enable application jobs to be continued.

Database superuser

A user defined in the database with access privileges for all database objects.

Encoding

Indicates the character set.

Fencing

A process that isolates a database server with an unstable status from the cluster system in database multiplexing mode. This process is implemented as a fencing command.

Fencing command

A user command that implements fencing in database multiplexing mode.

Global Meta Cache

The Global Meta Cache feature cache the informations about system catalogs information (catalog meta cache) in shared memory. The catalog meta cache on shared memory is called the Global Meta Cache (GMC).

Instance

A series of server processes for managing database clusters.

Instance administrator

The OS user account that owns the database cluster files and operates the database server processes.

Instance name

Indicates the instance name.

Local Meta Cache Limit

The ability to limit the size by removing the Local Meta Cache that has not been accessed for a long time.

Local Meta Cache is a meta cache (system catalog and table definition information) held in local memory.

Masking policy

A method of changing data under specific conditions when it is returned for a query from an application. You can configure masking target, masking type, masking condition and masking format.

Mirrored transaction log

The log that mirrors the transaction log at the backup data storage destination.

Mirroring Controller arbitration process

A process that performs arbitration and fencing on the arbitration server.

Mirroring Controller monitoring process

A process that performs heartbeat monitoring of the Mirroring Controller process. If the Mirroring Controller process returns no response or is down, the Mirroring Controller monitoring process is restarted automatically.

Mirroring Controller process

A process that performs operating system/server and process heartbeat monitoring and disk abnormality monitoring between database servers. Additionally, the process issues arbitration requests to the arbitration server and executes arbitration commands.

Pgpool-II connection pooling

The connection pooling feature of Pgpool-II supported by FUJITSU Enterprise Postgres.

This feature maintains the connection established with the database server and reuses that connection each time a new connection with the same properties (user name, database, and protocol version) arrives. By reducing the connection overhead for the database server, throughput of the whole system is improved.

Pgpool-II failover

The automatic failover feature of Pgpool-II supported by FUJITSU Enterprise Postgres.

If any of the database servers crashes or can no longer be reached, this feature disconnects the server and continues operation on the remaining servers. The streaming replication feature of PostgreSQL is combined with Pgpool-II to achieve a high-availability system.

Pgpool-II load balancing

The load balancing feature of Pgpool-II supported by FUJITSU Enterprise Postgres.

This feature distributes reference queries to multiple database servers, improving throughput of the whole system. The database multiplexing feature or PostgreSQL streaming replication feature is combined with Pgpool-II to reduce the load on the database server.

Pgpool-II server

A server for using the failover, connection pooling, and load balancing features of Pgpool-II. It is a dedicated server that has a server program installed for using these features.

Primary server

The server that processes the main database jobs during multiplexed database operation.

Server Assistant

A feature that objectively determines the status of database servers as a third party, and if necessary, isolates affected databases if the database servers are unable to accurately ascertain their mutual statuses in database multiplexing mode, such as due to a network error between database servers, or server instability.

Server Assistant program

A program to be installed on the arbitration server.

Server command

A command used on the database server. Also known as a server application.

Standby server

A server that generates a replicated database synchronized with the primary server, and that can run as an alternative server in case the primary server fails during multiplexed database operation.

State transition command

A user command called when Mirroring Controller performs a state transition of a database server in database multiplexing mode. State transition commands include the post-switch command, pre-detach command, and post-attach command.

Transaction log

Contains the history of updates made to the database by transactions. Also known as the WAL (Write-Ahead Log).

Transaction log storage destination

The directory that stores the transaction log.

VCI (Vertical Clustered Index)

An index with columnar data structure suitable for aggregation.

WAL (Write-Ahead Log)

Has the same meaning as 'transaction log'.

WebAdmin program

A GUI-based program installed on a database server or a dedicated WebAdmin server, used to manage database instances.

WebAdmin server

By using the WebAdmin program on a different server to the database server, instances on multiple database servers can be managed from a dedicated WebAdmin server on which the WebAdmin program is installed.

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Fujitsu Enterprise Postgres 14 SP1 on IBM LinuxONE

Reference Guide

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FUJITSU

J2UL-2754-02ZLZ0(00)
September-2022

Preface

Purpose of this document

This document is a command reference, and explains FUJITSU Enterprise Postgres commands and options with features expanded on from PostgreSQL.

Intended readers

This document is aimed at people who manage and operate FUJITSU Enterprise Postgres. Readers of this document are also assumed to have general knowledge of:

- PostgreSQL
- SQL
- Linux

Structure of this document

This document is structured as follows:

Chapter 1 Command List and Specification Format

Lists commands and describes their specification format.

Chapter 2 Client Commands

Explains options not listed in "PostgreSQL Client Applications" in the PostgreSQL Documentation.

Chapter 3 Server Commands

Explains commands and options not listed in "PostgreSQL Server Applications" in the PostgreSQL Documentation.

Chapter 4 Mirroring Controller Commands

Explains the Mirroring Controller commands.

Chapter 5 Connection Manager Commands

Explains the Connection Manager commands.

How to read this document

Examples in this document are predominantly for UNIX/Linux.

Export restrictions

If this document is to be exported or provided overseas, confirm legal requirements for the Foreign Exchange and Foreign Trade Act as well as other laws and regulations, including U.S. Export Administration Regulations, and follow the required procedures.

Issue date and version


```
Edition 2.0: September 2022
Edition 1.0: February 2022
```


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Contents

Chapter 1 Command List and Specification Format

This chapter lists commands and describes their specification format.

1.1 Command List

This chapter lists commands and options not explained in "PostgreSQL Client Applications" or in "PostgreSQL Server Applications" in the PostgreSQL Documentation.

1.1.1 Client Commands

The commands below have options not explained in "PostgreSQL Client Applications" in the PostgreSQL Documentation.

Command	Functional overview
pg_dumpall	Extract a PostgreSQL database cluster into a script file

The command below is not explained in "Client Applications" in the PostgreSQL Documentation.

Command	Functional overview
pgx_loader	Loads data from an external file into a PostgreSQL table.

1.1.2 Server Commands

The commands below have options not explained in "PostgreSQL Server Applications" in the PostgreSQL Documentation.

Command	Functional overview
pg_ctl	Initialize, start, stop, or control a PostgreSQL server
postgres	PostgreSQL database server

The commands below are not explained in "PostgreSQL Server Applications" in the PostgreSQL Documentation.

Command	Functional overview
pgx_dmpall	Backs up the data directory, tablespaces, and configuration files.
pgx_fjqssinf	Collects failure investigation data
pgx_keystore	Manages keystore
pgx_rcvall	Recovers the data directory, tablespaces, and configuration files.

1.1.3 Mirroring Controller Commands

Mirroring Controller has the following commands:

Command	Functional overview
mc_arb	Start, stop and display the status of the Mirroring Controller arbitration process.
mc_ctl	Start and stop Mirroring Controller, switch/disconnect the server, or display the server status.

1.1.4 Connection Manager Commands

Connection Manager has the following commands:

Command	Functional overview
cm_ctl	Start, stop or display the status of the conmgr process

1.2 Command Specification Format

The table below shows the command specification format.

Item	Explanation
[ ]	Indicates optional element.
...	Indicates that the item can be specified repeatedly.

Chapter 2 Client Commands

This chapter explains options not listed in "PostgreSQL Client Applications" in the PostgreSQL Documentation.

2.1 pg_dumpall

Name

pg_dumpall -- Extract a PostgreSQL database cluster into a script file

Synopsis

```
pg_dumpall [connectionOption...] [option...]
```

Options

--no-tablespace-encryption

Do not output commands to encrypt tablespaces. Running the generated SQL script will restore the originally encrypted data without being encrypted.

See

Refer to "pg_dumpall" in the PostgreSQL Documentation for details.

2.2 pgx_loader

Name

pgx_loader --Loads data from a file into a PostgreSQL table.

Overview

```
pgx_loader load -c command [options...]
```

```
pgx_loader recovery -t table
```

Description

The pgx_loader command loads data from an external file into PostgreSQL tables, and commits or rolls back transactions prepared during data load.

In load mode, data is loaded at high speed by executing the COPY FROM command specified in *command* at a certain degree of parallelism. If load is completed successfully, the message below is output to the standard output.

```
LOAD count
Note: count is the number of rows loaded.
```

Refer the pgx_stat_progress_loader view to see the progress of the load process.

In recovery mode, commit or rollback of transactions prepared during data load is performed.

Refer to "pgx_stat_progress_loader" in the Operation Guide for pgx_stat_progress_loader view.

Options

-a
--echo-sql

Display the executed command in the standard output.

-c *command*
--copy-command=*command*

Specify the COPY FROM command to be executed. If STDIN is specified for the FROM clause, data will be loaded from the standard input. In this case, SQL superuser privileges (or having one of the roles pg_read_server_files or pg_execute_server_program) are not required, because local user access privileges will be used for external files and external programs, instead of database server access privileges.

"binary" cannot be specified for the FORMAT option of the COPY FROM command specified in this option. Therefore, input files in binary format cannot be specified.

The FREEZE option cannot be specified for the COPY FROM command specified in this option.

See

Refer to "COPY" in the PostgreSQL Documentation for information on the COPY FROM command.

-j *number-of-jobs*
--jobs=*number-of-jobs*

Specify the number of background workers (parallel workers) that the COPY COMMAND should use to simultaneously perform data conversion, table creation, and index creation. This option can dramatically reduce the time for loading a large amount of data on instances that runs on multiple processor machines.

The optimal value depends on the server, client, and network configurations. The number of CPU cores and disk configuration also affect the optimal value. The number of CPU cores of the server is recommended as the initial value to try. Naturally, if a value that is too large is used, performance degradation will occur due to thrashing and context switching.

Specify a value from 2 to 128. The default is 2.

-t *table*
--table=*table*

Complete the prepared transactions only for the specified table.

-?
--help

Show how to use pgx_loader command line arguments, and exit.

The command line options below control the database connection parameters.

-d *connstr*
--dbname=*connstr*

Specify the database name to connect to.

If this option is not specified, the PGDATABASE environment variable will be used. If the environment variable is not set, your operating-system user name will be used.

-h *host*
--host=*host*

Specify the host name of the machine the database server runs on. If the specified value starts with a slash, it will be used as the directory for a Unix domain socket.

If this option is not specified, the PGHOST environment variable will be used. If the environment variable is not set, it will be considered a Unix domain socket connection.

-p *port*
--port=*port*

Specify the TCP port to be used by the server to monitor the connection, or extension of the local Unix domain socket file.

If this option is not specified, the PGPORT environment variable will be use. If the environment variables is not set, 27500 will be used.

-U *username*
--username=*username*

User name for connection to the database.

-w
--no-password

Never prompt for the password. If the server requires password authentication but other means (such as a .pgpass file) are not available, the connection attempt will fail. This option can be useful in batch jobs, scripts, and so on, where no user is present to enter a password.

-W
--password

Force pgx_loader to prompt for the password before connecting to the database. This option is never essential, since pgx_loader will automatically prompt for the password if the server demands password authentication. However, pgx_loader will waste a connection attempt finding out if the server requires a password. In some cases it is worth specifying this option to avoid the extra connection attempt.

Diagnostics

load mode

0: Normal exit

Other than 0: Abnormal exit

recovery mode

0: There are no prepared transactions that must be completed

3: A prepared transaction was committed

4: A prepared transaction was rolled back

Other than the above: Abnormal exit

The order of the table rows loaded by pgx_loader may not match the order of the file lines. This is because the file lines will have been inserted into the table in parallel, by multiple parallel workers.

Example

The example below loads the file /path/to/data.csv (2000 records) into table tbl using a degree of parallelism of 3.

```
$ pgx_loader load -j 3 -c "COPY tbl FROM '/path/to/data.csv' WITH CSV"
LOAD 2000
```

The example below reads the file /path/to/data.csv (2000 records) from the standard input and loads into table tbl using a degree of parallelism of 3.

```
$ pgx_loader load -j 3 -c "COPY tbl FROM STDIN WITH CSV" < /path/to/data.csv
LOAD 2000
```

The example below completes the transactions prepared for table tbl.

```
$ pgx_loader recovery -t tbl
```

Chapter 3 Server Commands

This chapter explains commands and options not listed in "PostgreSQL Server Applications" in the PostgreSQL Documentation.

3.1 pg_ctl

Name

pg_ctl -- Initialize, start, stop, or control a PostgreSQL server

Synopsis

```
pg_ctl start [-D datadir] [-l filename] [-W] [-t seconds] [-s]
           [-o options] [-p path] [-c] [--user-pin | --keystore-passphrase | --kms-secret]

pg_ctl restart [-D datadir] [-m s[mart] | f[ast] | i[mmediate] ]
             [-W] [-t seconds] [-s] [-o options] [-c]
             [--user-pin | --keystore-passphrase | --kms-secret]
```

Options

Hardware-based key store options

--user-pin

Prompts for a user pin to open a keystore.

File-based key store options

--keystore-passphrase

Prompt for the passphrase to open the keystore.

Keystore Options When Using a Key Management System as a Keystore

--kms-secret

Prompt for secret information to open the keystore.

See

Refer to "pg_ctl" in the PostgreSQL Documentation for details.

3.2 pgx_dmpall

Name

pgx_dmpall - Backs up the data directory, tablespaces, and configuration files.

Synopsis

```
pgx_dmpall  [option...]
```

Description

The pgx_dmpall command backs up the data directory, tablespaces, and configuration files. The backup data is stored in the directory specified by backup_destination parameter of postgresql.conf. The pgx_dmpall command also deletes archived Write Ahead Logs (WAL) that are no longer necessary for recovery when the backup completes successfully.

Options

-c

This option only backs up configuration files. The configuration files are as follows:

- postgresql.conf (postgresql.conf)
- File for host-based authentication (pg_hba.conf)
- Configuration file for ident authentication (pg_ident.conf)

If an external reference, such as 'include' in postgresql.conf, is set, the reference destination files are also backed up.

-C fast|spread
--checkpoint=fast|spread

Sets checkpoint mode to fast or spread (default).
If fast is specified, the checkpoint processing at the start of backup becomes quick, but the impact on performance of running applications gets larger due to intense I/O. In spread mode, the impact on applications is smaller but the backup takes longer, because the checkpoint is performed slowly.

-D *datadir*

Specify the data directory. If this option is omitted, the value of the environment variable PGDATA is used.

-f *configFile*

Specify the postgresql.conf configuration file. This option is set if the data directory and the configuration file set in the 'data_directory' parameter of the postgresql.conf file are running in separate directories.

-P *tablespacesListFile*
--tablespaces-list-file=*tablespacesListFile*

Specify the full path of the file containing the names of the tablespaces to be backed up using the copy command, using less than 1024 bytes.

The file format is described below:

tablespaceName<newline>
tablespaceName<newline>
...

Tablespaces not listed in the specified file are backed up to the backup storage directory. If this option is not specified, all tablespaces are backed up using the copy command.
This option can be specified if the -Y option has been specified, and it is used to limit the tablespaces backed up using the copy command.

-U *username*
--username=*username*

Specify the user name of the database superuser. This defaults to the name of the effective user running pgx_dmpall.

-Y *copyCommandFile*
--copy-command=*copyCommandFile*

Specify the full path of the file of the copy command for backup, using less than 1024 bytes. This option cannot be specified together with the -c option.

-w
--no-password

Never issue a password prompt. If the server requires password authentication and a password is not available by other means such as a .pgpass file, the connection attempt will fail. This option can be useful in batch jobs and scripts where no user is present to enter a password.

-W
--password

Force pgx_dmpall to prompt for a password before connecting to a database.

This option is never essential, since pgx_dmpall will automatically prompt for a password if the server demands password authentication. However, pgx_dmpall will waste a connection attempt finding out that the server wants a password. In some cases it is worth typing -W to avoid the extra connection attempt.

-z

Enables zlib compression of backup files with the default compression level.

This option cannot be specified together with the -c option.

-Z level
--compress=level

Enables compression by zlib for backup files by specifying a compression level. (0 through 9, 0 being no compression and 9 being highest compression)

This option cannot be specified together with the -c option.

--maintenance-db=*dbname*

Specifies the name of the database to connect to. If not specified, the postgres database will be used; if that does not exist, template1 will be used.

Any database can be specified as long as it can be connected to.

--exclude-copy-cluster

Excludes a database cluster from backup via the copy command. This option can be specified if the -Y option has been specified. If this option is not specified, the database cluster will be backed up using the copy command.

Environment

PGDATA

Specify the data directory. You can overwrite using the -D option.

Diagnostics

0: Normal end

Other than 0: Abnormal end

Notes

This command can only be executed when the database server is running.

Execute this command as a PostgreSQL user account.

Do not update or delete files in the backup storage directory. Otherwise, you may not be able to recover the database.

Do not store other files in the backup storage directory.

This command uses one database connection. To establish a connection, this command uses the UNIX domain socket on the operating systems. Therefore, permit this connections in pg_hba.conf.

This command cannot be executed on the standby server.

Example

In the following example, the data directory, tablespaces, and configuration files are backed up. At this time, stored WALs are no longer necessary because the backups are destroyed.

```
$ pgx_dmpall
```

Related item

pgx_rcvall

3.3 pgx_fjqssinf

Name

pgx_fjqssinf - Collects failure investigation data.

Synopsis

```
pgx_fjqssinf  -i {1|2|3} [-w directory]
```

Description

When the cause of a trouble that occurred during the construction or operation of the environment is not identified, information for the initial investigation is collected. The collected investigation information is created in the destination directory as pgx_fjqssinf_YYYYMMDD_HHMMSS/.

Options

-i {1|2|3}

Specifies the incident of the trouble that occurred. 1 is specified for for process error, 2 for process result error, and 3 for no response. This option must be specified for the database server to gather information. Specify 1 when collecting information with the arbitration server.

-w directory

Specifies the destination directory for the collected data. The default is /tmp.

Environment (When the information is collected by a database server)

PGDATA

Specifies the data directory.

PGDATABASE

Specifies the name of the database to connect to. Any database that can be connected to may be specified.

PGPORT

Specifies the port number of the instance. This should not be specified if the default port number (27500) has not been changed.

PGUSER

Specifies the user name of the database superuser. The database superuser must be configured to allow client authentication.

MCCONTROLDIR

Specifies the Mirroring Controller management directory. This should only be specified when database multiplexing operation is set up.

Environment (When information is collected by an arbitration server)

ARBCONTROLDIR

Specifies the management directory for the Mirroring Controller arbitration process.

ARBUSER

Specifies the OS user that initialized the Mirroring Controller arbitration process.

Diagnostics

0: Normal end

Other than 0: Abnormal end

Notes

This command must be executed as a superuser (root) account.

Example

Below is an example of collecting information for initial investigation in the event of a process failure.

```
$ /opt/fsepv14server64/bin/pgx_fjqssinf -i 1
```

Below is an example of collecting information for an initial investigation by an arbitration server.

```
$ /opt/fsepv14assistant/bin/pgx_fjqssinf -i 1
```

3.4 pgx_keystore

Name

pgx_keystore -- Manages keystore

Synopsis

```
pgx_keystore [-a|--enable-auto-open] [option...] keystore_location

pgx_keystore [-s|--obfuscate-secret] [option...]
```

Description

pgx_keystore enables auto-open of a keystore.

Options

To enable automatic opening using a file-based keystore

-a
--enable-auto-open

Enables auto-open of a keystore. This allows the keystore to open automatically without entering the passphrase when the database server starts.

When auto-open is enabled, an obfuscated copy keystore.aks is created in the same directory where the keystore file keystore.ks is stored. To disable auto-open, delete keystore.aks.

-P *passphrase*
--passphrase=*passphrase*

Specify the passphrase to open the keystore. If this option is omitted, the prompt to enter the passphrase is displayed.

keystore_location

Specify the absolute or relative path of the keystore file.

To enable automatic opening using a key management system as the keystore

-s

--obfuscate-secret

Obfuscates the secret information needed to connect to the key management system. By specifying obfuscated private information as an authentication option in the key management system connection information file, the keystore is opened automatically when the database server is started without entering the key management system credentials.

--secret = *secret*

Specify the secret information required to connect to the key management system. If you omit this option, you are prompted for the secret.

-o *obfuscated-secret-file*

Specifies the file that contains the obfuscated secret. If the file already exists, the command terminates abnormally without overwriting it.

Diagnostics

0: Normal exit

Other than 0: Abnormal exit

Notes

This command can be executed whether the database server is running or stopped. It does not connect to the database server.

This command does not connect to the key management system.

Example

Enables automatic keystore opening when using a file-based keystore.

```
$ pgx_keystore -a /key/store/location/keystore.ks
```

Enable automatic keystore opening by obfuscating sensitive credentials when using the key management system as a keystore.

```
$ pgx_keystore -s -o /example/keypassphrase.ksc
Enter secret:
```

3.5 pgx_rcvall

Name

pgx_rcvall - Recovers the data directory, tablespaces, and configuration files.

Synopsis

`pgx_rcvall [`*`option`*`...]`

Description

The pgx_rcvall command recovers the data directory, tablespaces, and configuration files using the data that was backed up with pgx_dmpall command and archived Write-Ahead-Log (WAL). If none of the options that indicate the recovery point is specified, all archived WAL are applied and the data will be recovered to the latest point.

Options

-B *backupdir*

Specify the backup storage directory. If the data directory is damaged, this option cannot be omitted.

-D *datadir*

Specify the data directory. If this option is omitted, the value of the environment variable PGDATA is used.

-e *targetTime*

Specify this option to recover the data as of the specified date and time.

targetTime

Specify the time at which the data is recovered. The format is as follows:

```
"YYYY-MM-DD HH:MM:SS"
```

-l

This option displays a list of the backup data information in the backup storage directory that was obtained using the pgx_dmpall command. If the pgx_dmpall command was executed using the copy command (-Y option) for backup, the resources backed up using the copy command will also be listed. This cannot be specified together with -p, -e or -n option.

-n *restorePoint*

Specify this option to recover the data to the specified restore point. Restore points are created with SQL function pg_create_restore_point. If multiple restore points with the same names were created, the first one after the backup was taken is used for recovery. If the specified restore point does not exist, the recovery fails. This cannot be specified together with -e or -p option.

-p

Specify this option to recover the data as of the time when the last backup completed. This cannot be specified together with -e or -n option.

-x

Specify this option if you do not want to include transactions committed at the time specified in the -e option as part of the recovery.

-Y *copyCommandFile*
--copy-command=*copyCommandFile*

Specify the full path of the file of the copy command for recovery, using less than 1024 bytes. This option cannot be specified together with the -l option.

--user-pin

Prompts for a user pin to open the keystore. This option can only be specified on Hardware-based key store.

--keystore-passphrase

Prompt for the passphrase to open the keystore when using a file-based keystore. This option can only be specified on File-based key store.

--kms-secret

When you use a key management system as a keystore, you are prompted to enter secret information to open the keystore.

--view-results-of-copying

Output the backup information file that was written by the copy command executed via the pgx_dmpall command. This option cannot be specified together with the -l, -p, -e, -n, or -Y option.

Environment

PGDATA

Specify the data directory. You can overwrite using the -D option.

PGPORT

Specify the port number for connecting to the database.

PGUSER

Specify the user name of the database superuser. This defaults to the name of the effective user running pgx_dmpall.

Diagnosis

0: Normal exit

Other than 0: Abnormal exit

Backup data information

Date

Date the backup data was created using the pgx_dmpall command.

Dir

This is the name of the directory in the backup storage directory that is used to store the backup data.
Directory naming format: Time format (YYYY-MM-DD_HH-MM-SS)

Status

This is the status of the pgx_dmpall command backup data.

COMPLETE: Complete

INCOMPLETE: Incomplete

Compression

This is the compression status of the pgx_dmpall command backup data.

USED: compressed

This information is not displayed if it is not compressed.

Resources backed up by the copy command

List of resources that were backed up by the copy command executed via the pgx_dmpall command.

If there are resources that were backed up by the copy command, then database clusters ('pg_data') or tablespace names will be listed, delimited by header and halfwidth comma.

Notes

This command can only be executed when the database server is stopped, except when it is executed with -l option.

Execute this command as a PostgreSQL user account.

Use backup data that was taken from the recovery target data directory.

Before executing this command, disconnect all application database connections. Additionally, do not connect to the database during recovery.

The configuration files are restored from those files that were taken by the last pgx_dmpall (including -c option).

This command connects to the database to determine whether the recovery has completed. So ensure that you set the port number with PGPORT environment variable in the environment where multiple instances exist.

Match the OS timezone setting when running pgx_dmpall/pgx_rcvall to the timezone specified by timezone parameter in postgresql.conf.

Otherwise, data might be recovered to an unexpected time when -e or -p is specified.

If you recover to a past point, a new timeline (history of database updates) begins at that point. That recovery point is the latest point in the new timeline when the recovery is completed. If you subsequently recover to the latest point, the database updates in the new timeline will be replayed.

Valid restore points are the ones that were created in the timeline where the backup had been taken. That means that if you recover to a past point, those restore points created thereafter are unavailable. Therefore, take a backup when you have restored the past data desired.

If the pgx_dmpall command was executed using the copy command (-Y option) for backup, it is necessary to execute this command using the copy command (-Y option) for recovery. However, because the list of resources (database cluster or tablespace) that were backed up using the copy command is recorded in the backup directory, there is no need to specify the target resources when executing this command. The -I option can be used to check the target resources for which a backup is retrieved using the copy command.

Example

In the following example, the data directory, tablespaces, and configuration files are recovered.

```
$ pgx_rcvall -B /home/pgsql/Backupdir
```

In the following example, the data directory and tablespaces are recovered at 10:00:00 on 01-02-2022. The configuration files are recovered at the point at which the last of the data is obtained.

```
$ pgx_rcvall -B /home/pgsql/Backupdir -e "2022-02-01 10:00:00"
```

In the following example, the data directory and tablespaces are recovered up to the time of restore point "before_match_20220210_1". The configuration files are restored from the latest backup.

```
$ pgx_rcvall -B /home/pgsql/Backupdir -n before_match_20220210_1
```

In the following example, the obtained backup data information in the backup storage directory is displayed in a list.

```
$ pgx_rcvall -l
```

Related item

pgx_dmpall

3.6 postgres

Name

postgres -- PostgreSQL database server

Synopsis

```
postgres [option...]
```

Options

-K

Prompt for the passphrase to open the keystore. This option works in single-user mode only, so you must also specify the --single option, as shown below:

postgres --single -K

See

Refer to "postgres" in the PostgreSQL Documentation for details.

Chapter 4 Mirroring Controller Commands

This chapter explains the Mirroring Controller commands.

4.1 mc_arb

Name

mc_arb - Start, stop, and display the status of the Mirroring Controller arbitration process

Overview

```
mc_arb start [-M mcdir] [-w| -W]

mc_arb stop [-M mcdir] [-e]

mc_arb status [-M mcdir]
```

Description

mc_arb starts, stops, and displays the status of the Mirroring Controller arbitration process.

The start mode starts the Mirroring Controller arbitration process.

The stop mode stops the Mirroring Controller arbitration process.

The status mode displays the connection status of the Mirroring Controller arbitration process with the Mirroring Controller processes of the primary server and standby server.

If the Mirroring Controller arbitration process has not been started on the server executing the command, stop mode and status mode will terminate with an error.

Additionally, if Mirroring Controller is forcibly stopped on the database server, it may take a few moments until the status mode displays the status of the server connection as offline.

This command can be executed by any user.

Options

-e

Specify this option to forcibly stop the Mirroring Controller arbitration process on the active server.

Specify this option to stop the Mirroring Controller arbitration process but keep Mirroring Controller running (to stop both, first stop Mirroring Controller of the database server, and then the Mirroring Controller arbitration process). This option can also be specified to halt the arbitration process (by stopping the Mirroring Controller arbitration process) when the fencing command called by the arbitration process becomes unresponsive.

-M *mcdir*

Specify the Mirroring Controller arbitration process management directory.

ASCII characters can be specified in the directory path.

If this option is omitted, the value of the environment variable ARBCONTROLDIR is used.

-w

Waits for operations to finish.

This option is the default of start mode.

-W

Does not wait for operations to finish.

Environment

ARBCONTROLDIR

Specify the Mirroring Controller arbitration process management directory.

ASCII characters can be specified in the directory path.

You can specify the -M option to override this value.

Diagnostics

0: Normal end

Other than 0: Abnormal end

Notes

If the Mirroring Controller arbitration process is forcibly stopped or communication between the command and the Mirroring Controller arbitration process is interrupted while the Mirroring Controller arbitration process is being stopped, a message that the command is being executed may be output and stopping may terminate in error, even though no other instances of the mc_arb command are being executed. To solve this issue, ensure that other instances of the mc_arb command are not being executed before forcibly stopping the Mirroring Controller arbitration process.

Example

Start the Mirroring Controller arbitration process.

```
$ mc_arb start -M /mcarb_dir/arbiter1
```

Display details of mc_arb status

```
server_id   host            status
(1)         (2)             (3)
```

```
(1) Server identifier
(2) Host name or IP address
(3) Server connection status
    online   : Connected
    offline  : Disconnected
```

4.2 mc_ctl

Name

mc_ctl - Start and stop Mirroring Controller, switch/disconnect the server, or display the server status.

Overview

```
mc_ctl start [-M mcdir] [-w| -W] [-f| -F] [--mc-only] [--async-connect-arbiter] [--local-server
server_id]

mc_ctl stop [-M mcdir] [[-a] [--mc-only]| [-e][--local-server server_id]]

mc_ctl status [-M mcdir] [--arbiter] [--local-server server_id]

mc_ctl switch [-M mcdir] [--force [--no-fencing ]] [--local-server server_id]

mc_ctl detach [-M mcdir] [--no-fencing] [--local-server server_id]

mc_ctl enable-failover [-M mcdir] [--local-server server_id]

mc_ctl disable-failover [-M mcdir] [--local-server server_id]
```

Description

mc_ctl starts and stops Mirroring Controller, switches/disconnects the server, or displays the server status.

The start mode starts Mirroring Controller. If the --mc-only option is omitted, the command starts a database instance.

The stop mode stops Mirroring Controller. If the --mc-only option is omitted, the database instance is stopped. If --mc-only option is not specified, database instance is also stopped. When executes on standby server without --mc-only, standby server will be detached from primary server.

The status mode displays the status of the servers, database instance processes, and disks monitored by Mirroring Controller. Additionally, if the --arbiter option is specified, Mirroring Controller arbitration process connection status is displayed.

The switch mode switches the primary server. When the server is switched, the database instance on the primary server stops, and the database instance on the standby server is upgraded to primary server and begins degrading operation. This mode can be executed on the primary server and standby server in an environment where the Mirroring Controller process can communicate with the Mirroring Controller process on the other server.

The detach mode forcibly disconnects the standby server. This mode is used to forcibly disconnect the other server when stopping of Mirroring Controller cannot be performed using stop mode (which requires login to the standby server). It can only be executed on the primary server.

The enable-failover mode enables automatic switching and disconnection.

The disable-failover mode disables automatic switching and disconnection.

If Mirroring Controller has not been started on the server that executes the command, commands for any mode other than the start mode, and status mode.

Execute this command as an instance administrator.

Until you start Mirroring Controller of standby server after starting Mirroring Controller of the primary server, operation can be started with only the primary server. Standby server is incorporated when you start the Mirroring Controller of standby server, and you should be able to operate in the multiplexing configuration.

Options

-a

Specify this option to stop Mirroring Controller on all servers.

-e

Specify this option to forcibly stop Mirroring Controller on the active server.

-f

Specify this option to enable automatic switching and disconnection of Mirroring Controller immediately after startup.

This option is the default of start mode.

-F

Specify this option to disable automatic switching and disconnection immediately after startup of Mirroring Controller.

--async-connect-arbiter

Specify this option to connect the Mirroring Controller start process asynchronously to the Mirroring Controller arbitration process. This option can be specified to forcibly start Mirroring Controller if the Mirroring Controller arbitration process is not started.

Specify this option if using the Mirroring Controller arbitration server.

--arbiter

Specify this option to display the connection status of the Mirroring Controller arbitration process. This option can be specified if using status mode.

Specify this option if using the Mirroring Controller arbitration server.

--local-server *server_id*

If you run a simulation build of the primary and standby servers in a single server (for system testing, for example), specify this option to identify the server to be operated.

For *server_id*, specify the server identifier specified in the network.conf file. ASCII characters other than single-byte space can be specified in the server identifier. The operations will be executed as if the user has logged in to *server_id*.

--mc-only

Specify this option to start and stop only Mirroring Controller processes. At the start mode, this option can be specified only while the database instance is running. If this option is omitted, the database instance is simultaneously started and stopped.

-M *mcdir*

Specify the Mirroring Controller management directory.

ASCII characters can be specified in the directory path.

If this option is omitted, the value of the environment variable MCCONTROLDIR is used.

--force

Switching with this option specified can only be specified on the standby server. This option is used to perform switching forcibly after performing fencing on the primary server if communication with the Mirroring Controller process of the other server is not possible (due to a network issue between database servers or unresponsive server, for example), thus preventing normal switching. However, if the --no-fencing option is specified, fencing will not be performed on the primary server.

--no-fencing

When switching or disconnection is executed with the --force option specified, fencing of the server to be degraded is circumvented. Therefore, it is necessary for the user to isolate the server to be degraded from the cluster system in advance.

-w

Waits for operations to finish.

This option is the default of start mode.

-W

Does not wait for operations to finish.

Environment variable

MCCONTROLDIR

Specifies the Mirroring Controller management directory.

ASCII characters can be specified in the directory path.

You can specify the -M option to override this value.

Diagnostics

0: Normal end

Other: Abnormal end

Notes

The message under execution might be output though the mc_ctl command is not being executed and, besides, it terminate abnormally when the server is downed while processing execution of this command, an automatic switch, and an automatic separation, and the communication between a primary server and the standby server is cut off. Besides, restart Mirroring Controller to solve this problem after confirming that the mc_ctl command is not in progress. Afterwards, execute a necessary operation.

If a time-out error occurs when the mc_ctl command is in progress, the messages may be different from the processes. Take the actions described in the "Action" section of the message.

Automatic switching and disconnection by the enable-failover mode, the disable-failover mode, and the start mode can be enabled/disabled only while Mirroring Controller is running. Therefore, if you want to enable/disable automatic switching and disconnection on starting, specify the -f option or -F option each time you start Mirroring Controller.

In case of postgresql.conf has any incorrect parameter when this command is executed, this command may be abnormally terminated. If this is the case, re-execute it again after correct the parameter in postgresql.conf.

If the arbitration server of Mirroring Controller is used, connection with the arbitration server will be performed on startup even if startup using start mode is executed with the -F option specified, or if executed with --local-server specified.

For operation using an arbitration server, the amount of time spent attempting to connect with the arbitration server is calculated, so the Mirroring Controller startup time may take longer.

Example

To start Mirroring Controller:

```
$ mc_ctl start -M /mcdir/inst1
```

Display details of mc_ctl status

```
mirroring status
----------------
(1)

server_id  host_role          host            host_status  db_proc_status         disk_status
(2)        (3)                (4)             (5)          (6)                    (7)
```

```
(1) Multiplexing status
    switchable        : Switchable
    switching         : Switching
    switched        : Switched (displayed when switching has finished and the degrading operations
status has been enabled)
   not-switchable    : Not switchable (displayed when a server is disconnected and switching is not
possible)
    unknown           : Unknown (*1)
    failover-disabled : Failover is disabled
(2) Server identifier
(3) Server role
    primary : Primary
    standby : Standby
    none(inactivated primary): No role
                              (primary is stopped or being defined as primary)
    none(inactivated standby): No role
                               (standby is stopped or being defined as primary)
(4) Host name or IP address
(5) Live/dead state of the server
    normal   : Normal operation
    abnormal : Abnormal
    unknown  : Unknown (*1)
(6) DBMS process status
    normal                        : Normal
    abnormal (abnormal process name (*2)) : Abnormal
    unknown                       : Unknown (*1)
(7) Disk status
    normal                            : Normal
    abnormal (abnormal disk type (*3)) : Abnormal
    unknown                           : Unknown (*1)

*1: Displayed when Mirroring Controller is stop state, the management network is abnormal, or
Mirroring Controller has failed or is unresponsive.

*2: The names of the DBMS processes in which the abnormality was detected are output. The name has
the following meaning: However, if multiple DBMS process issues are detected, only the DBMS for
which the first issue was detected is displayed.
```

```
     -postmaster: Process (postmaster) that accepts application connections
     -wal_sender or wal_receiver: Process (WAL sender or WAL receiver) that sends and receives
transaction logs
*3: The types of disks where the abnormality was detected are output separated by a comma. The type
has the following meaning:
     -data: Data storage disk
     -tran_log: Transaction log storage disk
     -tablespace: Tablespace storage disk
```

Display details of mc_ctl status (with the --arbiter option specified)

```
arbiter_id   host            status
(1)          (2)              (3)
```

```
(1) Arbitration server identifier
(2) Host name or IP address
(3) Mirroring Controller arbitration process connection status
    online  : Connected
    offline : Disconnected (*1)

*1: When Mirroring Controller is stopped, connections to the Mirroring Controller arbitration
process cannot be established, so it will be displayed as "offline".
```

Chapter 5 Connection Manager Commands

This chapter explains the Connection Manager commands.

5.1 cm_ctl

Name

cm_ctl - Start, stop or display the status of the conmgr process

Synopsis

```
cm_ctl start [-D diretory] [-W] [--complete] [-t seconds]

cm_ctl stop [-D diretory] [-W] [-m {smart | fast | immediate}] [-t seconds]

cm_ctl status [-D directory] [-t seconds] [-i {all | instance | application}]
```

Description

The start mode starts the conmgr process. The command returns at least after the heartbeat monitoring connection is completed with the primary server's instance.

When --complete is specified, wait until all instances configured in conmgr.conf have completed their heartbeat monitoring connections. You can set a timeout for these waits. The default of timeout is 60 seconds. Can be changed using the -t option. If it times out, it simply gives up waiting and the conmgr process remains up.

If the primary is not among the instances configured in the cmgr.conf, use the -W option when starting Connection Manager with the cm_ctl command. Without the -W option, the cm_ctl command will not return until the primary connection is complete.

The stop mode sends a signal to the conmgr process to shut down and wait until the process disappeares.

The default of wait time is 60 seconds. Can be changed using the -t option. If it times out, it simply gives up waiting. There are three shutdown methods, "smart", "fast", and "immediate", specify with the -m option. The "smart" waits until all applications using the conmgr process run out of SQL connections before shutting down. The "fast" forces all applications using the conmgr process to disconnect from the conmgr process before shutting it down. As a result, the SQL connection for the application receives an error. The "immediate" terminates the conmgr process immediately. If nothing is specified, it stops in fast mode.

The status mode, if the commgr process exists, queries the conmgr process for instance and application information known to the conmgr process, and display them to standard output along with the state of conmgr itself.

The -i option allows you to specify what information to query. The "instance" queries information about the instance; The "application" queries information about the application; The "all" queries information about both. conmgr's own information is always displayed. The default time to wait for a query to return is 60 seconds. Can be changed using the -t option.

Options

--complete

Wait until all instances configured in conmgr.conf have completed their heartbeat monitoring connections. If the When used with the -W option, the -W option takes precedence.

-D

-- directory=*directory*

Specify the directory where conmgr.conf is located. If omitted, it refers to the directory specified by the environment variable CMDATA. You cannot omit both.

-i {all | instance | application}

Specify the information to display the status.

-m

--mode={smart | fast | immediate}

Specify the mode of shutdown. The default is fast.

-t *seconds*

--timeout=*seconds*

Specify how long to wait for the operation to complete. The unit is seconds. The default is 60 seconds.

-W

--no-wait

In start mode, cm_ctl command returns immediately after forking conmgr process. In stop mode, the cm_ctl command returns without waiting for the process to disappeare.

Diagnostics

start mode or stop mode

0: Normal end

2: Timeout occurred

3: Unable to access the specified directory

Other than the above: None of the above

status mode

0: Normal end

3: Unable to access the specified directory

4: conmgr process does not exist

Other than the above: None of the above

Privileges

The conmgr process cannot be started by the administrator(e.g. superuser(root) on Linux).

Example

Display details of start mode

The block of information that can be specified with the -i option is used as a unit. There is one blank line between the blocks and no blank lines within the blocks. It includes one or more spaces between columns and between data.

```
$ cm_ctl status -i all
conmgr_status:
status pid
(1)     (2)
ready  3456

instance_information:
addr          port  database_attr
(3)           (4)   (5)
192.0.2.100   27500 standby
192.0.2.110   27500 primary
192.0.2.120   27500 standby
```

```
192.0.2.130   27500 unknown

application_information:
addr          port  pid   connected_time
(6)           (7)   (8)   (9)
127.0.0.1     12345 5678  2022-02-15 02:03:04
```

(1) Status of the conmgr process
    starting : The process is starting its startup sequence but is not ready to accept
               connections from clients.
    ready   : Ready to accept connections from clients.
    stopping : It has received an end instruction and is starting the stop sequence.
    inactive : The conmgr process does not exist.
(2) PID of the conmgr process
(3) Host name or IP address of the instance
(4) Port number the postmaster listens on
(5) Status of the instance (primary | primary(read-only) | standby | unknown)
    primary   : Primary server
    primary(read-only) : Primary server (default transaction mode is read-only)
    standby   : Standby server
    unknown   : Unknown (*1)
(6) Connection source IP address for conmgr process
(7) Connection source (ephemeral) port number for conmgr process
(8) PID of the connection source
(9) Date and time conmgr process connection
    The ISO 8601 compliant date is followed by a blank, followed by the ISO 8601
    compliant second precision time.
    This representation is a PostgreSQL string representation of type timestamp.

*1) Displays when you cannot connect to the instance.

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J2UL-2758-02ZLZ0(00)
September-2022