Oracle® Database

Administrator's Guide

11*g* Release 1 (11.1)

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Oracle Database Administrator's Guide, 11*g* Release 1 (11.1)

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Contents

Preface

This document describes how to create, configure, and administer an Oracle database.

Audience

This document is intended for database administrators who perform the following tasks:

- Create an Oracle database
- Ensure the smooth operation of an Oracle database
- Monitor the operation of an Oracle database

To use this document, you need to be familiar with relational database concepts. You should also be familiar with the operating system environment under which you are running Oracle Database.

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Related Documents

For more information, see these Oracle resources:

- *Oracle Database 2 Day DBA*
- *Oracle Database Concepts*
- *Oracle Database SQL Language Reference*
- *Oracle Database Reference*
- *Oracle Database PL/SQL Packages and Types Reference*
- *Oracle Database Storage Administrator's Guide*
- *Oracle Database VLDB and Partitioning Guide*
- *Oracle Database Error Messages*
- *Oracle Database Net Services Administrator's Guide*
- *Oracle Database Backup and Recovery User's Guide*
- *Oracle Database Performance Tuning Guide*
- *Oracle Database Advanced Application Developer's Guide*
- *Oracle Database PL/SQL Language Reference*
- *SQL*Plus User's Guide and Reference*

Many of the examples in this book use the sample schemas, which are installed by default when you select the Basic Installation option with an Oracle Database installation. Refer to *Oracle Database Sample Schemas* for information on how these schemas were created and how you can use them yourself.

Conventions

The following text conventions are used in this document:

Convention	Meaning
boldface	Boldface type indicates graphical user interface elements associated with an action, or terms defined in text or the glossary.
italic	Italic type indicates book titles, emphasis, or placeholder variables for which you supply particular values.
`monospace`	Monospace type indicates commands within a paragraph, URLs, code in examples, text that appears on the screen, or text that you enter.

What's New in Oracle Database Administrator's Guide?

This section describes new features of Oracle Database 11*g* Release 1 (11.1) that are documented in this guide, and provides pointers to additional information.

Oracle Database 11*g* Release 1 (11.1) New Features in the Administrator's Guide

- Simplified and improved automatic memory management

  You can now set a single initialization parameter (`MEMORY_TARGET`) to indicate the total amount of memory that is to be allocated to the database (the SGA and instance PGA). The system then automatically and dynamically tunes all SGA and PGA components for optimal performance. You can still designate minimum sizes individually for the SGA and instance PGA.

  See "Using Automatic Memory Management" on page 5-3

- New fault diagnosability infrastructure to prevent, detect, diagnose, and help resolve critical database errors

  The goals of the fault diagnosability infrastructure are preventing and detecting problems (critical errors) proactively, limiting damage and interruptions after a problem is detected, reducing problem diagnostic time, reducing problem resolution time, and simplifying customer interaction with Oracle Support. The framework includes technologies such as health checks that run when a critical error occurs; proactive in-memory tracing for many database components to permit first-failure data capture; an Incident Packaging Service that packages all diagnostic data for a problem into a zip file for transmission to Oracle Support; and Enterprise Manager Support Workbench, which provides a graphical environment for investigating, reporting, and resolving problems. Also included is integration with the new SQL Repair Advisor, for diagnosing and repairing SQL-related problems, the SQL Test Case Builder, which gathers all required schema and environment information to enable a SQL problem to be reproduced on another Oracle database, and the Data Recovery Advisor, which helps diagnose, evaluate the impact of, and repair data corruptions and other data failures.

  See Chapter 8, "Managing Diagnostic Data" on page 8-1

- Invisible Indexes

  Making an index invisible is an alternative to making it unusable or dropping it if you want to test whether overall performance will improve by removing an index.

An invisible index is by default ignored by the optimizer, but unlike an unusable index, is maintained during DML statements. You have the option to change an initialization parameter at the system or session level to cause the optimizer to use invisible indexes.

See "Creating an Invisible Index" on page 19-11

- Virtual columns

  Tables can now include virtual columns. The value of a virtual column in a row is derived by evaluating an expression. The expression can include columns from the same table, constants, SQL functions, and user-defined PL/SQL functions. In some cases, a virtual column eliminates the need to create a separate view. You can create an index on a virtual column, and you can use a virtual column as a partition or subpartition key.

  See "About Tables" on page 18-1. For detailed information on virtual columns, see *Oracle Database Concepts*.

- Enhanced security for password-based authentication by enabling use of mixed case in passwords.

  See "Database Administrator Authentication" on page 1-11.

- Database resident connection pooling

  Database resident connection pooling (DRCP) provides a connection pool in the database server for typical Web application usage scenarios where the application acquires a database connection, works on it for a relatively short duration, and then releases it. DRCP pools "dedicated" servers, which are the equivalent of a server foreground process and a database session combined. DRCP enables sharing of database connections across middle-tier processes on the same middle-tier host and across middle-tier hosts. This results in significant reduction in database resources needed to support a large number of client connections, thereby boosting the scalability of both middle-tier and database tiers.

  See "About Database Resident Connection Pooling" on page 4-4

- Tablespace-level encryption

  You can encrypt any permanent tablespace to protect sensitive data. Tablespace encryption is completely transparent to your applications. When you encrypt a tablespace, all tablespace blocks are encrypted. All segment types are supported for encryption, including tables, clusters, indexes, LOBs, table and index partitions, and so on.

  See "Encrypted Tablespaces" on page 12-8.

- Finer-grained schema object dependencies for increased availability

  Invalidation of dependent schema objects in response to changes in the objects they depend upon is greatly reduced in Oracle Database 11*g*, increasing application availability during maintenance, upgrades, and online table redefinition. Between a referenced object and each of its dependent objects, the database tracks the elements of the referenced object that are involved in the dependency. For example, if a single-table view selects only a subset of columns in a table, only those columns are involved in the dependency. For each dependent of an object, if a change is made to the definition of any element involved in the dependency (including dropping the element), the dependent object is invalidated. Conversely, if changes are made only to definitions of elements that are not involved in the dependency, the dependent object remains valid.

- Enhanced automated maintenance task infrastructure

You can now exercise finer control over automated maintenance task scheduling. New installations of Oracle Database have the following default configuration for automated maintenance tasks and for the maintenance windows that they run in:

- There are three automated maintenance tasks: optimizer statistics gathering, Automatic Segment Advisor, and Automatic SQL Tuning Advisor.

  Automatic SQL Tuning Advisor examines high load SQL statements and makes recommendations for improving query performance. It can be configured to automatically implement SQL profile recommendations.

- There is a separate maintenance window for each day of the week. All maintenance tasks are scheduled to run in all maintenance windows by default.

- There is a default Resource Manager plan enabled. It contains a subplan that limits the amount of resources that automated maintenance tasks consume.

With Enterprise Manager or with PL/SQL package procedures, you can change the start time and duration of all maintenance windows, eliminate or add maintenance windows, and prevent particular maintenance tasks from running in particular maintenance windows. You can also adjust resource allocations for maintenance tasks relative to each other and to your applications.

See Chapter 24, "Managing Automated Database Maintenance Tasks".

- Encrypting table columns using the transparent data encryption feature of Oracle Database now supports SecureFile LOBs.

  See *Oracle Database SecureFiles and Large Objects Developer's Guide* for more information.

- Table compression now supported in OLTP environments

  Compressed tables now support the following operations:

  - DML statements
  - Add and drop column

  See "Consider Using Table Compression" on page 18-5.

- Result cache in the system global area

  Results of queries and query fragments can be cached in memory in the result cache. The database can then use cached results to answer future executions of these queries and query fragments. Because retrieving results from the result cache is faster than rerunning a query, frequently run queries experience a significant performance improvement when their results are cached.

  The result cache occupies memory in the shared pool.

  See "Specifying the Result Cache Maximum Size" on page 5-18.

- Enhancements to Oracle Scheduler

  Oracle Scheduler includes the following enhancements:

  - Lightweight jobs—Lightweight jobs are not schema objects like regular Scheduler jobs. They are based on a job template from which privileges and (in some cases) job metadata are inherited. They have a significant improvement in create and drop time over regular jobs because they do not have the overhead of creating a schema object. Use lightweight jobs when you need to create and drop hundreds or thousands of jobs per second.

    See "Jobs" on page 26-4.

  - Remote external jobs—A remote external job is an operating system executable that runs outside the database, is scheduled by Oracle Scheduler, and runs on a host computer other than the computer running the Oracle database that schedules it. The remote host does not require an Oracle database. Instead, it has a Scheduler agent, installed separately, that the scheduling database communicates with to start external jobs. The agent is also involved in returning execution results to the scheduling database.

    See "External Jobs" on page 26-11.

  - Extended support for Oracle Data Guard environments—Scheduler jobs can be designated to run only when the database is in the role of the primary database, or only when the database is in the role of a logical standby database.

    See "Scheduler Support for Oracle Data Guard" on page 26-13.

- Enhancements to Oracle Database Resource Manager

  Oracle Database Resource Manager includes the following enhancements:

  - Per-session I/O limits—Sessions that exceed I/O resource consumption limits can be automatically switched to another consumer group.

    See "Specifying Automatic Resource Consumer Group Switching" on page 25-22.

  - New out-of-the-box mixed workload resource plan—Oracle Database 11*g* includes a predefined resource plan, `MIXED_WORKLOAD_PLAN`, that prioritizes interactive operations over batch operations, and includes the required subplans and consumer groups recommended by Oracle.

    See "An Oracle-Supplied Mixed Workload Plan" on page 25-34.

  - New Automatic Workload Repository (AWR) snapshots of Resource Manager dynamic performance views, for historical statistical data on resource plan activations, CPU resources consumed by consumer group, and CPU waits by consumer group.

    See "Monitoring Oracle Database Resource Manager" on page 25-39.

- Default automatic undo management mode

  A newly installed 11*g* instance defaults to automatic undo management mode, and if the database is created with Database Configuration Assistant, an undo tablespace is automatically created. A null value for the `UNDO_MANAGEMENT` initialization parameter now defaults to automatic undo management.

  See "Overview of Automatic Undo Management" on page 14-2

- Enhanced online index creation and rebuild

  Online index creation and rebuild prior to this release required a DML-blocking lock at the beginning and at the end of the rebuild for a short period of time. This lock could delay other DML statements and therefore cause a performance spike. This lock is no longer required, making these online index operations fully transparent.

  See "Creating an Index Online" on page 19-9.

- Ability to online redefine tables that have materialized view logs

  Tables with materialized view logs can now be redefined online. Materialized view logs are now one of the dependent objects that can be copied to the interim table with the DBMS_REDEFINITION.COPY_TABLE_DEPENDENTS package procedure.

See "Redefining Tables Online" on page 18-26

- Read-only tables

  You can set any table to read-only mode with the ALTER TABLE statement. This provides an alternative to placing a table's containing tablespace in read-only mode.

  See "Placing a Table in Read-Only Mode" on page 18-24.

- Transportable tablespace enhancements

  Data Pump now supports the transportable tablespace function for tablespaces with XMLType tables and with schema objects with XMLTypes.

  See "Transporting Tablespaces Between Databases" on page 12-29

- Optimized ALTER TABLE...ADD COLUMN

  For certain types of tables, when adding a column that has both a NOT NULL constraint and a default value, the database can optimize the resource usage and storage requirements for the operation. It does so by storing the default value for the new column as table metadata, avoiding the need to store the value in all existing records.

  In addition, the following ADD COLUMN operations can now run concurrently with DML operations:

  – Add a NOT NULL column with a default value

  – Add a nullable column without a default value

  – Add a virtual column

- Enhancements to initialization parameter management

  The following enhancements are made to the handling of initialization parameters:

  – The server parameter file (SPFILE) has a new format for compliance with Oracle's HARD initiative. This initiative helps to prevent writing corrupted data to disk, and is implemented at the software and storage hardware levels.

  – New commands enable you to create a text initialization parameter file (PFILE) or server parameter file (SPFILE) from the current values of initialization parameters in memory.

  – Upon startup, values of initialization parameters are written to the alert log in such a way as to make it easy to copy and paste them to create a new PFILE.

  – The name and path of the PFILE or SPFILE used to start the instance is written to the alert log.

  – Oracle Database automatically resilvers a mirrored copy of the SPFILE when needed.

- Data Definition Language (DDL) commands can wait for locks

  You can now set a single initialization parameter, DDL_LOCK_TIMEOUT, to specify how long a DDL command waits for the exclusive locks that it requires on internal structures before it fails.

  See "Specifying the DDL Lock Timeout" on page 2-24

Part I

Basic Database Administration

Part I provides an overview of the responsibilities of a database administrator, and describes how to accomplish basic database administration tasks. It contains the following chapters:

1 Overview of Administering an Oracle Database

This chapter presents an overview of the environment and tasks of an Oracle Database administrator (DBA). It also discusses DBA security and how you obtain the necessary administrative privileges.

The following topics are discussed:

- Types of Oracle Database Users
- Tasks of a Database Administrator
- Selecting an Instance with Environment Variables
- Identifying Your Oracle Database Software Release
- Database Administrator Security and Privileges
- Database Administrator Authentication
- Creating and Maintaining a Password File
- Data Utilities

Types of Oracle Database Users

The types of users and their roles and responsibilities depend on the database site. A small site can have one database administrator who administers the database for application developers and users. A very large site can find it necessary to divide the duties of a database administrator among several people and among several areas of specialization.

This section contains the following topics:

- Database Administrators
- Security Officers
- Network Administrators
- Application Developers
- Application Administrators
- Database Users

Database Administrators

Each database requires at least one database administrator (DBA). An Oracle Database system can be large and can have many users. Therefore, database administration is sometimes not a one-person job, but a job for a group of DBAs who share responsibility.

A database administrator's responsibilities can include the following tasks:

- Installing and upgrading the Oracle Database server and application tools
- Allocating system storage and planning future storage requirements for the database system
- Creating primary database storage structures (tablespaces) after application developers have designed an application
- Creating primary objects (tables, views, indexes) once application developers have designed an application
- Modifying the database structure, as necessary, from information given by application developers
- Enrolling users and maintaining system security
- Ensuring compliance with Oracle license agreements
- Controlling and monitoring user access to the database
- Monitoring and optimizing the performance of the database
- Planning for backup and recovery of database information
- Maintaining archived data on tape
- Backing up and restoring the database
- Contacting Oracle for technical support

Security Officers

In some cases, a site assigns one or more security officers to a database. A security officer enrolls users, controls and monitors user access to the database, and maintains system security. As a DBA, you might not be responsible for these duties if your site has a separate security officer. Please refer to *Oracle Database Security Guide* for information about the duties of security officers.

Network Administrators

Some sites have one or more network administrators. A network administrator, for example, administers Oracle networking products, such as Oracle Net Services. Please refer to *Oracle Database Net Services Administrator's Guide* for information about the duties of network administrators.

See Also: Part V, "Distributed Database Management", for information on network administration in a distributed environment

Application Developers

Application developers design and implement database applications. Their responsibilities include the following tasks:

- Designing and developing the database application

- Designing the database structure for an application
- Estimating storage requirements for an application
- Specifying modifications of the database structure for an application
- Relaying this information to a database administrator
- Tuning the application during development
- Establishing security measures for an application during development

Application developers can perform some of these tasks in collaboration with DBAs. Please refer to *Oracle Database Advanced Application Developer's Guide* for information about application development tasks.

Application Administrators

An Oracle Database site can assign one or more application administrators to administer a particular application. Each application can have its own administrator.

Database Users

Database users interact with the database through applications or utilities. A typical user's responsibilities include the following tasks:

- Entering, modifying, and deleting data, where permitted
- Generating reports from the data

Tasks of a Database Administrator

The following tasks present a prioritized approach for designing, implementing, and maintaining an Oracle Database:

Task 1: Evaluate the Database Server Hardware

Task 2: Install the Oracle Database Software

Task 3: Plan the Database

Task 4: Create and Open the Database

Task 5: Back Up the Database

Task 6: Enroll System Users

Task 7: Implement the Database Design

Task 8: Back Up the Fully Functional Database

Task 9: Tune Database Performance

Task 10: Download and Install Patches

Task 11: Roll Out to Additional Hosts

These tasks are discussed in the sections that follow.

Note: When upgrading to a new release, back up your existing production environment, both software and database, before installation. For information on preserving your existing production database, see *Oracle Database Upgrade Guide*.

Task 1: Evaluate the Database Server Hardware

Evaluate how Oracle Database and its applications can best use the available computer resources. This evaluation should reveal the following information:

- How many disk drives are available to the Oracle products
- How many, if any, dedicated tape drives are available to Oracle products
- How much memory is available to the instances of Oracle Database you will run (see your system configuration documentation)

Task 2: Install the Oracle Database Software

As the database administrator, you install the Oracle Database server software and any front-end tools and database applications that access the database. In some distributed processing installations, the database is controlled by a central computer (database server) and the database tools and applications are executed on remote computers (clients). In this case, you must also install the Oracle Net components necessary to connect the remote machines to the computer that executes Oracle Database.

For more information on what software to install, see "Identifying Your Oracle Database Software Release" on page 1-7.

See Also: For specific requirements and instructions for installation, refer to the following documentation:

- The Oracle documentation specific to your operating system
- The installation guides for your front-end tools and Oracle Net drivers

Task 3: Plan the Database

As the database administrator, you must plan:

- The logical storage structure of the database
- The overall database design
- A backup strategy for the database

It is important to plan how the logical storage structure of the database will affect system performance and various database management operations. For example, before creating any tablespaces for your database, you should know how many datafiles will make up the tablespace, what type of information will be stored in each tablespace, and on which disk drives the datafiles will be physically stored. When planning the overall logical storage of the database structure, take into account the effects that this structure will have when the database is actually created and running. Consider how the logical storage structure of the database will affect:

- The performance of the computer executing running Oracle Database
- The performance of the database during data access operations
- The efficiency of backup and recovery procedures for the database

Plan the relational design of the database objects and the storage characteristics for each of these objects. By planning the relationship between each object and its physical storage before creating it, you can directly affect the performance of the database as a unit. Be sure to plan for the growth of the database.

In distributed database environments, this planning stage is extremely important. The physical location of frequently accessed data dramatically affects application performance.

During the planning stage, develop a backup strategy for the database. You can alter the logical storage structure or design of the database to improve backup efficiency.

It is beyond the scope of this book to discuss relational and distributed database design. If you are not familiar with such design issues, please refer to accepted industry-standard documentation.

Part II, "Oracle Database Structure and Storage", and Part III, "Schema Objects", provide specific information on creating logical storage structures, objects, and integrity constraints for your database.

Task 4: Create and Open the Database

After you complete the database design, you can create the database and open it for normal use. You can create a database at installation time, using the Database Configuration Assistant, or you can supply your own scripts for creating a database.

Please refer to Chapter 2, "Creating and Configuring an Oracle Database", for information on creating a database and Chapter 3, "Starting Up and Shutting Down" for guidance in starting up the database.

Task 5: Back Up the Database

After you create the database structure, carry out the backup strategy you planned for the database. Create any additional redo log files, take the first full database backup (online or offline), and schedule future database backups at regular intervals.

See Also: *Oracle Database Backup and Recovery User's Guide*

Task 6: Enroll System Users

After you back up the database structure, you can enroll the users of the database in accordance with your Oracle license agreement, and grant appropriate privileges and roles to these users. Please refer to Chapter 6, "Managing Users and Securing the Database" for guidance in this task.

Task 7: Implement the Database Design

After you create and start the database, and enroll the system users, you can implement the planned logical structure database by creating all necessary tablespaces. When you have finished creating tablespaces, you can create the database objects.

Part II, "Oracle Database Structure and Storage" and Part III, "Schema Objects" provide information on creating logical storage structures and objects for your database.

Task 8: Back Up the Fully Functional Database

When the database is fully implemented, again back up the database. In addition to regularly scheduled backups, you should always back up your database immediately after implementing changes to the database structure.

Task 9: Tune Database Performance

Optimizing the performance of the database is one of your ongoing responsibilities as a DBA. Oracle Database provides a database resource management feature that helps you to control the allocation of resources among various user groups. The database resource manager is described in Chapter 25, "Managing Resource Allocation with Oracle Database Resource Manager".

See Also: *Oracle Database Performance Tuning Guide* for information about tuning your database and applications

Task 10: Download and Install Patches

After installation and on a regular basis, download and install patches. Patches are available as single interim patches and as patchsets (or **patch releases**). Interim patches address individual software bugs and may or may not be needed at your installation. Patch releases are collections of bug fixes that are applicable for all customers. Patch releases have release numbers. For example, if you installed Oracle Database 10.2.0.0, the first patch release will have a release number of 10.2.0.1.

See Also: *Oracle Database Installation Guide* for your platform for instructions on downloading and installing patches.

Task 11: Roll Out to Additional Hosts

After you have an Oracle Database installation properly configured, tuned, patched, and tested, you may want to roll that exact installation out to other hosts. Reasons to do this include the following:

- You have multiple production database systems.
- You want to create development and test systems that are identical to your production system.

Instead of installing, tuning, and patching on each additional host, you can **clone** your tested Oracle Database installation to other hosts, saving time and eliminating inconsistencies. There are two types of cloning available to you:

- Cloning an Oracle home—Just the configured and patched binaries from the Oracle home directory and subdirectories are copied to the destination host and "fixed" to match the new environment. You can then start an instance with this cloned home and create a database.

  You can use the Enterprise Manager Clone Oracle Home tool to clone an Oracle home to one or more destination hosts. You can also manually clone an Oracle home using a set of provided scripts and Oracle Universal Installer.

- Cloning a database—The tuned database, including database files, initialization parameters, and so on, are cloned to an existing Oracle home (possibly a cloned home).

  You can use the Enterprise Manager Clone Database tool to clone an Oracle database instance to an existing Oracle home.

See Also:

- *Oracle Universal Installer and OPatch User's Guide* and Enterprise Manager online help for details on how to clone an Oracle home.
- Enterprise Manager online help for instructions for cloning a database.

Selecting an Instance with Environment Variables

Before you attempt to use SQL*Plus to connect locally to an Oracle instance, you must ensure that environment variables are set properly. When multiple database instances exist on one server, or when an Automatic Storage Management (ASM) instance exists on the same server as one or more database instances, the environment variables determine which instance SQL*Plus connects to. (This is also true when there is only one Oracle instance on a server.)

For example, each Oracle instance (database or ASM) has a unique system identifier (SID). To connect to an instance, you must at a minimum set the `ORACLE_SID` environment variable to the SID of that instance. Depending on the operating system, you may need to set other environment variables to properly change from one instance to another.

Refer to the *Oracle Database Installation Guide* or administration guide for your operating system for details on environment variables and for information on switching instances.

Note: This discussion applies only when you make a local connection—that is, when you initiate a SQL*Plus connection from the same machine on which the target instance resides, without specifying an Oracle Net Services connect identifier. When you make a connection through Oracle Net Services, either with SQL*Plus on the local or a remote machine, or with Enterprise Manager, the environment is automatically set for you.

For more information on connect identifiers, see *Oracle Database Net Services Administrator's Guide*.

Solaris Example

The following Solaris example sets the environment variables that are required for selecting an instance. When switching between instances with different Oracle homes, the `ORACLE_HOME` environment variable must be changed.

```
% setenv ORACLE_SID SAL1
% setenv ORACLE_HOME /u01/app/oracle/product/10.1.0/db_1
% setenv LD_LIBRARY_PATH /usr/lib:/usr/dt/lib:/usr/openwin/lib:/usr/ccs/lib
```

Most UNIX installations come with two scripts, `oraenv` and `coraenv`, that can be used to easily set these environment variables. For more information, see *Administrator's Reference for UNIX Systems*.

Windows Example

On Windows, you must set only the ORACLE_SID environment variable to select an instance before starting SQL*Plus.

```
SET ORACLE_SID=SAL1
```

Identifying Your Oracle Database Software Release

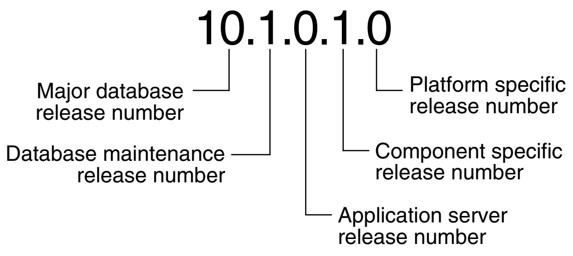
Because Oracle Database continues to evolve and can require maintenance, Oracle periodically produces new releases. Not all customers initially subscribe to a new release or require specific maintenance for their existing release. As a result, multiple releases of the product exist simultaneously.

As many as five numbers may be required to fully identify a release. The significance of these numbers is discussed in the sections that follow.

Release Number Format

To understand the release nomenclature used by Oracle, examine the following example of an Oracle Database server labeled "Release 10.1.0.1.0".

Figure 1–1 Example of an Oracle Database Release Number


10.1.0.1.0
Major database release number
Database maintenance release number
Application server release number
Component specific release number
Platform specific release number

Note: Starting with release 9.2, maintenance releases of Oracle Database are denoted by a change to the second digit of a release number. In previous releases, the third digit indicated a particular maintenance release.

Major Database Release Number

The first digit is the most general identifier. It represents a major new version of the software that contains significant new functionality.

Database Maintenance Release Number

The second digit represents a maintenance release level. Some new features may also be included.

Application Server Release Number

The third digit reflects the release level of the Oracle Application Server (OracleAS).

Component-Specific Release Number

The fourth digit identifies a release level specific to a component. Different components can have different numbers in this position depending upon, for example, component patch sets or interim releases.

Platform-Specific Release Number

The fifth digit identifies a platform-specific release. Usually this is a patch set. When different platforms require the equivalent patch set, this digit will be the same across the affected platforms.

Checking Your Current Release Number

To identify the release of Oracle Database that is currently installed and to see the release levels of other database components you are using, query the data dictionary view `PRODUCT_COMPONENT_VERSION`. A sample query follows. (You can also query the V$VERSION view to see component-level information.) Other product release levels may increment independent of the database server.

```
COL PRODUCT FORMAT A35
COL VERSION FORMAT A15
COL STATUS FORMAT A15
SELECT * FROM PRODUCT_COMPONENT_VERSION;

PRODUCT                                  VERSION     STATUS
---------------------------------------- ----------- -----------
NLSRTL                                   10.2.0.1.0  Production
Oracle Database 10g Enterprise Edition   10.2.0.1.0  Prod
PL/SQL                                   10.2.0.1.0  Production
...
```

It is important to convey to Oracle the results of this query when you report problems with the software.

Database Administrator Security and Privileges

To perform the administrative tasks of an Oracle Database DBA, you need specific privileges within the database and possibly in the operating system of the server on which the database runs. Access to a database administrator's account should be tightly controlled.

This section contains the following topics:

- The Database Administrator's Operating System Account
- Database Administrator Usernames

The Database Administrator's Operating System Account

To perform many of the administrative duties for a database, you must be able to execute operating system commands. Depending on the operating system on which Oracle Database is running, you might need an operating system account or ID to gain access to the operating system. If so, your operating system account might require operating system privileges or access rights that other database users do not require (for example, to perform Oracle Database software installation). Although you do not need the Oracle Database files to be stored in your account, you should have access to them.

See Also: Your operating system specific Oracle documentation. The method of creating the account of the database administrator is specific to the operating system.

Database Administrator Usernames

Two user accounts are automatically created when Oracle Database is installed:

- SYS (default password: CHANGE_ON_INSTALL)
- SYSTEM (default password: MANAGER)

Note: Both Oracle Universal Installer (OUI) and Database Configuration Assistant (DBCA) now prompt for `SYS` and `SYSTEM` passwords and do not accept the default passwords "change_on_install" or "manager", respectively.

If you create the database manually, Oracle strongly recommends that you specify passwords for `SYS` and `SYSTEM` at database creation time, rather than using these default passwords. Please refer to "Protecting Your Database: Specifying Passwords for Users SYS and SYSTEM" on page 2-10 for more information.

Create at least one additional administrative user and grant to that user an appropriate administrative role to use when performing daily administrative tasks. Do not use `SYS` and `SYSTEM` for these purposes.

Note Regarding Security Enhancements: In this release of Oracle Database and in subsequent releases, several enhancements are being made to ensure the security of default database user accounts. You can find a security checklist for this release in *Oracle Database Security Guide*. Oracle recommends that you read this checklist and configure your database accordingly.

SYS

When you create an Oracle Database, the user `SYS` is automatically created and granted the `DBA` role.

All of the base tables and views for the database data dictionary are stored in the schema `SYS`. These base tables and views are critical for the operation of Oracle Database. To maintain the integrity of the data dictionary, tables in the `SYS` schema are manipulated only by the database. They should never be modified by any user or database administrator, and no one should create any tables in the schema of user `SYS`. (However, you can change the storage parameters of the data dictionary settings if necessary.)

Ensure that most database users are never able to connect to Oracle Database using the `SYS` account.

SYSTEM

When you create an Oracle Database, the user `SYSTEM` is also automatically created and granted the `DBA` role.

The `SYSTEM` username is used to create additional tables and views that display administrative information, and internal tables and views used by various Oracle Database options and tools. Never use the `SYSTEM` schema to store tables of interest to non-administrative users.

The DBA Role

A predefined `DBA` role is automatically created with every Oracle Database installation. This role contains most database system privileges. Therefore, the DBA role should be granted only to actual database administrators.

Note: The DBA role does not include the `SYSDBA` or `SYSOPER` system privileges. These are special administrative privileges that allow an administrator to perform basic database administration tasks, such as creating the database and instance startup and shutdown. These system privileges are discussed in "Administrative Privileges" on page 1-11.

Database Administrator Authentication

As a DBA, you often perform special operations such as shutting down or starting up a database. Because only a DBA should perform these operations, the database administrator usernames require a secure authentication scheme.

This section contains the following topics:

- Administrative Privileges
- Selecting an Authentication Method for Database Administrators
- Using Operating System Authentication
- Using Password File Authentication

Administrative Privileges

Administrative privileges that are required for an administrator to perform basic database operations are granted through two special system privileges, `SYSDBA` and `SYSOPER`. You must have one of these privileges granted to you, depending upon the level of authorization you require.

Note: The `SYSDBA` and `SYSOPER` system privileges allow access to a database instance even when the database is not open. Control of these privileges is totally outside of the database itself.

The `SYSDBA` and `SYSOPER` privileges can also be thought of as types of connections that enable you to perform certain database operations for which privileges cannot be granted in any other fashion. For example, you if you have the `SYSDBA` privilege, you can connect to the database by specifying `CONNECT AS SYSDBA`.

SYSDBA and SYSOPER

The following operations are authorized by the `SYSDBA` and `SYSOPER` system privileges:

System Privilege	Operations Authorized
SYSDBA	▪ Perform STARTUP and SHUTDOWN operations ▪ ALTER DATABASE: open, mount, back up, or change character set ▪ CREATE DATABASE ▪ DROP DATABASE ▪ CREATE SPFILE ▪ ALTER DATABASE ARCHIVELOG ▪ ALTER DATABASE RECOVER ▪ Includes the RESTRICTED SESSION privilege Effectively, this system privilege allows a user to connect as user SYS.
SYSOPER	▪ Perform STARTUP and SHUTDOWN operations ▪ CREATE SPFILE ▪ ALTER DATABASE OPEN/MOUNT/BACKUP ▪ ALTER DATABASE ARCHIVELOG ▪ ALTER DATABASE RECOVER (Complete recovery only. Any form of incomplete recovery, such as UNTIL TIME|CHANGE|CANCEL|CONTROLFILE requires connecting as SYSDBA.) ▪ Includes the RESTRICTED SESSION privilege This privilege allows a user to perform basic operational tasks, but without the ability to look at user data.

The manner in which you are authorized to use these privileges depends upon the method of authentication that you use.

When you connect with SYSDBA or SYSOPER privileges, you connect with a default schema, not with the schema that is generally associated with your username. For SYSDBA this schema is SYS; for SYSOPER the schema is PUBLIC.

Connecting with Administrative Privileges: Example

This example illustrates that a user is assigned another schema (SYS) when connecting with the SYSDBA system privilege. Assume that the sample user oe has been granted the SYSDBA system privilege and has issued the following statements:

```
CONNECT oe/oe
CREATE TABLE admin_test(name VARCHAR2(20));
```

Later, user oe issues these statements:

```
CONNECT oe/oe AS SYSDBA
SELECT * FROM admin_test;
```

User oe now receives the following error:

```
ORA-00942: table or view does not exist
```

Having connected as SYSDBA, user oe now references the SYS schema, but the table was created in the oe schema.

See Also:

- "Using Operating System Authentication" on page 1-14
- "Using Password File Authentication" on page 1-15

Selecting an Authentication Method for Database Administrators

Database Administrators can authenticate through the database data dictionary, (using an account password) like other users. Keep in mind that beginning with Oracle Database 11*g* Release 1, database passwords are case sensitive. (You can disable case sensitivity and return to pre–Release 11*g* behavior by setting the `SEC_CASE_SENSITIVE_LOGON` initialization parameter to `FALSE`.)

In addition to normal data dictionary authentication, the following methods are available for authenticating database administrators with the `SYSDBA` or `SYSOPER` privilege:

- Operating system (OS) authentication
- A password file

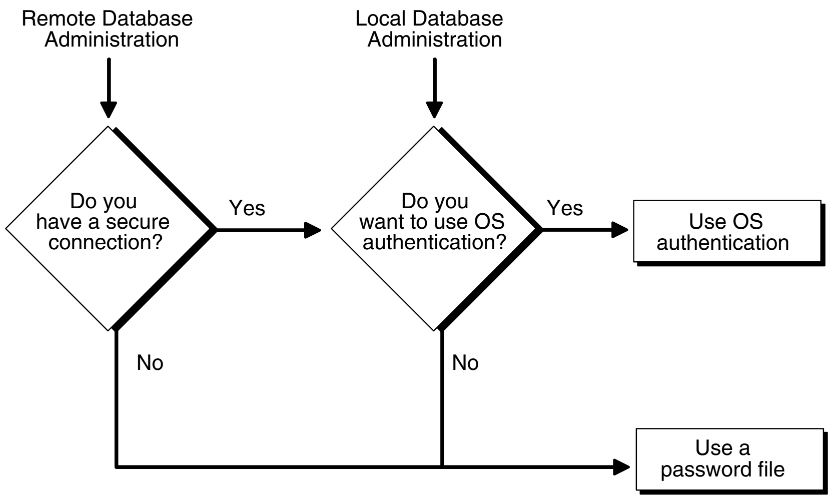
These methods are required to authenticate a database administrator when the database is not started or otherwise unavailable. (They can also be used when the database is available.)

Notes:

- These methods replace the `CONNECT INTERNAL` syntax provided with earlier versions of Oracle Database. `CONNECT INTERNAL` is no longer supported.
- Operating system authentication takes precedence over password file authentication. If you meet the requirements for operating system authentication, then even if you use a password file, you will be authenticated by operating system authentication.

Your choice will be influenced by whether you intend to administer your database locally on the same machine where the database resides, or whether you intend to administer many different databases from a single remote client. Figure 1–2 illustrates the choices you have for database administrator authentication schemes.

Figure 1–2 Database Administrator Authentication Methods


Remote Database Administration
Local Database Administration
Do you have a secure connection?
Yes
No
Do you want to use OS authentication?
Yes
No
Use OS authentication
Use a password file

If you are performing remote database administration, consult your Oracle Net documentation to determine whether you are using a secure connection. Most popular connection protocols, such as TCP/IP and DECnet, are not secure.

See Also: *Oracle Database Net Services Administrator's Guide*

Nonsecure Remote Connections

To connect to Oracle Database as a privileged user over a nonsecure connection, you must be authenticated by a password file. When using password file authentication, the database uses a password file to keep track of database usernames that have been granted the `SYSDBA` or `SYSOPER` system privilege. This form of authentication is discussed in "Using Password File Authentication" on page 1-15.

Local Connections and Secure Remote Connections

You can connect to Oracle Database as a privileged user over a local connection or a secure remote connection in two ways:

- If the database has a password file and you have been granted the `SYSDBA` or `SYSOPER` system privilege, then you can connect and be authenticated by a password file.
- If the server is not using a password file, or if you have not been granted `SYSDBA` or `SYSOPER` privileges and are therefore not in the password file, you can use operating system authentication. On most operating systems, authentication for database administrators involves placing the operating system username of the database administrator in a special group, generically referred to as OSDBA. Users in that group are granted `SYSDBA` privileges. A similar group, OSOPER, is used to grant `SYSOPER` privileges to users.

Using Operating System Authentication

This section describes how to authenticate an administrator using the operating system.

OSDBA and OSOPER

Two special operating system groups control database administrator connections when using operating system authentication. These groups are generically referred to as OSDBA and OSOPER. The groups are created and assigned specific names as part of the database installation process. The specific names vary depending upon your operating system and are listed in the following table:

Operating System Group	UNIX User Group	Windows User Group
OSDBA	`dba`	`ORA_DBA`
OSOPER	`oper`	`ORA_OPER`

The default names assumed by the Oracle Universal Installer can be overridden. How you create the OSDBA and OSOPER groups is operating system specific.

Membership in the OSDBA or OSOPER group affects your connection to the database in the following ways:

- If you are a member of the OSDBA group and you specify `AS SYSDBA` when you connect to the database, then you connect to the database with the `SYSDBA` system privilege.

- If you are a member of the OSOPER group and you specify `AS SYSOPER` when you connect to the database, then you connect to the database with the `SYSOPER` system privilege.
- If you are not a member of either of these operating system groups and you attempt to connect as `SYSDBA` or `SYSOPER`, the `CONNECT` command fails.

> **See Also:** Your operating system specific Oracle documentation for information about creating the OSDBA and OSOPER groups

Preparing to Use Operating System Authentication

To enable operating system authentication of an administrative user:

1. Create an operating system account for the user.
2. Add the account to the `OSDBA` or `OSOPER` operating system defined groups.

Connecting Using Operating System Authentication

A user can be authenticated, enabled as an administrative user, and connected to a local database by typing one of the following SQL*Plus commands:

```
CONNECT / AS SYSDBA
CONNECT / AS SYSOPER
```

For a remote database connection over a secure connection, the user must also specify the net service name of the remote database:

```
CONNECT /@net_service_name AS SYSDBA
CONNECT /@net_service_name AS SYSOPER
```

> **See Also:** *SQL*Plus User's Guide and Reference* for syntax of the `CONNECT` command

Using Password File Authentication

This section describes how to authenticate an administrative user using password file authentication.

Preparing to Use Password File Authentication

To enable authentication of an administrative user using password file authentication you must do the following:

1. If not already created, create the password file using the `ORAPWD` utility:

   ```
   ORAPWD FILE=filename PASSWORD=password ENTRIES=max_users
   ```

   > **Notes:**
   >
   > - When you invoke Database Configuration Assistant (DBCA) as part of the Oracle Database installation process, DBCA creates a password file.
   > - Beginning with Oracle Database 11*g* Release 1, passwords in the password file are case sensitive unless you include the `IGNORECASE = Y` command-line argument.

2. Set the `REMOTE_LOGIN_PASSWORDFILE` initialization parameter to `EXCLUSIVE`. (This is the default).

Note: `REMOTE_LOGIN_PASSWORDFILE` is a static initialization parameter and therefore cannot be changed without restarting the database.

---

3. Connect to the database as user `SYS` (or as another user with the administrative privileges).
4. If the user does not already exist in the database, create the user and assign a password.

   Keep in mind that beginning with Oracle Database 11*g* Release 1, database passwords are case sensitive. (You can disable case sensitivity and return to pre–Release 11*g* behavior by setting the `SEC_CASE_SENSITIVE_LOGON` initialization parameter to `FALSE`.
5. Grant the `SYSDBA` or `SYSOPER` system privilege to the user:

   ```
   GRANT SYSDBA to oe;
   ```

   This statement adds the user to the password file, thereby enabling connection `AS SYSDBA`.

   See Also: "Creating and Maintaining a Password File" on page 1-17 for instructions for creating and maintaining a password file.

Connecting Using Password File Authentication

Administrative users can be connected and authenticated to a local or remote database by using the SQL*Plus `CONNECT` command. They must connect using their username and password and the `AS SYSDBA` or `AS SYSOPER` clause. Note that beginning with Oracle Database 11*g* Release 1, passwords are case-sensitive unless the password file was created with the `IGNORECASE = Y` option..

For example, user `oe` has been granted the `SYSDBA` privilege, so `oe` can connect as follows:

```
CONNECT oe/oe AS SYSDBA
```

However, user `oe` has not been granted the `SYSOPER` privilege, so the following command will fail:

```
CONNECT oe/oe AS SYSOPER
```

Note: Operating system authentication takes precedence over password file authentication. Specifically, if you are a member of the OSDBA or OSOPER group for the operating system, and you connect as SYSDBA or SYSOPER, you will be connected with associated administrative privileges regardless of the *username/password* that you specify.

If you are not in the OSDBA or OSOPER groups, and you are not in the password file, then attempting to connect as `SYSDBA` or as `SYSOPER` fails.

See Also: *SQL*Plus User's Guide and Reference* for syntax of the `CONNECT` command

Creating and Maintaining a Password File

You can create a password file using the password file creation utility, ORAPWD. For some operating systems, you can create this file as part of your standard installation.

This section contains the following topics:

- Using ORAPWD
- Setting REMOTE_LOGIN_ PASSWORDFILE
- Adding Users to a Password File
- Maintaining a Password File

See Also:

- "Using Password File Authentication" on page 1-15
- "Selecting an Authentication Method for Database Administrators" on page 1-13

Using ORAPWD

The syntax of the ORAPWD command is as follows:

```
ORAPWD FILE=filename PASSWORD=password [ENTRIES=numusers]
   [FORCE={Y|N}] [IGNORECASE={Y|N}] [NOSYSDBA={Y|N}]
```

Command parameters are summarized in the following table.

Parameter	Description
FILE	Name to assign to the password file. See your operating system documentation for name requirements. You must supply a complete path. If you supply only a file name, the file is written to the current directory.
PASSWORD	The SYS user password. The SYS user name and password are written to the file.
ENTRIES	(Optional) Maximum number of entries (user accounts) to permit in the file.
FORCE	(Optional) If y, permits overwriting an existing password file.
IGNORECASE	(Optional) If y, passwords are treated as case-insensitive.
NOSYSDBA	(Optional) For Data Vault installations. See the Data Vault installation guide for your platform for more information.

There are no spaces permitted around the equal-to (=) character.

The following command creates a password file named orapworcl that allows up to 30 privileged users with different passwords. In this example, the file is initially created with the password secret for users connecting as SYS.

```
orapwd FILE=orapworcl PASSWORD=secret ENTRIES=30
```

The parameters in the ORAPWD utility are described in detail in the sections that follow.

FILE

This parameter sets the name of the password file being created. You must specify the full path name for the file. If you supply only a file name, the file is written to the current directory. The contents of this file are encrypted, and the file cannot be read directly. This parameter is mandatory.

The types of filenames allowed for the password file are operating system specific. Some operating systems require the password file to adhere to a specific format and be located in a specific directory. Other operating systems allow the use of environment variables to specify the name and location of the password file. For name and location information for the Unix and Linux operating systems, see *Administrator's Reference for UNIX-Based Operating Systems*. For Windows, see *Platform Guide for Microsoft Windows*. For other operating systems, see your operating system documentation.

If you are running multiple instances of Oracle Database using Oracle Real Application Clusters, the environment variable for each instance should point to the same password file.

Caution: It is critically important to the security of your system that you protect your password file and the environment variables that identify the location of the password file. Any user with access to these could potentially compromise the security of the connection.

PASSWORD

This parameter sets the password for user `SYS`. If you issue the `ALTER USER` statement to change the password for `SYS` after connecting to the database, both the password stored in the data dictionary and the password stored in the password file are updated. This parameter is mandatory.

Note: You cannot change the password for `SYS` if `REMOTE_LOGIN_PASSWORDFILE` is set to `SHARED`. An error message is issued if you attempt to do so.

ENTRIES

This parameter specifies the number of entries that you require the password file to accept. This number corresponds to the number of distinct users allowed to connect to the database as `SYSDBA` or `SYSOPER`. The actual number of allowable entries can be higher than the number of users, because the `ORAPWD` utility continues to assign password entries until an operating system block is filled. For example, if your operating system block size is 512 bytes, it holds four password entries. The number of password entries allocated is always a multiple of four.

Entries can be reused as users are added to and removed from the password file. If you intend to specify `REMOTE_LOGIN_PASSWORDFILE=EXCLUSIVE`, and to allow the granting of `SYSDBA` and `SYSOPER` privileges to users, this parameter is required.

Caution: When you exceed the allocated number of password entries, you must create a new password file. To avoid this necessity, allocate a number of entries that is larger than you think you will ever need.

FORCE

This parameter, if set to `Y`, enables you to overwrite an existing password file. An error is returned if a password file of the same name already exists and this parameter is omitted or set to `N`.

IGNORECASE

If this parameter is set to `y`, passwords are case-insensitive. That is, case is ignored when comparing the password that the user supplies during login with the password in the password file.

> **See Also:** *Oracle Database Security Guide* for more information about case-sensitivity in passwords.

Setting REMOTE_LOGIN_ PASSWORDFILE

In addition to creating the password file, you must also set the initialization parameter `REMOTE_LOGIN_PASSWORDFILE` to the appropriate value. The values recognized are:

- `NONE`: Setting this parameter to `NONE` causes Oracle Database to behave as if the password file does not exist. That is, no privileged connections are allowed over nonsecure connections.
- `EXCLUSIVE`: (The default) An `EXCLUSIVE` password file can be used with only one instance of one database. Only an `EXCLUSIVE` file can be modified. Using an `EXCLUSIVE` password file enables you to add, modify, and delete users. It also enables you to change the `SYS` password with the `ALTER USER` command.
- `SHARED`: A `SHARED` password file can be used by multiple databases running on the same server, or multiple instances of an Oracle Real Application Clusters (RAC) database. A `SHARED` password file cannot be modified. This means that you cannot add users to a `SHARED` password file. Any attempt to do so or to change the password of `SYS` or other users with the `SYSDBA` or `SYSOPER` privileges generates an error. All users needing `SYSDBA` or `SYSOPER` system privileges must be added to the password file when `REMOTE_LOGIN_PASSWORDFILE` is set to `EXCLUSIVE`. After all users are added, you can change `REMOTE_LOGIN_PASSWORDFILE` to `SHARED`, and then share the file.

  This option is useful if you are administering multiple databases or a RAC database.

If `REMOTE_LOGIN_PASSWORDFILE` is set to `EXCLUSIVE` or `SHARED` and the password file is missing, this is equivalent to setting `REMOTE_LOGIN_PASSWORDFILE` to `NONE`.

Adding Users to a Password File

When you grant `SYSDBA` or `SYSOPER` privileges to a user, that user's name and privilege information are added to the password file. If the server does not have an `EXCLUSIVE` password file (that is, if the initialization parameter `REMOTE_LOGIN_PASSWORDFILE` is `NONE` or `SHARED`, or the password file is missing), Oracle Database issues an error if you attempt to grant these privileges.

A user's name remains in the password file only as long as that user has at least one of these two privileges. If you revoke both of these privileges, Oracle Database removes the user from the password file.

Creating a Password File and Adding New Users to It

Use the following procedure to create a password and add new users to it:

1. Follow the instructions for creating a password file as explained in "Using ORAPWD" on page 1-17.
2. Set the `REMOTE_LOGIN_PASSWORDFILE` initialization parameter to `EXCLUSIVE`. (This is the default.)

Note: REMOTE_LOGIN_PASSWORDFILE is a static initialization parameter and therefore cannot be changed without restarting the database.

---

3. Connect with SYSDBA privileges as shown in the following example:

```
CONNECT SYS/password AS SYSDBA
```

4. Start up the instance and create the database if necessary, or mount and open an existing database.
5. Create users as necessary. Grant SYSDBA or SYSOPER privileges to yourself and other users as appropriate. See "Granting and Revoking SYSDBA and SYSOPER Privileges", later in this section.

Granting and Revoking SYSDBA and SYSOPER Privileges

If your server is using an EXCLUSIVE password file, use the GRANT statement to grant the SYSDBA or SYSOPER system privilege to a user, as shown in the following example:

```
GRANT SYSDBA TO oe;
```

Use the REVOKE statement to revoke the SYSDBA or SYSOPER system privilege from a user, as shown in the following example:

```
REVOKE SYSDBA FROM oe;
```

Because SYSDBA and SYSOPER are the most powerful database privileges, the WITH ADMIN OPTION is not used in the GRANT statement. That is, the grantee cannot in turn grant the SYSDBA or SYSOPER privilege to another user. Only a user currently connected as SYSDBA can grant or revoke another user's SYSDBA or SYSOPER system privileges. These privileges cannot be granted to roles, because roles are available only after database startup. Do not confuse the SYSDBA and SYSOPER database privileges with operating system roles.

See Also: *Oracle Database Security Guide* for more information on system privileges

Viewing Password File Members

Use the V$PWFILE_USERS view to see the users who have been granted SYSDBA or SYSOPER system privileges for a database. The columns displayed by this view are as follows:

Column	Description
USERNAME	This column contains the name of the user that is recognized by the password file.
SYSDBA	If the value of this column is TRUE, then the user can log on with SYSDBA system privileges.
SYSOPER	If the value of this column is TRUE, then the user can log on with SYSOPER system privileges.

Maintaining a Password File

This section describes how to:

- Expand the number of password file users if the password file becomes full
- Remove the password file

Expanding the Number of Password File Users

If you receive the file full error (`ORA-1996`) when you try to grant `SYSDBA` or `SYSOPER` system privileges to a user, you must create a larger password file and regrant the privileges to the users.

Replacing a Password File

Use the following procedure to replace a password file:

1. Identify the users who have `SYSDBA` or `SYSOPER` privileges by querying the `V$PWFILE_USERS` view.
2. Delete the existing password file.
3. Follow the instructions for creating a new password file using the `ORAPWD` utility in "Using ORAPWD" on page 1-17. Ensure that the `ENTRIES` parameter is set to a number larger than you think you will ever need.
4. Follow the instructions in "Adding Users to a Password File" on page 1-19.

Removing a Password File

If you determine that you no longer require a password file to authenticate users, you can delete the password file and then optionally reset the `REMOTE_LOGIN_PASSWORDFILE` initialization parameter to `NONE`. After you remove this file, only those users who can be authenticated by the operating system can perform `SYSDBA` or `SYSOPER` database administration operations.

Data Utilities

Oracle utilities are available to help you maintain the data in your Oracle Database.

SQL*Loader

SQL*Loader is used both by database administrators and by other users of Oracle Database. It loads data from standard operating system files (such as, files in text or C data format) into database tables.

Export and Import Utilities

The Data Pump utility enables you to archive data and to move existing data between one Oracle Database and another. Also available is the original Import utility for importing data from earlier releases. Beginning with Release 11*g*, the original Export utility is desupported for general use and is recommended only in very specific circumstances.

> **See Also:** *Oracle Database Utilities* for detailed information about these utilities

2 Creating and Configuring an Oracle Database

This chapter describes how to create and configure an Oracle Database, and contains the following topics:

See Also:

- Chapter 15, "Using Oracle-Managed Files" for information about creating a database whose underlying operating system files are automatically created and managed by the Oracle Database server
- Your platform-specific Oracle Real Application Clusters Installation Guide for additional information specific to an Oracle Real Application Clusters environment

Deciding How to Create an Oracle Database

You can create an Oracle Database in three ways:

- Use the Database Configuration Assistant (DBCA).

  DBCA can be launched by the Oracle Universal Installer, depending upon the type of install that you select, and provides a graphical user interface (GUI) that guides you through the creation of a database. You can also launch DBCA as a standalone tool at any time after Oracle Database installation to create or make a copy (clone) of a database. Refer to *Oracle Database 2 Day DBA* for detailed information on creating a database using DBCA.

- Use the `CREATE DATABASE` statement.

  You can use the `CREATE DATABASE` SQL statement to create a database. If you do so, you must complete additional actions before you have an operational database. These actions include creating users and temporary tablespaces, building views of the data dictionary tables, and installing Oracle built-in packages. These actions can be performed by executing prepared scripts, many of which are supplied for you.

  If you have existing scripts for creating your database, consider editing those scripts to take advantage of new Oracle Database features. Oracle provides a sample database creation script and a sample initialization parameter file with the Oracle Database software files. Both the script and the file can be edited to suit your needs. See "Manually Creating an Oracle Database" on page 2-2.

- Upgrade an existing database.

  If you are already using a earlier release of Oracle Database, database creation is required only if you want an entirely new database. You can upgrade your existing Oracle Database and use it with the new release of the database software. The *Oracle Database Upgrade Guide* manual contains information about upgrading an existing Oracle Database.

The remainder of this chapter discusses creating a database manually.

Manually Creating an Oracle Database

This section takes you through the planning stage and the actual creation of the database.

Considerations Before Creating the Database

Database creation prepares several operating system files to work together as an Oracle Database. You need only create a database once, regardless of how many datafiles it has or how many instances access it. You can create a database to erase information in an existing database and create a new database with the same name and physical structure.

The following topics can help prepare you for database creation.

- Planning for Database Creation
- Meeting Creation Prerequisites

Planning for Database Creation

Prepare to create the database by research and careful planning. Table 2–1 lists some recommended actions:

Table 2–1 Database Planning Tasks

Action	Additional Information
Plan the database tables and indexes and estimate the amount of space they will require.	Part II, "Oracle Database Structure and Storage" Part III, "Schema Objects"

Table 2–1 (Cont.) Database Planning Tasks

Action	Additional Information
Plan the layout of the underlying operating system files your database will comprise. Proper distribution of files can improve database performance dramatically by distributing the I/O during file access. You can distribute I/O in several ways when you install Oracle software and create your database. For example, you can place redo log files on separate disks or use striping. You can situate datafiles to reduce contention. And you can control data density (number of rows to a data block).	*Oracle Database Performance Tuning Guide* Your Oracle operating system specific documentation
Consider using Oracle-managed files and Automatic Storage Management to create and manage the operating system files that make up your database storage.	Chapter 15, "Using Oracle-Managed Files" *Oracle Database Storage Administrator's Guide*
Select the **global database name**, which is the name and location of the database within the network structure. Create the global database name by setting both the `DB_NAME` and `DB_DOMAIN` initialization parameters.	"Determining the Global Database Name" on page 2-21
Familiarize yourself with the initialization parameters contained in the initialization parameter file. Become familiar with the concept and operation of a **server parameter file**. A server parameter file lets you store and manage your initialization parameters persistently in a server-side disk file.	"Understanding Initialization Parameters" on page 2-19 "What Is a Server Parameter File?" on page 2-27 *Oracle Database Reference*
Select the database character set. All character data, including data in the data dictionary, is stored in the database character set. You must specify the database character set when you create the database. If clients using different character sets will access the database, then choose a superset that includes all client character sets. Otherwise, character conversions may be necessary at the cost of increased overhead and potential data loss. You can also specify an alternate character set. **Caution**: `AL32UTF8` is the Oracle Database character set that is appropriate for XMLType data. It is equivalent to the IANA registered standard `UTF-8` encoding, which supports all valid XML characters. Do not confuse Oracle Database database character set `UTF8` (no hyphen) with database character set `AL32UTF8` or with character *encoding* `UTF-8`. Database character set `UTF8` has been superseded by `AL32UTF8`. Do not use `UTF8` for XML data. `UTF8` supports only Unicode version 3.1 and earlier; it does not support all valid XML characters. `AL32UTF8` has no such limitation. Using database character set `UTF8` for XML data could potentially cause a fatal error or affect security negatively. If a character that is not supported by the database character set appears in an input-document element name, a replacement character (usually "?") is substituted for it. This will terminate parsing and raise an exception.	*Oracle Database Globalization Support Guide*
Consider what time zones your database must support. Oracle Database uses one of two time zone files as the source of valid time zones. The default time zone file is `timezonelrg.dat`. It contains more time zones than the other time zone file, `timezone.dat`.	"Specifying the Database Time Zone File" on page 2-17

Table 2–1 (Cont.) Database Planning Tasks

Action	Additional Information
Select the standard database block size. This is specified at database creation by the `DB_BLOCK_SIZE` initialization parameter and cannot be changed after the database is created. The `SYSTEM` tablespace and most other tablespaces use the standard block size. Additionally, you can specify up to four nonstandard block sizes when creating tablespaces.	"Specifying Database Block Sizes" on page 2-23
Determine the appropriate initial sizing for the `SYSAUX` tablespace.	"Creating the SYSAUX Tablespace" on page 2-12
Plan to use a default tablespace for non-`SYSTEM` users to prevent inadvertent saving of database objects in the `SYSTEM` tablespace.	"Creating a Default Permanent Tablespace" on page 2-14
Plan to use an undo tablespace to manage your undo data.	Chapter 14, "Managing Undo"
Develop a backup and recovery strategy to protect the database from failure. It is important to protect the control file by multiplexing, to choose the appropriate backup mode, and to manage the online and archived redo logs.	Chapter 10, "Managing the Redo Log" Chapter 11, "Managing Archived Redo Logs" Chapter 9, "Managing Control Files" *Oracle Database Backup and Recovery User's Guide*
Familiarize yourself with the principles and options of starting up and shutting down an instance and mounting and opening a database.	Chapter 3, "Starting Up and Shutting Down"

Meeting Creation Prerequisites

Before you can create a new database, the following prerequisites must be met:

- The desired Oracle software must be installed. This includes setting various environment variables unique to your operating system and establishing the directory structure for software and database files.
- You must have the operating system privileges associated with a fully operational database administrator. You must be specially authenticated by your operating system or through a password file, allowing you to start up and shut down an instance before the database is created or opened. This authentication is discussed in "Database Administrator Authentication" on page 1-11.
- Sufficient memory must be available to start the Oracle Database instance.
- Sufficient disk storage space must be available for the planned database on the computer that runs Oracle Database.

All of these are discussed in the *Oracle Database Installation Guide* specific to your operating system. If you use the Oracle Universal Installer, it will guide you through your installation and provide help in setting environment variables and establishing directory structure and authorizations.

Creating the Database

This section presents the steps involved when you create a database manually. These steps should be followed in the order presented. The prerequisites described in the preceding section must already have been completed. That is, you have established the environment for creating your Oracle Database, including most operating system dependent environmental variables, as part of the Oracle software installation process.

Step 1: Decide on Your Instance Identifier (SID)

Step 2: Establish the Database Administrator Authentication Method

Step 3: Create the Initialization Parameter File

Step 4: Connect to the Instance

Step 5: Create a Server Parameter File (Recommended)

Step 6: Start the Instance

Step 7: Issue the CREATE DATABASE Statement

Step 8: Create Additional Tablespaces

Step 9: Run Scripts to Build Data Dictionary Views

Step 10: Run Scripts to Install Additional Options (Optional)

Step 11: Back Up the Database.

The examples shown in these steps create an example database `mynewdb`.

Notes:

- The steps in this section contain cross-references to other parts of this book and to other books. These cross-references take you to material that will help you to learn about and understand the initialization parameters and database structures with which you are not yet familiar.
- If you are using Oracle Automatic Storage Management to manage your disk storage, you must start the ASM instance and configure your disk groups before performing the following steps. For information about Automatic Storage Management, see *Oracle Database Storage Administrator's Guide*.

Step 1: Decide on Your Instance Identifier (SID)

An instance is made up of the system global area (SGA) and the background processes of an Oracle Database. Decide on a unique Oracle system identifier (SID) for your instance and set the `ORACLE_SID` environment variable accordingly. This identifier is used to distinguish this instance from other Oracle Database instances that you may create later and run concurrently on your system.

The following example for UNIX operating systems sets the SID for the instance that you will connect to in Step 4: Connect to the Instance:

```
% setenv ORACLE_SID mynewdb
```

Step 2: Establish the Database Administrator Authentication Method

You must be authenticated and granted appropriate system privileges in order to create a database. You can use the password file or operating system authentication method. Database administrator authentication and authorization is discussed in the following sections of this book:

- "Database Administrator Security and Privileges" on page 1-9

- "Database Administrator Authentication" on page 1-11
- "Creating and Maintaining a Password File" on page 1-17

Step 3: Create the Initialization Parameter File

When an Oracle instance starts, it reads an initialization parameter file. This file can be a read-only text file, which must be modified with a text editor, or a read/write binary file, which can be modified dynamically by the database (for tuning) or with SQL commands that you submit. The binary file, which is preferred, is called a **server parameter file**. In this step, you create a text initialization parameter file. In a later step, you can optionally create a server parameter file from the text file.

One way to create the text initialization parameter file is to edit a copy of the sample initialization parameter file that Oracle provides on the distribution media, or the sample presented in this book.

Note: On Unix operating systems, the Oracle Universal Installer installs a sample text initialization parameter file in the following location:

```
$ORACLE_HOME/dbs/init.ora
```

For convenience, store your initialization parameter file in the Oracle Database default location, using the default name. Then when you start your database, it will not be necessary to specify the `PFILE` clause of the `STARTUP` command, because Oracle Database automatically looks in the default location for the initialization parameter file.

For name, location, and sample content for the initialization parameter file, and for a discussion of how to set initialization parameters, see "Understanding Initialization Parameters" on page 2-19.

Step 4: Connect to the Instance

Start SQL*Plus and connect to your Oracle Database instance `AS SYSDBA`.

```
$ SQLPLUS /nolog
CONNECT SYS/password AS SYSDBA
```

Step 5: Create a Server Parameter File (Recommended)

Oracle recommends that you create a server parameter file. The server parameter file enables you to change initialization parameters with database commands and persist the changes across a shutdown and startup. You create the server parameter file from your edited text initialization file. For more information, see "Managing Initialization Parameters Using a Server Parameter File" on page 2-27.

The following script creates a server parameter file from the text initialization parameter file and writes it to the default location. The script can be executed before or after instance startup, but after you connect as `SYSDBA`. The database must be restarted before the server parameter file takes effect.

```
-- create the server parameter file
CREATE SPFILE='/u01/oracle/dbs/spfilemynewdb.ora' FROM
       PFILE='/u01/oracle/admin/initmynewdb/scripts/init.ora';
SHUTDOWN
-- the next startup will use the server parameter file
EXIT
```

Step 6: Start the Instance

Start an instance without mounting a database. Typically, you do this only during database creation or while performing maintenance on the database. Use the `STARTUP` command with the `NOMOUNT` clause. In this example, because the server parameter file is stored in the default location, you are not required to specify the `PFILE` clause:

```
STARTUP NOMOUNT
```

At this point, the SGA is created and background processes are started in preparation for the creation of a new database. The database itself does not yet exist.

See Also:

- "Managing Initialization Parameters Using a Server Parameter File" on page 2-27
- Chapter 3, "Starting Up and Shutting Down", to learn how to use the `STARTUP` command

Step 7: Issue the CREATE DATABASE Statement

To create the new database, use the `CREATE DATABASE` statement. The following statement creates database `mynewdb`:

```
CREATE DATABASE mynewdb
   USER SYS IDENTIFIED BY pz6r58
   USER SYSTEM IDENTIFIED BY y1tz5p
   LOGFILE GROUP 1 ('/u01/oracle/oradata/mynewdb/redo01.log') SIZE 100M,
           GROUP 2 ('/u01/oracle/oradata/mynewdb/redo02.log') SIZE 100M,
           GROUP 3 ('/u01/oracle/oradata/mynewdb/redo03.log') SIZE 100M
   MAXLOGFILES 5
   MAXLOGMEMBERS 5
   MAXLOGHISTORY 1
   MAXDATAFILES 100
   MAXINSTANCES 1
   CHARACTER SET US7ASCII
   NATIONAL CHARACTER SET AL16UTF16
   DATAFILE '/u01/oracle/oradata/mynewdb/system01.dbf' SIZE 325M REUSE
   EXTENT MANAGEMENT LOCAL
   SYSAUX DATAFILE '/u01/oracle/oradata/mynewdb/sysaux01.dbf' SIZE 325M REUSE
   DEFAULT TABLESPACE tbs_1
   DEFAULT TEMPORARY TABLESPACE tempts1
      TEMPFILE '/u01/oracle/oradata/mynewdb/temp01.dbf'
      SIZE 20M REUSE
   UNDO TABLESPACE undotbs
      DATAFILE '/u01/oracle/oradata/mynewdb/undotbs01.dbf'
      SIZE 200M REUSE AUTOEXTEND ON MAXSIZE UNLIMITED;
```

A database is created with the following characteristics:

- The database is named `mynewdb`. Its global database name is `mynewdb.us.oracle.com`. See "DB_NAME Initialization Parameter" and "DB_DOMAIN Initialization Parameter" on page 2-22.
- Three control files are created as specified by the `CONTROL_FILES` initialization parameter, which was set before database creation in the initialization parameter file. See "Sample Initialization Parameter File" on page 2-20 and "Specifying Control Files" on page 2-22.
- The password for user `SYS` is `pz6r58` and the password for `SYSTEM` is `y1tz5p`. The two clauses that specify the passwords for `SYS` and `SYSTEM` are not

mandatory in this release of Oracle Database. However, if you specify either clause, you must specify both clauses. For further information about the use of these clauses, see "Protecting Your Database: Specifying Passwords for Users SYS and SYSTEM" on page 2-10.

- The new database has three redo log files as specified in the `LOGFILE` clause. `MAXLOGFILES`, `MAXLOGMEMBERS`, and `MAXLOGHISTORY` define limits for the redo log. See Chapter 10, "Managing the Redo Log".
- `MAXDATAFILES` specifies the maximum number of datafiles that can be open in the database. This number affects the initial sizing of the control file.

> **Note:** You can set several limits during database creation. Some of these limits are limited by and affected by operating system limits. For example, if you set `MAXDATAFILES`, Oracle Database allocates enough space in the control file to store `MAXDATAFILES` filenames, even if the database has only one datafile initially. However, because the maximum control file size is limited and operating system dependent, you might not be able to set all `CREATE DATABASE` parameters at their theoretical maximums.
>
> For more information about setting limits during database creation, see the *Oracle Database SQL Language Reference* and your operating system specific Oracle documentation.

- `MAXINSTANCES` specifies that only one instance can have this database mounted and open.
- The `US7ASCII` character set is used to store data in this database.
- The `AL16UTF16` character set is specified as the `NATIONAL CHARACTER SET`, used to store data in columns specifically defined as `NCHAR`, `NCLOB`, or `NVARCHAR2`.
- The `SYSTEM` tablespace, consisting of the operating system file `/u01/oracle/oradata/mynewdb/system01.dbf` is created as specified by the `DATAFILE` clause. If a file with that name already exists, it is overwritten.
- The `SYSTEM` tablespace is a locally managed tablespace. See "Creating a Locally Managed SYSTEM Tablespace" on page 2-11.
- A `SYSAUX` tablespace is created, consisting of the operating system file `/u01/oracle/oradata/mynewdb/sysaux01.dbf` as specified in the `SYSAUX DATAFILE` clause. See "Creating the SYSAUX Tablespace" on page 2-12.
- The `DEFAULT TABLESPACE` clause creates and names a default permanent tablespace for this database.
- The `DEFAULT TEMPORARY TABLESPACE` clause creates and names a default temporary tablespace for this database. See "Creating a Default Temporary Tablespace" on page 2-14.
- The `UNDO TABLESPACE` clause creates and names an undo tablespace that is used to store undo data for this database if you have specified `UNDO_MANAGEMENT=AUTO` in the initialization parameter file. See "Using Automatic Undo Management: Creating an Undo Tablespace" on page 2-13.
- Redo log files will not initially be archived, because the `ARCHIVELOG` clause is not specified in this `CREATE DATABASE` statement. This is customary during database creation. You can later use an `ALTER DATABASE` statement to switch to

ARCHIVELOG mode. The initialization parameters in the initialization parameter file for mynewdb relating to archiving are LOG_ARCHIVE_DEST_1 and LOG_ARCHIVE_FORMAT. See Chapter 11, "Managing Archived Redo Logs".

See Also:

- "Understanding the CREATE DATABASE Statement" on page 2-10
- *Oracle Database SQL Language Reference* for more information about specifying the clauses and parameter values for the CREATE DATABASE statement

Step 8: Create Additional Tablespaces

To make the database functional, you need to create additional files and tablespaces for users. The following sample script creates some additional tablespaces:

```
CONNECT SYS/password AS SYSDBA
-- create a user tablespace to be assigned as the default tablespace for users
CREATE TABLESPACE users LOGGING
     DATAFILE '/u01/oracle/oradata/mynewdb/users01.dbf'
     SIZE 25M REUSE AUTOEXTEND ON NEXT  1280K MAXSIZE UNLIMITED
     EXTENT MANAGEMENT LOCAL;
-- create a tablespace for indexes, separate from user tablespace
CREATE TABLESPACE indx LOGGING
     DATAFILE '/u01/oracle/oradata/mynewdb/indx01.dbf'
     SIZE 25M REUSE AUTOEXTEND ON NEXT  1280K MAXSIZE UNLIMITED
     EXTENT MANAGEMENT LOCAL;
```

For information about creating tablespaces, see Chapter 12, "Managing Tablespaces".

Step 9: Run Scripts to Build Data Dictionary Views

Run the scripts necessary to build views, synonyms, and PL/SQL packages:

```
CONNECT SYS/password AS SYSDBA
@/u01/oracle/rdbms/admin/catalog.sql
@/u01/oracle/rdbms/admin/catproc.sql
EXIT
```

The following table contains descriptions of the scripts:

Script	Description
CATALOG.SQL	Creates the views of the data dictionary tables, the dynamic performance views, and public synonyms for many of the views. Grants PUBLIC access to the synonyms.
CATPROC.SQL	Runs all scripts required for or used with PL/SQL.

Step 10: Run Scripts to Install Additional Options (Optional)

You may want to run other scripts. The scripts that you run are determined by the features and options you choose to use or install. Many of the scripts available to you are described in the *Oracle Database Reference.*

If you plan to install other Oracle products to work with this database, see the installation instructions for those products. Some products require you to create additional data dictionary tables. Usually, command files are provided to create and load these tables into the database data dictionary.

See your Oracle documentation for the specific products that you plan to install for installation and administration instructions.

Step 11: Back Up the Database.

Take a full backup of the database to ensure that you have a complete set of files from which to recover if a media failure occurs. For information on backing up a database, see *Oracle Database Backup and Recovery User's Guide.*

Understanding the CREATE DATABASE Statement

When you execute a `CREATE DATABASE` statement, Oracle Database performs (at least) a number of operations. The actual operations performed depend on the clauses that you specify in the `CREATE DATABASE` statement and the initialization parameters that you have set. Oracle Database performs at least these operations:

- Creates the datafiles for the database
- Creates the control files for the database
- Creates the redo log files for the database and establishes the `ARCHIVELOG` mode.
- Creates the `SYSTEM` tablespace
- Creates the `SYSAUX` tablespace
- Creates the data dictionary
- Sets the character set that stores data in the database
- Sets the database time zone
- Mounts and opens the database for use

This section discusses several of the clauses of the `CREATE DATABASE` statement. It expands upon some of the clauses discussed in "Step 7: Issue the CREATE DATABASE Statement" on page 2-7 and introduces additional ones. Many of the `CREATE DATABASES` clauses discussed here can be used to simplify the creation and management of your database.

The following topics are contained in this section:

- Protecting Your Database: Specifying Passwords for Users SYS and SYSTEM
- Creating a Locally Managed SYSTEM Tablespace
- Creating the SYSAUX Tablespace
- Using Automatic Undo Management: Creating an Undo Tablespace
- Creating a Default Temporary Tablespace
- Specifying Oracle-Managed Files at Database Creation
- Supporting Bigfile Tablespaces During Database Creation
- Specifying the Database Time Zone and Time Zone File
- Specifying FORCE LOGGING Mode

Protecting Your Database: Specifying Passwords for Users SYS and SYSTEM

The clauses of the `CREATE DATABASE` statement used for specifying the passwords for users `SYS` and `SYSTEM` are:

- `USER SYS IDENTIFIED BY` *`password`*

- `USER SYSTEM IDENTIFIED BY` *`password`*

If you omit these clauses, these users are assigned the default passwords `change_on_install` and `manager`, respectively. A record is written to the alert log indicating that the default passwords were used. To protect your database, you should change these passwords using the `ALTER USER` statement immediately after database creation.

Oracle strongly recommends that you specify these clauses, even though they are optional in this release of Oracle Database. The default passwords are commonly known, and if you neglect to change them later, you leave database vulnerable to attack by malicious users.

See Also: "Some Security Considerations" on page 2-39

Creating a Locally Managed SYSTEM Tablespace

Specify the `EXTENT MANAGEMENT LOCAL` clause in the `CREATE DATABASE` statement to create a locally managed `SYSTEM` tablespace. The `COMPATIBLE` initialization parameter must be set to 10.0.0 or higher for this statement to be successful. If you do not specify the `EXTENT MANAGEMENT LOCAL` clause, by default the database creates a dictionary-managed `SYSTEM` tablespace. Dictionary-managed tablespaces are deprecated.

A locally managed `SYSTEM` tablespace has `AUTOALLOCATE` enabled by default, which means that the system determines and controls the number and size of extents. You may notice an increase in the initial size of objects created in a locally managed `SYSTEM` tablespace because of the autoallocate policy. It is not possible to create a locally managed `SYSTEM` tablespace and specify `UNIFORM` extent size.

When you create your database with a locally managed `SYSTEM` tablespace, ensure that the following conditions are met:

- A default temporary tablespace must exist, and that tablespace cannot be the `SYSTEM` tablespace.

  To meet this condition, you can specify the `DEFAULT TEMPORARY TABLESPACE` clause in the `CREATE DATABASE` statement, or you can omit the clause and let Oracle Database create the tablespace for you using a default name and in a default location.

- You can include the `UNDO TABLESPACE` clause in the `CREATE DATABASE` statement to create a specific undo tablespace. If you omit that clause, Oracle Database creates a locally managed undo tablespace for you using the default name and in a default location.

See Also:

- *Oracle Database SQL Language Reference* for more specific information about the use of the `DEFAULT TEMPORARY TABLESPACE` and `UNDO TABLESPACE` clauses when `EXTENT MANAGEMENT LOCAL` is specified for the `SYSTEM` tablespace
- "Locally Managed Tablespaces" on page 12-3
- "Migrating the SYSTEM Tablespace to a Locally Managed Tablespace" on page 12-28

Creating the SYSAUX Tablespace

The SYSAUX tablespace is always created at database creation. The SYSAUX tablespace serves as an auxiliary tablespace to the SYSTEM tablespace. Because it is the default tablespace for many Oracle Database features and products that previously required their own tablespaces, it reduces the number of tablespaces required by the database and that you must maintain. Other functionality or features that previously used the SYSTEM tablespace can now use the SYSAUX tablespace, thus reducing the load on the SYSTEM tablespace.

You can specify only datafile attributes for the SYSAUX tablespace, using the SYSAUX DATAFILE clause in the CREATE DATABASE statement. Mandatory attributes of the SYSAUX tablespace are set by Oracle Database and include:

- PERMANENT
- READ WRITE
- EXTENT MANAGMENT LOCAL
- SEGMENT SPACE MANAGMENT AUTO

You cannot alter these attributes with an ALTER TABLESPACE statement, and any attempt to do so will result in an error. You cannot drop or rename the SYSAUX tablespace.

The size of the SYSAUX tablespace is determined by the size of the database components that occupy SYSAUX. See Table 2–2 for a list of all SYSAUX occupants. Based on the initial sizes of these components, the SYSAUX tablespace needs to be at least 240 MB at the time of database creation. The space requirements of the SYSAUX tablespace will increase after the database is fully deployed, depending on the nature of its use and workload. For more information on how to manage the space consumption of the SYSAUX tablespace on an ongoing basis, please refer to the "Managing the SYSAUX Tablespace" on page 12-24.

If you include a DATAFILE clause for the SYSTEM tablespace, then you must specify the SYSAUX DATAFILE clause as well, or the CREATE DATABASE statement will fail. This requirement does not exist if the Oracle-managed files feature is enabled (see "Specifying Oracle-Managed Files at Database Creation" on page 2-15).

If you issue the CREATE DATABASE statement with no other clauses, then the software creates a default database with datafiles for the SYSTEM and SYSAUX tablespaces stored in system-determined default locations, or where specified by an Oracle-managed files initialization parameter.

The SYSAUX tablespace has the same security attributes as the SYSTEM tablespace.

Note: This book discusses the creation of the SYSAUX database at database creation. When upgrading from a release of Oracle Database that did not require the SYSAUX tablespace, you must create the SYSAUX tablespace as part of the upgrade process. This is discussed in *Oracle Database Upgrade Guide*.

Table 2–2 lists the components that use the SYSAUX tablespace as their default tablespace during installation, and the tablespace in which they were stored in earlier releases:

Table 2–2 Database Components and the SYSAUX Tablespace

Component Using SYSAUX	Tablespace in Earlier Releases
Analytical Workspace Object Table	`SYSTEM`
Enterprise Manager Repository	`OEM_REPOSITORY`
LogMiner	`SYSTEM`
Logical Standby	`SYSTEM`
OLAP API History Tables	`CWMLITE`
Oracle Data Mining	`ODM`
Oracle Spatial	`SYSTEM`
Oracle Streams	`SYSTEM`
Oracle Text	`DRSYS`
Oracle Ultra Search	`DRSYS`
Oracle *inter*Media `ORDPLUGINS` Components	`SYSTEM`
Oracle *inter*Media `ORDSYS` Components	`SYSTEM`
Oracle *inter*Media `SI_INFORMTN_SCHEMA` Components	`SYSTEM`
Server Manageability Components	New in Oracle Database 11*g*
Statspack Repository	User-defined
Oracle Scheduler	New in Oracle Database 11*g*
Workspace Manager	`SYSTEM`

The installation procedures for these components provide the means of establishing their occupancy of the `SYSAUX` tablespace.

> **See Also:** "Managing the SYSAUX Tablespace" on page 12-24 for information about managing the `SYSAUX` tablespace

Using Automatic Undo Management: Creating an Undo Tablespace

Automatic undo management uses an undo tablespace.To enable automatic undo management, set the `UNDO_MANAGEMENT` initialization parameter to `AUTO` in your initialization parameter file. In this mode, **undo data** is stored in an undo tablespace and is managed by Oracle Database. If you want to define and name the undo tablespace yourself, you must also include the `UNDO TABLESPACE` clause in the `CREATE DATABASE` statement at database creation time. If you omit this clause, and automatic undo management is enabled (by setting the `UNDO_MANAGEMENT` initialization parameter to `AUTO`), the database creates a default undo tablespace named `SYS_UNDOTBS`.

> **See Also:**
>
> - "Specifying the Method of Undo Space Management" on page 2-25
> - Chapter 14, "Managing Undo", for information about the creation and use of undo tablespaces

Creating a Default Permanent Tablespace

The DEFAULT TABLESPACE clause of the CREATE DATABASE statement specifies a default permanent tablespace for the database. Oracle Database assigns to this tablespace any non-SYSTEM users for whom you do not explicitly specify a different permanent tablespace. If you do not specify this clause, then the SYSTEM tablespace is the default permanent tablespace for non-SYSTEM users. Oracle strongly recommends that you create a default permanent tablespace.

> **See Also:** *Oracle Database SQL Language Reference* for the syntax of the DEFAULT TABLESPACE clause of CREATE DATABASE and ALTER DATABASE

Creating a Default Temporary Tablespace

The DEFAULT TEMPORARY TABLESPACE clause of the CREATE DATABASE statement creates a default temporary tablespace for the database. Oracle Database assigns this tablespace as the temporary tablespace for users who are not explicitly assigned a temporary tablespace.

You can explicitly assign a temporary tablespace or tablespace group to a user in the CREATE USER statement. However, if you do not do so, and if no default temporary tablespace has been specified for the database, then by default these users are assigned the SYSTEM tablespace as their temporary tablespace. It is not good practice to store temporary data in the SYSTEM tablespace, and it is cumbersome to assign every user a temporary tablespace individually. Therefore, Oracle recommends that you use the DEFAULT TEMPORARY TABLESPACE clause of CREATE DATABASE.

> **Note:** When you specify a locally managed SYSTEM tablespace, the SYSTEM tablespace *cannot* be used as a temporary tablespace. In this case the database creates a default temporary tablespace. This behavior is explained in "Creating a Locally Managed SYSTEM Tablespace" on page 2-11.

You can add or change the default temporary tablespace after database creation. You do this by creating a new temporary tablespace or tablespace group with a CREATE TEMPORARY TABLESPACE statement, and then assign it as the temporary tablespace using the ALTER DATABASE DEFAULT TEMPORARY TABLESPACE statement. Users will automatically be switched (or assigned) to the new default temporary tablespace.

The following statement assigns a new default temporary tablespace:

```
ALTER DATABASE DEFAULT TEMPORARY TABLESPACE tempts2;
```

The new default temporary tablespace must already exist. When using a locally managed SYSTEM tablespace, the new default temporary tablespace must also be locally managed.

You cannot drop or take offline a default temporary tablespace, but you can assign a new default temporary tablespace and then drop or take offline the former one. You cannot change a default temporary tablespace to a permanent tablespace.

Users can obtain the name of the current default temporary tablespace by querying the PROPERTY_NAME and PROPERTY_VALUE columns of the DATABASE_PROPERTIES view. These columns contain the values "DEFAULT_TEMP_TABLESPACE" and the default temporary tablespace name, respectively.

See Also:

- *Oracle Database SQL Language Reference* for the syntax of the `DEFAULT TEMPORARY TABLESPACE` clause of `CREATE DATABASE` and `ALTER DATABASE`
- "Temporary Tablespaces" on page 12-10 for information about creating and using temporary tablespaces
- "Multiple Temporary Tablespaces: Using Tablespace Groups" on page 12-12 for information about creating and using temporary tablespace groups

Specifying Oracle-Managed Files at Database Creation

You can minimize the number of clauses and parameters that you specify in your `CREATE DATABASE` statement by using the Oracle-managed files feature. You do this either by specifying a directory in which your files are created and managed by Oracle Database, or by using Automatic Storage Management. When you use Automatic Storage Management, you specify a disk group in which the database creates and manages your files, including file redundancy and striping.

By including any of the initialization parameters `DB_CREATE_FILE_DEST`, `DB_CREATE_ONLINE_LOG_DEST_`*n*, or `DB_RECOVERY_FILE_DEST` in your initialization parameter file, you instruct Oracle Database to create and manage the underlying operating system files of your database. Oracle Database will automatically create and manage the operating system files for the following database structures, depending on which initialization parameters you specify and how you specify clauses in your `CREATE DATABASE` statement:

- Tablespaces
- Temporary tablespaces
- Control files
- Redo log files
- Archive log files
- Flashback logs
- Block change tracking files
- RMAN backups

See Also: "Specifying a Flash Recovery Area" on page 2-22 for information about setting initialization parameters that create a flash recovery area

The following `CREATE DATABASE` statement shows briefly how the Oracle-managed files feature works, assuming you have specified required initialization parameters:

```
CREATE DATABASE rbdb1
     USER SYS IDENTIFIED BY pz6r58
     USER SYSTEM IDENTIFIED BY y1tz5p
     UNDO TABLESPACE undotbs
     DEFAULT TEMPORARY TABLESPACE tempts1;
```

- No `DATAFILE` clause is specified, so the database creates an Oracle-managed datafile for the `SYSTEM` tablespace.

- No LOGFILE clauses are included, so the database creates two Oracle-managed redo log file groups.
- No SYSAUX DATAFILE is included, so the database creates an Oracle-managed datafile for the SYSAUX tablespace.
- No DATAFILE subclause is specified for the UNDO TABLESPACE clause, so the database creates an Oracle-managed datafile for the undo tablespace.
- No TEMPFILE subclause is specified for the DEFAULT TEMPORARY TABLESPACE clause, so the database creates an Oracle-managed tempfile.
- If no CONTROL_FILES initialization parameter is specified in the initialization parameter file, then the database also creates an Oracle-managed control file.
- If you are using a server parameter file (see "Managing Initialization Parameters Using a Server Parameter File" on page 2-27), the database automatically sets the appropriate initialization parameters.

See Also:

- Chapter 15, "Using Oracle-Managed Files", for information about the Oracle-managed files feature and how to use it
- *Oracle Database Storage Administrator's Guide*. for information about Automatic Storage Management

Supporting Bigfile Tablespaces During Database Creation

Oracle Database simplifies management of tablespaces and enables support for ultra-large databases by letting you create **bigfile tablespaces**. Bigfile tablespaces can contain only one file, but that file can have up to 4G blocks. The maximum number of datafiles in an Oracle Database is limited (usually to 64K files). Therefore, bigfile tablespaces can significantly enhance the storage capacity of an Oracle Database.

This section discusses the clauses of the CREATE DATABASE statement that let you include support for bigfile tablespaces.

See Also: "Bigfile Tablespaces" on page 12-6 for more information about bigfile tablespaces

Specifying the Default Tablespace Type

The SET DEFAULT...TABLESPACE clause of the CREATE DATABASE statement to determines the default type of tablespace for this database in subsequent CREATE TABLESPACE statements. Specify either SET DEFAULT BIGFILE TABLESPACE or SET DEFAULT SMALLFILE TABLESPACE. If you omit this clause, the default is a **smallfile tablespace**, which is the traditional type of Oracle Database tablespace. A smallfile tablespace can contain up to 1022 files with up to 4M blocks each.

The use of bigfile tablespaces further enhances the Oracle-managed files feature, because bigfile tablespaces make datafiles completely transparent for users. SQL syntax for the ALTER TABLESPACE statement has been extended to allow you to perform operations on tablespaces, rather than the underlying datafiles.

The CREATE DATABASE statement shown in "Specifying Oracle-Managed Files at Database Creation" on page 2-15 can be modified as follows to specify that the default type of tablespace is a bigfile tablespace:

```
CREATE DATABASE rbdb1
     USER SYS IDENTIFIED BY pz6r58
     USER SYSTEM IDENTIFIED BY y1tz5p
     SET DEFAULT BIGFILE TABLESPACE
     UNDO TABLESPACE undotbs
     DEFAULT TEMPORARY TABLESPACE tempts1;
```

To dynamically change the default tablespace type after database creation, use the `SET DEFAULT TABLESPACE` clause of the `ALTER DATABASE` statement:

```
ALTER DATABASE SET DEFAULT BIGFILE TABLESPACE;
```

You can determine the current default tablespace type for the database by querying the `DATABASE_PROPERTIES` data dictionary view as follows:

```
SELECT PROPERTY_VALUE FROM DATABASE_PROPERTIES
   WHERE PROPERTY_NAME = 'DEFAULT_TBS_TYPE';
```

Overriding the Default Tablespace Type

The `SYSTEM` and `SYSAUX` tablespaces are always created with the default tablespace type. However, you can explicitly override the default tablespace type for the `UNDO` and `DEFAULT TEMPORARY` tablespace during the `CREATE DATABASE` operation.

For example, you can create a bigfile `UNDO` tablespace in a database with the default tablespace type of smallfile as follows:

```
CREATE DATABASE rbdb1
...
     BIGFILE UNDO TABLESPACE undotbs
        DATAFILE '/u01/oracle/oradata/mynewdb/undotbs01.dbf'
        SIZE 200M REUSE AUTOEXTEND ON MAXSIZE UNLIMITED;
```

You can create a smallfile `DEFAULT TEMPORARY` tablespace in a database with the default tablespace type of bigfile as follows:

```
CREATE DATABASE rbdb1
   SET DEFAULT BIGFILE TABLSPACE
...
     SMALLFILE DEFAULT TEMPORARY TABLESPACE tempts1
        TEMPFILE '/u01/oracle/oradata/mynewdb/temp01.dbf'
        SIZE 20M REUSE
...
```

Specifying the Database Time Zone and Time Zone File

You can specify the database time zone and the supporting time zone file.

Setting the Database Time Zone

Set the database time zone when the database is created by using the `SET TIME_ZONE` clause of the `CREATE DATABASE` statement. If you do not set the database time zone, then it defaults to the time zone of the server's operating system.

You can change the database time zone for a session by using the `SET TIME_ZONE` clause of the `ALTER SESSION` statement.

See Also: *Oracle Database Globalization Support Guide* for more information about setting the database time zone

Specifying the Database Time Zone File

Two time zone files are included in the Oracle home directory. The default time zone file is `$ORACLE_HOME/oracore/zoneinfo/timezonelrg.dat`. A smaller time zone file can be found in `$ORACLE_HOME/oracore/zoneinfo/timezone.dat`.

If you are already using the smaller time zone file and you want to continue to use it in an Oracle Database 11*g* environment or if you want to use the smaller time zone file instead of the default time zone file, then complete the following tasks:

1. Shut down the database.
2. Set the `ORA_TZFILE` environment variable to the full path name of the `timezone.dat` file.
3. Restart the database.

If you are already using the default time zone file, then it is not practical to change to the smaller time zone file because the database may contain data with time zones that are not part of the smaller time file.

All databases that share information must use the same time zone datafile.

The time zone files contain the valid time zone names. The following information is also included for each time zone:

- Offset from Coordinated Universal Time (UTC)
- Transition times for Daylight Saving Time
- Abbreviations for standard time and Daylight Saving Time

To view the time zone names in the file being used by your database, use the following query:

```
SELECT * FROM V$TIMEZONE_NAMES;
```

Specifying FORCE LOGGING Mode

Some data definition language statements (such as CREATE TABLE) allow the `NOLOGGING` clause, which causes some database operations not to generate redo records in the database redo log. The `NOLOGGING` setting can speed up operations that can be easily recovered outside of the database recovery mechanisms, but it can negatively affect media recovery and standby databases.

Oracle Database lets you force the writing of redo records even when `NOLOGGING` has been specified in DDL statements. The database never generates redo records for temporary tablespaces and temporary segments, so forced logging has no affect for objects.

See Also: *Oracle Database SQL Language Reference* for information about operations that can be done in `NOLOGGING` mode

Using the FORCE LOGGING Clause

To put the database into `FORCE LOGGING` mode, use the `FORCE LOGGING` clause in the `CREATE DATABASE` statement. If you do not specify this clause, the database is not placed into `FORCE LOGGING` mode.

Use the `ALTER DATABASE` statement to place the database into `FORCE LOGGING` mode after database creation. This statement can take a considerable time for completion, because it waits for all unlogged direct writes to complete.

You can cancel `FORCE LOGGING` mode using the following SQL statement:

```
ALTER DATABASE NO FORCE LOGGING;
```

Independent of specifying `FORCE LOGGING` for the database, you can selectively specify `FORCE LOGGING` or `NO FORCE LOGGING` at the tablespace level. However, if `FORCE LOGGING` mode is in effect for the database, it takes precedence over the tablespace setting. If it is not in effect for the database, then the individual tablespace settings are enforced. Oracle recommends that either the entire database is placed into `FORCE LOGGING` mode, or individual tablespaces be placed into `FORCE LOGGING` mode, but not both.

The `FORCE LOGGING` mode is a persistent attribute of the database. That is, if the database is shut down and restarted, it remains in the same logging mode. However, if you re-create the control file, the database is not restarted in the `FORCE LOGGING` mode unless you specify the `FORCE LOGGING` clause in the `CREATE CONTROL FILE` statement.

> **See Also:** "Controlling the Writing of Redo Records" on page 12-14 for information about using the `FORCE LOGGING` clause for tablespace creation.

Performance Considerations of FORCE LOGGING Mode

`FORCE LOGGING` mode results in some performance degradation. If the primary reason for specifying `FORCE LOGGING` is to ensure complete media recovery, and there is no standby database active, then consider the following:

- How many media failures are likely to happen?
- How serious is the damage if unlogged direct writes cannot be recovered?
- Is the performance degradation caused by forced logging tolerable?

If the database is running in `NOARCHIVELOG` mode, then generally there is no benefit to placing the database in `FORCE LOGGING` mode. Media recovery is not possible in `NOARCHIVELOG` mode, so if you combine it with `FORCE LOGGING`, the result may be performance degradation with little benefit.

Understanding Initialization Parameters

When an Oracle instance starts, it reads initialization parameters from an initialization parameter file. This file can be either a read-only text file, or a read/write binary file. The binary file is called a **server parameter file**, and it always resides on the server. A server parameter file enables you to change initialization parameters with `ALTER SYSTEM` commands and to persist the changes across a shutdown and startup. It also provides a basis for self-tuning by the Oracle Database server. For these reasons, it is recommended that you use a server parameter file. You can create one manually from your edited text initialization file, or automatically by using Database Configuration Assistant (DBCA) to create your database.

Before you manually create a server parameter file, you can start an instance with a text initialization parameter file. Upon startup, the Oracle instance first searches for a server parameter file in a default location, and if it does not find one, searches for a text initialization parameter file. You can also override an existing server parameter file by naming a text initialization parameter file as an argument of the `STARTUP` command.

For more information on server parameter files, see "Managing Initialization Parameters Using a Server Parameter File" on page 2-27. For more information on the `STARTUP` command, see "Understanding Initialization Parameter Files" on page 3-2.

Default file names and locations for the text initialization parameter file are shown in the following table:

Platform	Default Name	Default Location

UNIX and Linux	`init`*`$ORACLE_SID`*.ora
	For example, the initialization parameter file for the `mynewdb` database is named:
	`initmynewdb.ora`
		`$ORACLE_HOME/dbs`
		For example, the initialization parameter file for the `mynewdb` database is stored in the following location:
		`/u01/oracle/dbs/initmynewdb.ora`

Windows	`init%`*`ORACLE_SID`*`%.ora`	`%ORACLE_HOME%\database`

Sample Initialization Parameter File

The following is an example of a text initialization parameter file used to start a database instance on a UNIX system.

```
control_files             = (/u0d/lcg03/control.001.dbf,
                             /u0d/lcg03/control.002.dbf,
                             /u0d/lcg03/control.003.dbf)
db_name                   = lcg03
db_domain                 = us.oracle.com

log_archive_dest_1        =
"LOCATION=/net/fstlcg03/private/yaliu/testlog/log.lcg03.fstlcg03/lcg03/arch"

log_archive_dest_state_1   = enable

db_recovery_file_dest      =
/net/fstlcg03/private/yaliu/testlog/log.lcg03.fstlcg03/lcg03/arch

db_recovery_file_dest_size = 100G

db_block_size             = 8192

processes                 = 1000
sessions                  = 1200
open_cursors              = 1024
shared_servers            = 4
remote_listener           = tnsfstlcg03

compatible                = 11.1.0

memory_target             = 1500M
ddl_lock_timeout          = 10

nls_language              = AMERICAN
nls_territory             = AMERICA
```

Oracle Database provides generally appropriate values in the sample initialization parameter file provided with your database software or created for you by DBCA. You can edit these Oracle-supplied initialization parameters and add others, depending upon your configuration and options and how you plan to tune the database. For any relevant initialization parameters not specifically included in the initialization parameter file, the database supplies defaults.

If you are creating an Oracle Database for the first time, Oracle suggests that you minimize the number of parameter values that you alter. As you become more familiar with your database and environment, you can dynamically tune many initialization parameters using the `ALTER SYSTEM` statement. If you are using a text initialization parameter file, your changes are effective only for the current instance. To make them permanent, you must update them manually in the initialization parameter file, or they will be lost over the next shutdown and startup of the database. If you are using a server parameter file, initialization parameter file changes made by the `ALTER SYSTEM` statement can persist across shutdown and startup. This is discussed in "Managing Initialization Parameters Using a Server Parameter File".

This section introduces you to some of the basic initialization parameters you can add or edit before you create your new database.

The following topics are contained in this section:

- Determining the Global Database Name
- Specifying a Flash Recovery Area
- Specifying Control Files
- Specifying Database Block Sizes
- Specifying the Maximum Number of Processes
- Specifying the DDL Lock Timeout
- Specifying the Method of Undo Space Management
- The COMPATIBLE Initialization Parameter and Irreversible Compatibility
- Setting the License Parameter

See Also:

- *Oracle Database Reference* for descriptions of all initialization parameters including their default settings
- Chapter 5, "Managing Memory" for a discussion of the initialization parameters that pertain to memory management

Determining the Global Database Name

The global database name consists of the user-specified local database name and the location of the database within a network structure. The `DB_NAME` initialization parameter determines the local name component of the database name, and the `DB_DOMAIN` parameter indicates the domain (logical location) within a network structure. The combination of the settings for these two parameters must form a database name that is unique within a network.

For example, to create a database with a global database name of `test.us.acme.com`, edit the parameters of the new parameter file as follows:

```
DB_NAME = test
DB_DOMAIN = us.acme.com
```

You can rename the `GLOBAL_NAME` of your database using the `ALTER DATABASE RENAME GLOBAL_NAME` statement. However, you must also shut down and restart the database after first changing the `DB_NAME` and `DB_DOMAIN` initialization parameters and re-creating the control file.

See Also: *Oracle Database Utilities* for information about using the `DBNEWID` utility, which is another means of changing a database name

DB_NAME Initialization Parameter

`DB_NAME` must be set to a text string of no more than eight characters. During database creation, the name provided for `DB_NAME` is recorded in the datafiles, redo log files, and control file of the database. If during database instance startup the value of the `DB_NAME` parameter (in the parameter file) and the database name in the control file are not the same, the database does not start.

DB_DOMAIN Initialization Parameter

`DB_DOMAIN` is a text string that specifies the network domain where the database is created. This is typically the name of the organization that owns the database. If the database you are about to create will ever be part of a distributed database system, give special attention to this initialization parameter before database creation.

> **See Also:** Part V, "Distributed Database Management" for more information about distributed databases

Specifying a Flash Recovery Area

A flash recovery area is a location in which Oracle Database can store and manage files related to backup and recovery. It is distinct from the database area, which is a location for the Oracle-managed current database files (datafiles, control files, and online redo logs).

You specify a flash recovery area with the following initialization parameters:

- `DB_RECOVERY_FILE_DEST`: Location of the flash recovery area. This can be a directory, file system, or Automatic Storage Management (ASM) disk group. It cannot be a raw file system.

  In a RAC environment, this location must be on a cluster file system, ASM disk group, or a shared directory configured through NFS.

- `DB_RECOVERY_FILE_DEST_SIZE`: Specifies the maximum total bytes to be used by the flash recovery area. This initialization parameter must be specified before `DB_RECOVERY_FILE_DEST` is enabled.

In a RAC environment, the settings for these two parameters must be the same on all instances.

You cannot enable these parameters if you have set values for the `LOG_ARCHIVE_DEST` and `LOG_ARCHIVE_DUPLEX_DEST` parameters. You must disable those parameters before setting up the flash recovery area. You can instead set values for the `LOG_ARCHIVE_DEST_`*n* parameters. If you do not set values for local `LOG_ARCHIVE_DEST_`*n*, then setting up the flash recovery area will implicitly set `LOG_ARCHIVE_DEST_10` to the flash recovery area.

Oracle recommends using a flash recovery area, because it can simplify backup and recovery operations for your database.

> **See Also:** *Oracle Database Backup and Recovery User's Guide* to learn how to create and use a flash recovery area

Specifying Control Files

The `CONTROL_FILES` initialization parameter specifies one or more control filenames for the database. When you execute the `CREATE DATABASE` statement, the control files listed in the `CONTROL_FILES` parameter are created.

If you do not include CONTROL_FILES in the initialization parameter file, then Oracle Database creates a control file using a default operating system dependent filename or, if you have enabled Oracle-managed files, creates Oracle-managed control files.

If you want the database to create new operating system files when creating database control files, the filenames listed in the CONTROL_FILES parameter must not match any filenames that currently exist on your system. If you want the database to reuse or overwrite existing files when creating database control files, ensure that the filenames listed in the CONTROL_FILES parameter match the filenames that are to be reused.

Caution: Use extreme caution when setting this specifying CONTROL_FILE filenames. If you inadvertently specify a file that already exists and execute the CREATE DATABASE statement, the previous contents of that file will be overwritten.

Oracle strongly recommends you use at least two control files stored on separate physical disk drives for each database.

See Also:

- Chapter 9, "Managing Control Files"
- "Specifying Oracle-Managed Files at Database Creation" on page 2-15

Specifying Database Block Sizes

The DB_BLOCK_SIZE initialization parameter specifies the standard block size for the database. This block size is used for the SYSTEM tablespace and by default in other tablespaces. Oracle Database can support up to four additional nonstandard block sizes.

DB_BLOCK_SIZE Initialization Parameter

The most commonly used block size should be picked as the standard block size. In many cases, this is the only block size that you need to specify. Typically, DB_BLOCK_SIZE is set to either 4K or 8K. If you do not set a value for this parameter, the default data block size is operating system specific, which is generally adequate.

You cannot change the block size after database creation except by re-creating the database. If the database block size is different from the operating system block size, ensure that the database block size is a multiple of the operating system block size. For example, if your operating system block size is 2K (2048 bytes), the following setting for the DB_BLOCK_SIZE initialization parameter is valid:

```
DB_BLOCK_SIZE=4096
```

A larger data block size provides greater efficiency in disk and memory I/O (access and storage of data). Therefore, consider specifying a block size larger than your operating system block size if the following conditions exist:

- Oracle Database is on a large computer system with a large amount of memory and fast disk drives. For example, databases controlled by mainframe computers with vast hardware resources typically use a data block size of 4K or greater.
- The operating system that runs Oracle Database uses a small operating system block size. For example, if the operating system block size is 1K and the default data block size matches this, the database may be performing an excessive amount

of disk I/O during normal operation. For best performance in this case, a database block should consist of multiple operating system blocks.

See Also: Your operating system specific Oracle documentation for details about the default block size.

Nonstandard Block Sizes

Tablespaces of nonstandard block sizes can be created using the CREATE TABLESPACE statement and specifying the BLOCKSIZE clause. These nonstandard block sizes can have any of the following power-of-two values: 2K, 4K, 8K, 16K or 32K. Platform-specific restrictions regarding the maximum block size apply, so some of these sizes may not be allowed on some platforms.

To use nonstandard block sizes, you must configure subcaches within the buffer cache area of the SGA memory for all of the nonstandard block sizes that you intend to use. The initialization parameters used for configuring these subcaches are described in "Using Automatic Shared Memory Management" on page 5-7.

The ability to specify multiple block sizes for your database is especially useful if you are transporting tablespaces between databases. You can, for example, transport a tablespace that uses a 4K block size from an OLTP environment to a data warehouse environment that uses a standard block size of 8K.

See Also:

- "Creating Tablespaces" on page 12-2
- "Transporting Tablespaces Between Databases" on page 12-29

Specifying the Maximum Number of Processes

The PROCESSES initialization parameter determines the maximum number of operating system processes that can be connected to Oracle Database concurrently. The value of this parameter must be a minimum of one for each background process plus one for each user process. The number of background processes will vary according the database features that you are using. For example, if you are using Advanced Queuing or the file mapping feature, you will have additional background processes. If you are using Automatic Storage Management, then add three additional processes.

If you plan on running 50 user processes, a good estimate would be to set the PROCESSES initialization parameter to 70.

Specifying the DDL Lock Timeout

Data Definition Language (DDL) statements require exclusive locks on internal structures. If these locks are unavailable when a DDL statement runs, the DDL statement fails, though it might have succeeded if it had been executed subseconds later.

To enable DDL statements to wait for locks, specify a **DDL lock timeout**—the number of seconds a DDL command waits for its required locks before failing.

To specify a DDL lock timeout, use the DDL_LOCK_TIMEOUT parameter. The permissible range of values for DDL_LOCK_TIMEOUT is 0 to 100,000. The default is 0.

You can set DDL_LOCK_TIMEOUT at the system level, or at the session level with an ALTER SESSION statement.

Specifying the Method of Undo Space Management

Every Oracle Database must have a method of maintaining information that is used to undo changes to the database. Such information consists of records of the actions of transactions, primarily before they are committed. Collectively these records are called **undo data**. This section provides instructions for setting up an environment for automatic undo management using an undo tablespace.

See Also: Chapter 14, "Managing Undo"

UNDO_MANAGEMENT Initialization Parameter

The `UNDO_MANAGEMENT` initialization parameter determines whether or not an instance starts in automatic undo management mode, which stores undo in an undo tablespace. Set this parameter to `AUTO` to enable automatic undo management mode. Beginning with Release 11*g*, `AUTO` is the default if the parameter is omitted or has no value.

UNDO_TABLESPACE Initialization Parameter

When an instance starts up in automatic undo management mode, it attempts to select an undo tablespace for storage of undo data. If the database was created in undo management mode, then the default undo tablespace (either the system-created `SYS_UNDOTS` tablespace or the user-specified undo tablespace) is the undo tablespace used at instance startup. You can override this default for the instance by specifying a value for the `UNDO_TABLESPACE` initialization parameter. This parameter is especially useful for assigning a particular undo tablespace to an instance in an Oracle Real Application Clusters environment.

If no undo tablespace has been specified during database creation or by the `UNDO_TABLESPACE` initialization parameter, then the first available undo tablespace in the database is chosen. If no undo tablespace is available, then the instance starts without an undo tablespace. You should avoid running in this mode.

The COMPATIBLE Initialization Parameter and Irreversible Compatibility

The `COMPATIBLE` initialization parameter enables or disables the use of features in the database that affect file format on disk. For example, if you create an Oracle Database 11*g* Release 1 (11.1) database, but specify `COMPATIBLE = 10.0.0` in the initialization parameter file, then features that requires 11.1 compatibility generate an error if you try to use them. Such a database is said to be at the 10.0.0 compatibility level.

You can advance the compatibility level of your database. If you do advance the compatibility of your database with the `COMPATIBLE` initialization parameter, there is no way to start the database using a lower compatibility level setting, except by doing a point-in-time recovery to a time before the compatibility was advanced.

The default value for the `COMPATIBLE` parameter is the release number of the most recent major release.

Note: For Oracle Database 11*g* Release 1 (11.1), the default value of the `COMPATIBLE` parameter is 11.1.0. The minimum value is 10.0.0. If you create an Oracle Database using the default value, you can immediately use all the new features in this release, and you can never downgrade the database.

See Also:

- *Oracle Database Upgrade Guide* for a detailed discussion of database compatibility and the `COMPATIBLE` initialization parameter
- *Oracle Database Backup and Recovery User's Guide* for information about point-in-time recovery of your database

Setting the License Parameter

Note: Oracle no longer offers licensing by the number of concurrent sessions. Therefore the `LICENSE_MAX_SESSIONS` and `LICENSE_SESSIONS_WARNING` initialization parameters are no longer needed and have been deprecated.

If you use named user licensing, Oracle Database can help you enforce this form of licensing. You can set a limit on the number of users created in the database. Once this limit is reached, you cannot create more users.

Note: This mechanism assumes that each person accessing the database has a unique user name and that no people share a user name. Therefore, so that named user licensing can help you ensure compliance with your Oracle license agreement, do not allow multiple users to log in using the same user name.

To limit the number of users created in a database, set the `LICENSE_MAX_USERS` initialization parameter in the database initialization parameter file, as shown in the following example:

```
LICENSE_MAX_USERS = 200
```

Troubleshooting Database Creation

If database creation fails, you can look at the alert log to determine the reason for the failure and to determine corrective action. The alert log is discussed in "Monitoring Errors with Trace Files and the Alert Log" on page 7-1.

You should shut down the instance and delete any files created by the `CREATE DATABASE` statement before you attempt to create it again. After correcting the error that caused the failure of the database creation, try re-creating the database.

Dropping a Database

Dropping a database involves removing its datafiles, redo log files, control files, and initialization parameter files. The `DROP DATABASE` statement deletes all control files and all other database files listed in the control file. To use the `DROP DATABASE` statement successfully, all of the following conditions must apply:

- The database must be mounted and closed.
- The database must be mounted exclusively--not in shared mode.
- The database must be mounted as `RESTRICTED`.

An example of this statement is:

```
DROP DATABASE;
```

The `DROP DATABASE` statement has no effect on archived log files, nor does it have any effect on copies or backups of the database. It is best to use RMAN to delete such files. If the database is on raw disks, the actual raw disk special files are not deleted.

If you used the Database Configuration Assistant to create your database, you can use that tool to delete (drop) your database and remove the files.

Managing Initialization Parameters Using a Server Parameter File

Initialization parameters for the Oracle Database have traditionally been stored in a text initialization parameter file. For better manageability, you can choose to maintain initialization parameters in a binary server parameter file that is persistent across database startup and shutdown. This section introduces the server parameter file, and explains how to manage initialization parameters using either method of storing the parameters. The following topics are contained in this section.

What Is a Server Parameter File?

A server parameter file can be thought of as a repository for initialization parameters that is maintained on the machine running the Oracle Database server. It is, by design, a server-side initialization parameter file. Initialization parameters stored in a server parameter file are persistent, in that any changes made to the parameters while an instance is running can persist across instance shutdown and startup. This arrangement eliminates the need to manually update initialization parameters to make persistent any changes effected by `ALTER SYSTEM` statements. It also provides a basis for self-tuning by the Oracle Database server.

A server parameter file is initially built from a text initialization parameter file using the `CREATE SPFILE` statement. (It can also be created directly by the Database Configuration Assistant.) The server parameter file is a binary file that cannot be edited using a text editor. Oracle Database provides other interfaces for viewing and modifying parameter settings in a server parameter file.

Caution: Although you can open the binary server parameter file with a text editor and view its text, *do not* manually edit it. Doing so will corrupt the file. You will not be able to start your instance, and if the instance is running, it could fail.

When you issue a `STARTUP` command with no `PFILE` clause, the Oracle instance searches an operating system–specific default location for a server parameter file from which to read initialization parameter settings. If no server parameter file is found, the instance searches for a text initialization parameter file. If a server parameter file exists but you want to override it with settings in a text initialization parameter file, you must specify the `PFILE` clause when issuing the `STARTUP` command. Instructions for starting an instance using a server parameter file are contained in "Starting Up a Database" on page 3-1.

Migrating to a Server Parameter File

If you are currently using a text initialization parameter file, use the following steps to migrate to a server parameter file.

1. If the initialization parameter file is located on a client machine, transfer the file (for example, FTP) from the client machine to the server machine.

   Note: If you are migrating to a server parameter file in an Oracle Real Application Clusters environment, you must combine all of your instance-specific initialization parameter files into a single initialization parameter file. Instructions for doing this and other actions unique to using a server parameter file for instances that are part of an Oracle Real Application Clusters installation are discussed in *Oracle Real Application Clusters Administration and Deployment Guide* and in your platform-specific Oracle Real Application Clusters Installation Guide.

2. Create a server parameter file in the default location using the `CREATE SPFILE FROM PFILE` statement. See "Creating a Server Parameter File" on page 2-28 for instructions.

   This statement reads the text initialization parameter file to create a server parameter file. The database does not have to be started to issue a `CREATE SPFILE` statement.

3. Start up or restart the instance.

   The instance finds the new SPFILE in the default location and starts up with it.

Creating a Server Parameter File

You use the `CREATE SPFILE` statement to create a server parameter file. You must have the `SYSDBA` or the `SYSOPER` system privilege to execute this statement.

Note: When you use the Database Configuration Assistant to create a database, it automatically creates a server parameter file for you.

The `CREATE SPFILE` statement can be executed before or after instance startup. However, if the instance has been started using a server parameter file, an error is raised if you attempt to re-create the same server parameter file that is currently being used by the instance.

You can create a server parameter file (SPFILE) from an existing text initialization parameter file or from memory. Creating the SPFILE from memory means copying the current values of initialization parameters in the running instance to the SPFILE.

The following example creates a server parameter file from text initialization parameter file `/u01/oracle/dbs/init.ora`. In this example no `SPFILE` name is specified, so the file is created with the platform-specific default name and location shown in Table 2–3 on page 2-29.

```
CREATE SPFILE FROM PFILE='/u01/oracle/dbs/init.ora';
```

The next example illustrates creating a server parameter file and supplying a name and location.

```
CREATE SPFILE='/u01/oracle/dbs/test_spfile.ora'
       FROM PFILE='/u01/oracle/dbs/test_init.ora';
```

The next example illustrates creating a server parameter file in the default location from the current values of the initialization parameters in memory.

```
CREATE SPFILE FROM MEMORY;
```

Whether you use the default SPFILE name and default location or specify an SPFILE name and location, if an SPFILE of the same name already exists in the location, it is overwritten without a warning message.

When you create an SPFILE from a text initialization parameter file, comments specified on the same lines as a parameter setting in the initialization parameter file are maintained in the SPFILE. All other comments are ignored.

Oracle recommends that you allow the database to give the SPFILE the default name and store it in the default location. This eases administration of your database. For example, the `STARTUP` command assumes this default location to read the SPFILE.

Table 2–3 shows the default name and location for both the text initialization parameter file (PFILE) and server parameter file (SPFILE) for the UNIX, Linux, and Windows platforms. The table assumes that the SPFILE is a file. If it is a raw device, the default name could be a logical volume name or partition device name, and the default location could differ.

Table 2–3 PFILE and SPFILE Default Names and Locations on UNIX, LInux, and Windows

Platform	PFILE Default Name	SPFILE Default Name	Default Location (PFILE and SPFILE)
UNIX and Linux	`init`*`ORACLE_SID`*`.ora`	`spfile`*`ORACLE_SID`*`.ora`	*ORACLE_HOME*`/dbs` or the same location as the datafiles
Windows	`init`*`ORACLE_SID`*`.ora`	`spfile`*`ORACLE_SID`*`.ora`	*ORACLE_HOME*`\database`

Note: Upon startup, the instance first searches for an SPFILE named `spfile`*`ORACLE_SID`*`.ora`, and if not found, searches for `spfile.ora`. Using `spfile.ora` enables all Real Application Cluster (RAC) instances to use the same server parameter file.

If neither SPFILE is found, the instance searches for the text initialization parameter file `init`*`ORACLE_SID`*`.ora`.

If you create an SPFILE in a location other than the default location, you must create a text initialization parameter file that points to the server parameter file. For more information, see "Starting Up a Database" on page 3-1.

Storing the Server Parameter File on HARD-Enabled Storage

Starting with Release 11*g*, the server parameter file (SPFILE) is in a new format that is compliant with the Oracle Hardware Assisted Resilient Data (HARD) initiative. HARD defines a comprehensive set of data validation algorithms, implemented at both the software and storage hardware levels, to ensure that no corrupt data is written to permanent storage. To fully enable HARD protection for the data in your SPFILE, the SPFILE must reside on HARD-enabled storage, and compatibility for your database instance must be advanced to at least 11.0.0.

You can store the HARD-compliant SPFILE on non-HARD-enabled storage. In this case, the new SPFILE format supports only *detection* of corrupt SPFILE data. Storing the SPFILE on HARD-enabled storage *prevents* corrupt data from being written to storage in the first place.

For more information about HARD, and for a list of storage vendors that supply HARD-enabled storage systems, visit: `http://www.oracle.com/technology/deploy/availability/htdocs/HARD.html`.

Follow these guidelines for full HARD protection when installing or upgrading your Oracle database:

When Installing or Initially Creating a Release 11*g* Database

When first installing or creating a Release 11*g* database, the `COMPATIBLE` initialization parameter defaults to 11.1.0, so this requirement for a HARD-compliant server parameter file (SPFILE) is met. You must then ensure that the SPFILE is stored on HARD-enabled storage. To meet this requirement, do one of the following:

- For an Oracle Real Application Clusters environment without shared storage, when DBCA prompts for the location of the SPFILE, specify a location on HARD-enabled storage.
- For a single-instance installation, or for an Oracle Real Application Clusters environment with shared storage, complete these steps:
  1. Complete the database installation with Database Configuration Assistant (DBCA).

     The SPFILE is created in the default location. See Table 2–3 on page 2-29 for information on default locations.
  2. Do one of the following:
     – Using an operating system command, copy the SPFILE to HARD-enabled storage.

   – In SQL*Plus or another interactive environment such as SQL Developer, connect to the database as user SYS and then submit the following command:

     ```
     CREATE SPFILE = 'spfile_name' FROM MEMORY;
     ```

     where *spfile_name* is a complete path name, including file name, that points to HARD-enabled storage.

3. Do one of the following:

   – Create a text initialization parameter file (PFILE) in the default location with the following single entry:

     ```
     SPFILE = spfile_name
     ```

     where *spfile_name* is the complete path to the SPFILE on HARD-enabled storage.

   – On the UNIX and Linux platforms, in the default SPFILE location, create a symbolic link to the SPFILE on HARD-enabled storage.

   See Table 2–3 for default name and location information for PFILEs and SPFILEs.

4. Shut down the database instance.
5. Delete the SPFILE in the default location.
6. Start up the database instance.

When Upgrading to Release 11*g* from an Earlier Database Release

When upgrading to Release 11*g* from an earlier database release, complete these steps to migrate your SPFILE to the HARD-compliant format and to store the SPFILE on HARD-enabled storage:

1. Start SQL*Plus or another interactive query application, log in to the database as user SYS or SYSTEM, and then enter the following command:

   ```
   ALTER SYSTEM SET COMPATIBLE = '11.1.0' SCOPE = SPFILE;
   ```

   WARNING: Advancing the compatibility level to 11.1.0 enables Release 11*g* features and file formats and has wide repercussions. Consult *Oracle Database Upgrade Guide* before proceeding.

2. Restart the database instance.

   The database is now at compatibility level 11.1.0.

3. If your SPFILE is not already on HARD-enabled storage, complete the following steps:

   a. In SQL*Plus or another interactive environment, connect to the database as user SYS and then submit the following command:

      ```
      CREATE SPFILE = 'spfile_name' FROM MEMORY;
      ```

      where *spfile_name* is a complete path name, including file name, that points to HARD-enabled storage.

   b. Do one of the following:

– Create a text initialization parameter file (PFILE) in the default location with the following single entry:

```
SPFILE = spfile_name
```

where *spfile_name* is the complete path to the SPFILE on HARD-enabled storage.

– On the UNIX and Linux platforms, in the default SPFILE location, create a symbolic link to the SPFILE on HARD-enabled storage.

See Table 2–3 for default name and location information for PFILEs and SPFILEs.

c. Shut down the database instance.

d. Delete the SPFILE in the default location.

e. Start up the database instance.

The SPFILE Initialization Parameter

The SPFILE initialization parameter contains the name of the current server parameter file. When the default server parameter file is used by the database—that is, you issue a STARTUP command and do not specify a PFILE parameter—the value of SPFILE is internally set by the server. The SQL*Plus command SHOW PARAMETERS SPFILE (or any other method of querying the value of a parameter) displays the name of the server parameter file that is currently in use.

Changing Initialization Parameter Values

The ALTER SYSTEM statement enables you to set, change, or restore to default the values of initialization parameters. If you are using a text initialization parameter file, the ALTER SYSTEM statement changes the value of a parameter only for the current instance, because there is no mechanism for automatically updating text initialization parameters on disk. You must update them manually to be passed to a future instance. Using a server parameter file overcomes this limitation.

There are two kinds of initialization parameters:

- **Dynamic initialization parameters** can be changed for the current Oracle Database instance. The changes take effect immediately.
- **Static initialization parameters** cannot be changed for the current instance. You must change these parameters in the text initialization file or server parameter file and then restart the database before changes take effect.

Setting or Changing Initialization Parameter Values

Use the SET clause of the ALTER SYSTEM statement to set or change initialization parameter values. The optional SCOPE clause specifies the scope of a change as described in the following table:

SCOPE Clause	Description
`SCOPE = SPFILE`	The change is applied in the server parameter file only. The effect is as follows: ■ No change is made to the current instance. ■ For both dynamic and static parameters, the change is effective at the next startup and is persistent. This is the only `SCOPE` specification allowed for static parameters.
`SCOPE = MEMORY`	The change is applied in memory only. The effect is as follows: ■ The change is made to the current instance and is effective immediately. ■ For dynamic parameters, the effect is immediate, but it is not persistent because the server parameter file is not updated. For static parameters, this specification is not allowed.
`SCOPE = BOTH`	The change is applied in both the server parameter file and memory. The effect is as follows: ■ The change is made to the current instance and is effective immediately. ■ For dynamic parameters, the effect is persistent because the server parameter file is updated. For static parameters, this specification is not allowed.

It is an error to specify `SCOPE=SPFILE` or `SCOPE=BOTH` if the instance did not start up with a server parameter file. The default is `SCOPE=BOTH` if a server parameter file was used to start up the instance, and `MEMORY` if a text initialization parameter file was used to start up the instance.

For dynamic parameters, you can also specify the `DEFERRED` keyword. When specified, the change is effective only for future sessions.

When you specify `SCOPE` as `SPFILE` or `BOTH`, an optional `COMMENT` clause lets you associate a text string with the parameter update. The comment is written to the server parameter file.

The following statement changes the maximum number of failed login attempts before the connection is dropped. It includes a comment, and explicitly states that the change is to be made only in the server parameter file.

```
ALTER SYSTEM SET SEC_MAX_FAILED_LOGIN_ATTEMPTS=3
                 COMMENT='Reduce from 10 for tighter security.'
                 SCOPE=SPFILE;
```

The next example sets a complex initialization parameter that takes a list of attributes. Specifically, the parameter value being set is the `LOG_ARCHIVE_DEST_n` initialization parameter. This statement could change an existing setting for this parameter or create a new archive destination.

```
ALTER SYSTEM
     SET LOG_ARCHIVE_DEST_4='LOCATION=/u02/oracle/rbdb1/',MANDATORY,'REOPEN=2'
         COMMENT='Add new destimation on Nov 29'
         SCOPE=SPFILE;
```

When a value consists of a list of parameters, you cannot edit individual attributes by the position or ordinal number. You must specify the complete list of values each time the parameter is updated, and the new list completely replaces the old list.

Clearing Initialization Parameter Values

You can use the `ALTER SYSTEM RESET` command to clear (remove) the setting of any initialization parameter in the SPFILE that was used to start the instance. Neither `SCOPE=MEMORY` nor `SCOPE=BOTH` are allowed. The `SCOPE = SPFILE` clause is not required, but can be included.

You may want to clear a parameter in the SPFILE so that upon the next database startup a default value is used.

> **See Also:** *Oracle Database SQL Language Reference* for information about the `ALTER SYSTEM` command

Exporting the Server Parameter File

You can use the `CREATE PFILE` statement to export a server parameter file (SPFILE) to a text initialization parameter file. Doing so might be necessary for several reasons:

- For diagnostic purposes, listing all of the parameter values currently used by an instance. This is analogous to the SQL*Plus `SHOW PARAMETERS` command or selecting from the `V$PARAMETER` or `V$PARAMETER2` views.
- To modify the server parameter file by first exporting it, editing the resulting text file, and then re-creating it using the `CREATE SPFILE` statement

The exported file can also be used to start up an instance using the `PFILE` clause.

You must have the `SYSDBA` or the `SYSOPER` system privilege to execute the `CREATE PFILE` statement. The exported file is created on the database server machine. It contains any comments associated with the parameter in the same line as the parameter setting.

The following example creates a text initialization parameter file from the SPFILE:

```
CREATE PFILE FROM SPFILE;
```

Because no names were specified for the files, the database creates an initialization parameter file with a platform-specific name, and it is created from the platform-specific default server parameter file.

The following example creates a text initialization parameter file from a server parameter file, but in this example the names of the files are specified:

```
CREATE PFILE='/u01/oracle/dbs/test_init.ora'
       FROM SPFILE='/u01/oracle/dbs/test_spfile.ora';
```

> **Note:** An alternative is to create a PFILE from the current values of the initialization parameters in memory. The following is an example of the required command:
>
> ```
> CREATE PFILE='/u01/oracle/dbs/test_init.ora' FROM MEMORY;
> ```

Backing Up the Server Parameter File

You can create a backup of your server parameter file (SPFILE) by exporting it, as described in "Exporting the Server Parameter File". If the backup and recovery strategy for your database is implemented using Recovery Manager (RMAN), then you can use RMAN to create a backup of the SPFILE. The SPFILE is backed up automatically by RMAN when you back up your database, but RMAN also enables you to specifically create a backup of the currently active SPFILE.

See Also: *Oracle Database Backup and Recovery User's Guide*

Recovering a Lost or Damaged Server Parameter File

If your server parameter file (SPFILE) becomes lost or corrupted, the current instance may fail, or the next attempt at starting the database instance may fail. There are a number of ways to recover the SPFILE:

- If the instance is running, issue the following command to recreate the SPFILE from the current values of initialization parameters in memory:

  ```
  CREATE SPFILE FROM MEMORY;
  ```

  This command creates the SPFILE with the default name and in the default location. You can also create the SPFILE with a new name or in a specified location. See "Creating a Server Parameter File" on page 2-28 for examples.

- If you have a valid text initialization parameter file (PFILE), recreate the SPFILE from the PFILE with the following command:

  ```
  CREATE SPFILE FROM PFILE;
  ```

  This command assumes that the PFILE is in the default location and has the default name. See "Creating a Server Parameter File" on page 2-28 for the command syntax to use when the PFILE is not in the default location or has a non-default name.

- Restore the SPFILE from backup.

  See "Backing Up the Server Parameter File" on page 2-34 for more information.

- If none of the previous methods are possible in your situation, perform these steps:

  1. Create a text initialization parameter file (PFILE) from the parameter value listings in the alert log.

     When an instance starts up, the initialization parameters used for startup are written to the alert log. You can copy and paste this section from the text version of the alert log (without XML tags) into a new PFILE.

     See "Viewing the Alert Log" on page 8-18 for more information.

  2. Create the SPFILE from the PFILE.

     See "Creating a Server Parameter File" on page 2-28 for instructions.

Read/Write Errors During a Parameter Update

If an error occurs while reading or writing the server parameter file during a parameter update, the error is reported in the alert log and all subsequent parameter updates to the server parameter file are ignored. At this point, you can take one of the following actions:

- Shut down the instance, recover the server parameter file and described earlier in this section, and then restart the instance.

- Continue to run the database if you do not care that subsequent parameter updates will not be persistent.

Viewing Parameter Settings

You can view parameter settings in several ways, as shown in the following table.

Method	Description
`SHOW PARAMETERS`	This SQL*Plus command displays the values of initialization parameters in effect for the current session.
`SHOW SPPARAMETERS`	This SQL*Plus command displays the values of initialization parameters in the server parameter file (SPFILE).
`CREATE PFILE`	This SQL statement creates a text initialization parameter file (PFILE) from the SPFILE or from the current in-memory settings. You can then view the PFILE with any text editor.
`V$PARAMETER`	This view displays the values of initialization parameters in effect for the current session.
`V$PARAMETER2`	This view displays the values of initialization parameters in effect for the current session. It is easier to distinguish list parameter values in this view because each list parameter value appears in a separate row.
`V$SYSTEM_PARAMETER`	This view displays the values of initialization parameters in effect for the instance. A new session inherits parameter values from the instance-wide values.
`V$SYSTEM_PARAMETER2`	This view displays the values of initialization parameters in effect for the instance. A new session inherits parameter values from the instance-wide values. It is easier to distinguish list parameter values in this view because each list parameter value appears in a separate row.
`V$SPPARAMETER`	This view displays the current contents of the SPFILE. The view returns `FALSE` values in the `ISSPECIFIED` column if an SPFILE is not being used by the instance.

See Also: *Oracle Database Reference* for a complete description of views

Defining Database Services

This section describes database services and includes the following topics:

- Deploying Services
- Configuring Services
- Using Services

Database services (services) are logical abstractions for managing workloads in Oracle Database. Services divide workloads into mutually disjoint groupings. Each service represents a workload with common attributes, service-level thresholds, and priorities. The grouping is based on attributes of work that might include the application function to be used, the priority of execution for the application function, the job class to be managed, or the data range used in the application function or job class. For example, the Oracle E-Business suite defines a service for each responsibility, such as general ledger, accounts receivable, order entry, and so on.

Services are built into the Oracle Database, providing a single system image for workloads, prioritization for workloads, performance measures for real transactions, and alerts and actions when performance goals are violated. Services enable you to configure a workload, administer it, enable and disable it, and measure the workload as a single entity. You can do this using standard tools such as the Database Configuration Assistant (DBCA), Net Configuration Assistant (NetCA), and Enterprise Manager (EM). Enterprise Manager supports viewing and operating services as a whole, with drill down to the instance-level when needed.

In Real Application Clusters (RAC), a service can span one or more instances and facilitate real workload balancing based on real transaction performance. This provides end-to-end unattended recovery, rolling changes by workload, and full location transparency. RAC also enables you to manage a number of service features with Enterprise Manager, the DBCA, and the Server Control utility (SRVCTL).

Services also offer an extra dimension in performance tuning. Tuning by "service and SQL" can replace tuning by "session and SQL" in the majority of systems where all sessions are anonymous and shared. With services, workloads are visible and measurable. Resource consumption and waits are attributable by application. Additionally, resources assigned to services can be augmented when loads increase or decrease. This dynamic resource allocation enables a cost-effective solution for meeting demands as they occur. For example, services are measured automatically and the performance is compared to service-level thresholds. Performance violations are reported to Enterprise Manager, enabling the execution of automatic or scheduled solutions.

See Also: *Oracle Real Application Clusters Administration and Deployment Guide*

Deploying Services

When you configure database services, you give each service a unique global name, associated performance goals, and associated importance. The services are tightly integrated with Oracle Database and are maintained in the data dictionary. You can find service information in the following service-specific views:

- `DBA_SERVICES`
- `ALL_SERVICES` or `V$SERVICES`
- `V$ACTIVE_SERVICES`
- `V$SERVICE_STATS`
- `V$SERVICE_EVENTS`
- `V$SERVICE_WAIT_CLASSES`
- `V$SERV_MOD_ACT_STATS`
- `V$SERVICE_METRICS`
- `V$SERVICE_METRICS_HISTORY`

The following additional views also contain some information about services:

- `V$SESSION`
- `V$ACTIVE_SESSION_HISTORY`
- `DBA_RSRC_GROUP_MAPPINGS`
- `DBA_SCHEDULER_JOB_CLASSES`
- `DBA_THRESHOLDS`

See Also: *Oracle Database Reference* for detailed information about these views

Several Oracle Database features support services. The Automatic Workload Repository (AWR) manages the performance of services. AWR records service performance, including execution times, wait classes, and resources consumed by service. AWR alerts warn when service response time thresholds are exceeded. The dynamic views report current service performance metrics with one hour of history. Each service has quality-of-service thresholds for response time and CPU consumption.

In addition, the Database Resource Manager maps services to consumer groups. This enables you to automatically manage the priority of one service relative to others. You can use consumer groups to define relative priority in terms of either ratios or resource consumption. This is described in more detail, for example, in *Oracle Real Application Clusters Deployment and Performance Guide*.

Configuring Services

Services describe applications, application functions, and data ranges as either functional services or data-dependent services. Functional services are the most common mapping of workloads. Sessions using a particular function are grouped together. For Oracle*Applications, ERP, CRM, and *i*Support functions create a functional division of the work. For SAP, dialog and update functions create a functional division of the work.

In contrast, data-dependent routing routes sessions to services based on data keys. The mapping of work requests to services occurs in the object relational mapping layer for application servers and TP monitors. For example, in RAC, these ranges can be completely dynamic and based on demand because the database is shared.

You can also define preconnect application services in RAC databases. Preconnect services span instances to support a service in the event of a failure. The preconnect service supports TAF preconnect mode and is managed transparently when using RAC.

In addition to application services, Oracle Database also supports two internal services: `SYS$BACKGROUND` is used by the background processes only and `SYS$USERS` is the default service for user sessions that are not associated with services.

Use the `DBMS_SERVICE` package or set the `SERVICE_NAMES` parameter to create application services on a single-instance Oracle Database. You can later define the response time goal or importance of each service through EM, either individually or by using the Enterprise Manager feature "Copy Thresholds From a Baseline" on the Manage Metrics/Edit Threshold pages. You can also do this using PL/SQL.

Using Services

Using services requires no changes to your application code. Client-side work connects to a service. Server-side work specifies the service when creating the job class for the Job Scheduler and the database links for distributed databases. Work requests executing under a service inherit the performance thresholds for the service and are measured as part of the service.

Client-Side Use

Middle-tier applications and client-server applications use a service by specifying the service as part of the connection in TNS connect data. This connect data may be in the TNSnames file for thick Net drivers, in the URL specification for thin drivers, or may be maintained in the Oracle Internet Directory. For example, data sources for the Oracle Application Server 10*g* are set to route to a service. Using Easy Connect Naming, this connection needs only the host name and service name (for example, `hr/hr@myDBhost/myservice`). For Oracle E-Business Suite, the service is also maintained in the application database identifier and in the cookie for the ICX parameters.

Server-Side Use

Server-side work, such as the Oracle Scheduler, parallel execution, and Oracle Streams Advanced Queuing, set the service name as part of the workload definition.

For the Oracle Scheduler, the service that the job class uses is defined when the job class is created. During execution, jobs are assigned to job classes, and job classes run within services. Using services with job classes ensures that the work executed by the job scheduler is identified for workload management and performance tuning.

For parallel query and parallel DML, the query coordinator connects to a service just like any other client. The parallel query processes inherit the service for the duration of the execution. At the end of query execution, the parallel execution processes revert to the default service.

See Also: Chapter 27, "Scheduling Jobs with Oracle Scheduler" for more information about the Oracle Scheduler.

Considerations After Creating a Database

After you create a database, the instance is left running, and the database is open and available for normal database use. You may want to perform other actions, some of which are discussed in this section.

Some Security Considerations

Note Regarding Security Enhancements: In this release of Oracle Database and in subsequent releases, several enhancements are being made to ensure the security of default database user accounts. You can find a security checklist for this release in *Oracle Database Security Guide*. Oracle recommends that you read this checklist and configure your database accordingly.

After the database is created, you can configure it to take advantage of Oracle Identity Management. For information on how to do this, please refer to *Oracle Database Enterprise User Security Administrator's Guide*.

A newly created database has at least three user accounts that are important for administering your database: `SYS`, `SYSTEM`, and `SYSMAN`.

Caution: To prevent unauthorized access and protect the integrity of your database, it is important that new passwords for user accounts `SYS` and `SYSTEM` be specified when the database is created. This is accomplished by specifying the following `CREATE DATABASE` clauses when manually creating you database, or by using DBCA to create the database:

- `USER SYS IDENTIFIED BY`
- `USER SYSTEM IDENTIFIED BY`

Additional administrative accounts are provided by Oracle Database that should be used only by authorized users. To protect these accounts from being used by unauthorized users familiar with their Oracle-supplied passwords, these accounts are initially locked with their passwords expired. As the database administrator, you are responsible for the unlocking and resetting of these accounts.

See *Oracle Database 2 Day + Security Guide* for a complete list of predefined user accounts created with each new Oracle Database installation.

See Also:

- "Database Administrator Usernames" on page 1-9 for more information about the users `SYS` and `SYSTEM`
- *Oracle Database Security Guide* to learn how to add new users and change passwords
- *Oracle Database SQL Language Reference* for the syntax of the `ALTER USER` statement used for unlocking user accounts

Enabling Transparent Data Encryption

Transparent data encryption is a feature that enables encryption of individual database columns before storing them in the datafile, or enables encryption of entire tablespaces. If users attempt to circumvent the database access control mechanisms by looking inside datafiles directly with operating system tools, transparent data encryption prevents such users from viewing sensitive information.

Users who have the `CREATE TABLE` privilege can choose one or more columns in a table to be encrypted. The data is encrypted in the data files and in the audit logs (if audit is turned on). Database users with appropriate privileges can view the data in unencrypted format. For information on enabling and disabling transparent data encryption, see *Oracle Database Advanced Security Administrator's Guide*.

See Also:

- "Consider Encrypting Columns That Contain Sensitive Data" on page 18-6
- "Encrypted Tablespaces" on page 12-8

Creating a Secure External Password Store

For large-scale deployments where applications use password credentials to connect to databases, it is possible to store such credentials in a client-side Oracle wallet. An Oracle wallet is a secure software container that is used to store authentication and signing credentials.

Storing database password credentials in a client-side Oracle wallet eliminates the need to embed usernames and passwords in application code, batch jobs, or scripts. This reduces the risk of exposing passwords in the clear in scripts and application code, and simplifies maintenance because you need not change your code each time usernames and passwords change. In addition, not having to change application code also makes it easier to enforce password management policies for these user accounts.

When you configure a client to use the external password store, applications can use the following syntax to connect to databases that use password authentication:

```
CONNECT /@database_alias
```

Note that you need not specify database login credentials in this CONNECT statement. Instead your system looks for database login credentials in the client wallet.

> **See Also:** *Oracle Database Advanced Security Administrator's Guide* for information about configuring your client to use a secure external password store and for information about managing credentials in it.

Installing the Oracle Database Sample Schemas

The Oracle Database distribution media includes various SQL files that let you experiment with the system, learn SQL, or create additional tables, views, or synonyms.

Oracle Database includes sample schemas that help you to become familiar with Oracle Database functionality. All Oracle Database documentation and training materials are being converted to the Sample Schemas environment as those materials are updated.

The Sample Schemas can be installed automatically by the Database Configuration Assistant, or you can install them manually. The schemas and installation instructions are described in detail in *Oracle Database Sample Schemas*.

Database Data Dictionary Views

In addition to the views listed previously in "Viewing Parameter Settings", you can view information about your database content and structure using the following views:

View	Description
`DATABASE_PROPERTIES`	Displays permanent database properties
`GLOBAL_NAME`	Displays the global database name
`V$DATABASE`	Contains database information from the control file

3 Starting Up and Shutting Down

This chapter describes the procedures for starting up and shutting down an Oracle Database instance and contains the following topics:

- Starting Up a Database
- Altering Database Availability
- Shutting Down a Database
- Quiescing a Database
- Suspending and Resuming a Database

See Also: *Oracle Real Application Clusters Administration and Deployment Guide* for additional information specific to an Oracle Real Application Clusters environment

Starting Up a Database

When you start up a database, you create an instance of that database and you determine the state of the database. Normally, you start up an instance by mounting and opening the database. Doing so makes the database available for any valid user to connect to and perform typical data access operations. Other options exist, and these are also discussed in this section.

This section contains the following topics relating to starting up an instance of a database:

- Options for Starting Up a Database
- Understanding Initialization Parameter Files
- Preparing to Start Up an Instance
- Starting Up an Instance

Options for Starting Up a Database

You can start up a database instance with SQL*Plus, Recovery Manager, or Enterprise Manager.

Starting Up a Database Using SQL*Plus

You can start a SQL*Plus session, connect to Oracle Database with administrator privileges, and then issue the `STARTUP` command. Using SQL*Plus in this way is the only method described in detail in this book.

Starting Up a Database Using Recovery Manager

You can also use Recovery Manager (RMAN) to execute `STARTUP` and `SHUTDOWN` commands. You may prefer to do this if your are within the RMAN environment and do not want to invoke SQL*Plus.

> **See Also:** *Oracle Database Backup and Recovery User's Guide* for information on starting up the database using RMAN

Starting Up a Database Using Oracle Enterprise Manager

You can use Oracle Enterprise Manager (EM) to administer your database, including starting it up and shutting it down. EM combines a GUI console, agents, common services, and tools to provide an integrated and comprehensive systems management platform for managing Oracle products. EM Database Control, which is the portion of EM that is dedicated to administering an Oracle database, enables you to perform the functions discussed in this book using a GUI interface, rather than command line operations.

> **See Also:**
>
> - *Oracle Enterprise Manager Concepts*
> - *Oracle Enterprise Manager Grid Control Installation and Basic Configuration*
> - *Oracle Database 2 Day DBA*

The remainder of this section describes using SQL*Plus to start up a database instance.

Understanding Initialization Parameter Files

To start an instance, the database must read instance configuration parameters (the initialization parameters) from either a server parameter file (`SPFILE`) or a text initialization parameter file.

When you issue the SQL*Plus `STARTUP` command, the database attempts to read the initialization parameters from an `SPFILE` in a platform-specific default location. If it finds no `SPFILE`, it searches for a text initialization parameter file.

> **Note:** For UNIX or Linux, the platform-specific default location (directory) for the `SPFILE` and text initialization parameter file is:
>
> ```
> $ORACLE_HOME/dbs
> ```
>
> For Windows NT and Windows 2000 the location is:
>
> ```
> %ORACLE_HOME%\database
> ```

In the platform-specific default location, Oracle Database locates your initialization parameter file by examining filenames in the following order:

1. `spfile`*`$ORACLE_SID`*`.ora`
2. `spfile.ora`
3. `init`*`$ORACLE_SID`*`.ora`

The first two filenames represent `SPFILE`s and the third represents a text initialization parameter file.

Note: The `spfile.ora` file is included in this search path because in an Oracle Real Application Clusters environment one server parameter file is used to store the initialization parameter settings for all instances. There is no instance-specific location for storing a server parameter file.

For more information about the server parameter file for an Oracle Real Application Clusters environment, see *Oracle Real Application Clusters Administration and Deployment Guide*.

If you (or the Database Configuration Assistant) created a server parameter file, but you want to override it with a text initialization parameter file, you can specify the `PFILE` clause of the `STARTUP` command to identify the initialization parameter file.

```
STARTUP PFILE = /u01/oracle/dbs/init.ora
```

Starting Up with a Non-Default Server Parameter File

A non-default server parameter file (`SPFILE`) is an `SPFILE` that is in a location other than the default location. It is not usually necessary to start an instance with a non-default `SPFILE`. However, should such a need arise, you can use the `PFILE` clause to start an instance with a non-default server parameter file as follows:

1. Create a one-line text initialization parameter file that contains only the `SPFILE` parameter. The value of the parameter is the non-default server parameter file location.

   For example, create a text initialization parameter file `/u01/oracle/dbs/spf_init.ora` that contains only the following parameter:

   ```
   SPFILE = /u01/oracle/dbs/test_spfile.ora
   ```

   Note: You cannot use the `IFILE` initialization parameter within a text initialization parameter file to point to a server parameter file. In this context, you must use the `SPFILE` initialization parameter.

   ---

2. Start up the instance pointing to this initialization parameter file.

   ```
   STARTUP PFILE = /u01/oracle/dbs/spf_init.ora
   ```

The `SPFILE` must reside on the machine running the database server. Therefore, the preceding method also provides a means for a client machine to start a database that uses an `SPFILE`. It also eliminates the need for a client machine to maintain a client-side initialization parameter file. When the client machine reads the initialization parameter file containing the `SPFILE` parameter, it passes the value to the server where the specified `SPFILE` is read.

Note that on the UNIX and Linux platforms, if your SPFILE is not in the default location, you can also create a symbolic link to the SPFILE and place the symbolic link in the default location.

See Table 2–3 on page 2-29 for information on PFILE and SPFILE default names and locations.

Initialization Files and Automatic Storage Management

A database that uses Automatic Storage Management (ASM) usually has a non-default `SPFILE`. If you use the Database Configuration Assistant (DBCA) to configure a database to use ASM, DBCA creates an `SPFILE` for the database instance in an ASM disk group, and then creates a text initialization parameter file in the default location in the local file system to point to the `SPFILE`.

> **See Also:** Chapter 2, "Creating and Configuring an Oracle Database", for more information about initialization parameters, initialization parameter files, and server parameter files

Preparing to Start Up an Instance

You must perform some preliminary steps before attempting to start an instance of your database using SQL*Plus.

1. Ensure that environment variables are set so that you connect to the desired Oracle instance. For details, see "Selecting an Instance with Environment Variables" on page 1-7.
2. Start SQL*Plus without connecting to the database:

   ```
   SQLPLUS /NOLOG
   ```

3. Connect to Oracle Database as `SYSDBA`:

   ```
   CONNECT username/password AS SYSDBA
   ```

Now you are connected to the database and ready to start up an instance of your database.

> **See Also:** *SQL*Plus User's Guide and Reference* for descriptions and syntax for the `CONNECT`, `STARTUP`, and `SHUTDOWN` commands.

Starting Up an Instance

You use the SQL*Plus `STARTUP` command to start up an Oracle Database instance. You can start an instance in various modes:

- Start the instance without mounting a database. This does not allow access to the database and usually would be done only for database creation or the re-creation of control files.
- Start the instance and mount the database, but leave it closed. This state allows for certain DBA activities, but does not allow general access to the database.
- Start the instance, and mount and open the database. This can be done in unrestricted mode, allowing access to all users, or in restricted mode, allowing access for database administrators only.
- Force the instance to start after a startup or shutdown problem, or start the instance and have complete media recovery begin immediately.

> **Note:** You cannot start a database instance if you are connected to the database through a shared server process.

The following scenarios describe and illustrate the various states in which you can start up an instance. Some restrictions apply when combining clauses of the `STARTUP` command.

Note: It is possible to encounter problems starting up an instance if control files, database files, or redo log files are not available. If one or more of the files specified by the `CONTROL_FILES` initialization parameter does not exist or cannot be opened when you attempt to mount a database, Oracle Database returns a warning message and does not mount the database. If one or more of the datafiles or redo log files is not available or cannot be opened when attempting to open a database, the database returns a warning message and does not open the database.

See Also: *SQL*Plus User's Guide and Reference* for information about the restrictions that apply when combining clauses of the `STARTUP` command

Starting an Instance, and Mounting and Opening a Database

Normal database operation means that an instance is started and the database is mounted and open. This mode allows any valid user to connect to the database and perform data access operations.

The following command starts an instance, reads the initialization parameters from the default location, and then mounts and opens the database. (You can optionally specify a `PFILE` clause.)

```
STARTUP
```

Starting an Instance Without Mounting a Database

You can start an instance without mounting a database. Typically, you do so only during database creation. Use the `STARTUP` command with the `NOMOUNT` clause:

```
STARTUP NOMOUNT
```

Starting an Instance and Mounting a Database

You can start an instance and mount a database without opening it, allowing you to perform specific maintenance operations. For example, the database must be mounted but not open during the following tasks:

- Enabling and disabling redo log archiving options. For more information, please refer to Chapter 11, "Managing Archived Redo Logs".
- Performing full database recovery. For more information, please refer to *Oracle Database Backup and Recovery User's Guide*

The following command starts an instance and mounts the database, but leaves the database closed:

```
STARTUP MOUNT
```

Restricting Access to an Instance at Startup

You can start an instance, and optionally mount and open a database, in restricted mode so that the instance is available only to administrative personnel (not general database users). Use this mode of instance startup when you need to accomplish one of the following tasks:

- Perform an export or import of data
- Perform a data load (with SQL*Loader)

- Temporarily prevent typical users from using data
- Perform certain migration or upgrade operations

Typically, all users with the `CREATE SESSION` system privilege can connect to an open database. Opening a database in restricted mode allows database access only to users with both the `CREATE SESSION` and `RESTRICTED SESSION` system privilege. Only database administrators should have the `RESTRICTED SESSION` system privilege. Further, when the instance is in restricted mode, a database administrator cannot access the instance remotely through an Oracle Net listener, but can only access the instance locally from the machine that the instance is running on.

The following command starts an instance (and mounts and opens the database) in restricted mode:

```
STARTUP RESTRICT
```

You can use the `RESTRICT` clause in combination with the `MOUNT`, `NOMOUNT`, and `OPEN` clauses.

Later, use the `ALTER SYSTEM` statement to disable the `RESTRICTED SESSION` feature:

```
ALTER SYSTEM DISABLE RESTRICTED SESSION;
```

If you open the database in nonrestricted mode and later find that you need to restrict access, you can use the `ALTER SYSTEM` statement to do so, as described in "Restricting Access to an Open Database" on page 3-8.

> **See Also:** *Oracle Database SQL Language Reference* for more information on the `ALTER SYSTEM` statement

Forcing an Instance to Start

In unusual circumstances, you might experience problems when attempting to start a database instance. You should not force a database to start unless you are faced with the following:

- You cannot shut down the current instance with the `SHUTDOWN NORMAL`, `SHUTDOWN IMMEDIATE`, or `SHUTDOWN TRANSACTIONAL` commands.
- You experience problems when starting an instance.

If one of these situations arises, you can usually solve the problem by starting a new instance (and optionally mounting and opening the database) using the `STARTUP` command with the `FORCE` clause:

```
STARTUP FORCE
```

If an instance is running, `STARTUP FORCE` shuts it down with mode `ABORT` before restarting it. In this case, beginning with Oracle Database 10g Release 2, the alert log shows the message "`Shutting down instance (abort)`" followed by "`Starting ORACLE instance (normal)`." (Earlier versions of the database showed only "`Starting ORACLE instance (force)`" in the alert log.)

> **See Also:** "Shutting Down with the ABORT Clause" on page 3-10 to understand the side effects of aborting the current instance

Starting an Instance, Mounting a Database, and Starting Complete Media Recovery

If you know that media recovery is required, you can start an instance, mount a database to the instance, and have the recovery process automatically start by using the `STARTUP` command with the `RECOVER` clause:

```
STARTUP OPEN RECOVER
```

If you attempt to perform recovery when no recovery is required, Oracle Database issues an error message.

Automatic Database Startup at Operating System Start

Many sites use procedures to enable automatic startup of one or more Oracle Database instances and databases immediately following a system start. The procedures for performing this task are specific to each operating system. For information about automatic startup, see your operating system specific Oracle documentation.

Starting Remote Instances

If your local Oracle Database server is part of a distributed database, you might want to start a remote instance and database. Procedures for starting and stopping remote instances vary widely depending on communication protocol and operating system.

Altering Database Availability

You can alter the availability of a database. You may want to do this in order to restrict access for maintenance reasons or to make the database read only. The following sections explain how to alter the availability of a database:

- Mounting a Database to an Instance
- Opening a Closed Database
- Opening a Database in Read-Only Mode
- Restricting Access to an Open Database

Mounting a Database to an Instance

When you need to perform specific administrative operations, the database must be started and mounted to an instance, but closed. You can achieve this scenario by starting the instance and mounting the database.

To mount a database to a previously started, but not opened instance, use the SQL statement `ALTER DATABASE` with the `MOUNT` clause as follows:

```
ALTER DATABASE MOUNT;
```

See Also: "Starting an Instance and Mounting a Database" on page 3-5 for a list of operations that require the database to be mounted and closed (and procedures to start an instance and mount a database in one step)

Opening a Closed Database

You can make a mounted but closed database available for general use by opening the database. To open a mounted database, use the `ALTER DATABASE` statement with the `OPEN` clause:

```
ALTER DATABASE OPEN;
```

After executing this statement, any valid Oracle Database user with the `CREATE SESSION` system privilege can connect to the database.

Opening a Database in Read-Only Mode

Opening a database in read-only mode enables you to query an open database while eliminating any potential for online data content changes. While opening a database in read-only mode guarantees that datafile and redo log files are not written to, it does not restrict database recovery or operations that change the state of the database without generating redo. For example, you can take datafiles offline or bring them online since these operations do not affect data content.

If a query against a database in read-only mode uses temporary tablespace, for example to do disk sorts, then the issuer of the query must have a locally managed tablespace assigned as the default temporary tablespace. Otherwise, the query will fail. This is explained in "Creating a Locally Managed Temporary Tablespace" on page 12-11.

The following statement opens a database in read-only mode:

```
ALTER DATABASE OPEN READ ONLY;
```

You can also open a database in read/write mode as follows:

```
ALTER DATABASE OPEN READ WRITE;
```

However, read/write is the default mode.

Note: You cannot use the `RESETLOGS` clause with a `READ ONLY` clause.

See Also: *Oracle Database SQL Language Reference* for more information about the `ALTER DATABASE` statement

Restricting Access to an Open Database

To place an instance in restricted mode, where only users with administrative privileges can access it, use the SQL statement `ALTER SYSTEM` with the `ENABLE RESTRICTED SESSION` clause. After placing an instance in restricted mode, you should consider killing all current user sessions before performing any administrative tasks.

To lift an instance from restricted mode, use `ALTER SYSTEM` with the `DISABLE RESTRICTED SESSION` clause.

See Also:

- "Terminating Sessions" on page 4-22 for directions for killing user sessions
- "Restricting Access to an Instance at Startup" on page 3-5 to learn some reasons for placing an instance in restricted mode

Shutting Down a Database

To initiate database shutdown, use the SQL*Plus `SHUTDOWN` command. Control is not returned to the session that initiates a database shutdown until shutdown is complete.

Users who attempt connections while a shutdown is in progress receive a message like the following:

```
ORA-01090: shutdown in progress - connection is not permitted
```

Note: You cannot shut down a database if you are connected to the database through a shared server process.

To shut down a database and instance, you must first connect as SYSOPER or SYSDBA. There are several modes for shutting down a database. These are discussed in the following sections:

- Shutting Down with the NORMAL Clause
- Shutting Down with the IMMEDIATE Clause
- Shutting Down with the TRANSACTIONAL Clause
- Shutting Down with the ABORT Clause

Some shutdown modes wait for certain events to occur (such as transactions completing or users disconnecting) before actually bringing down the database. There is a one-hour timeout period for these events. This timeout behavior is discussed in this additional section:

- Shutdown Timeout

Shutting Down with the NORMAL Clause

To shut down a database in normal situations, use the SHUTDOWN command with the NORMAL clause:

```
SHUTDOWN NORMAL
```

The NORMAL clause is optional, because this is the default shutdown method if no clause is provided.

Normal database shutdown proceeds with the following conditions:

- No new connections are allowed after the statement is issued.
- Before the database is shut down, the database waits for all currently connected users to disconnect from the database.

The next startup of the database will not require any instance recovery procedures.

Shutting Down with the IMMEDIATE Clause

Use immediate database shutdown only in the following situations:

- To initiate an automated and unattended backup
- When a power shutdown is going to occur soon
- When the database or one of its applications is functioning irregularly and you cannot contact users to ask them to log off or they are unable to log off

To shut down a database immediately, use the SHUTDOWN command with the IMMEDIATE clause:

```
SHUTDOWN IMMEDIATE
```

Immediate database shutdown proceeds with the following conditions:

- No new connections are allowed, nor are new transactions allowed to be started, after the statement is issued.
- Any uncommitted transactions are rolled back. (If long uncommitted transactions exist, this method of shutdown might not complete quickly, despite its name.)
- Oracle Database does not wait for users currently connected to the database to disconnect. The database implicitly rolls back active transactions and disconnects all connected users.

The next startup of the database will not require any instance recovery procedures.

Shutting Down with the TRANSACTIONAL Clause

When you want to perform a planned shutdown of an instance while allowing active transactions to complete first, use the `SHUTDOWN` command with the `TRANSACTIONAL` clause:

```
SHUTDOWN TRANSACTIONAL
```

Transactional database shutdown proceeds with the following conditions:

- No new connections are allowed, nor are new transactions allowed to be started, after the statement is issued.
- After all transactions have completed, any client still connected to the instance is disconnected.
- At this point, the instance shuts down just as it would when a `SHUTDOWN IMMEDIATE` statement is submitted.

The next startup of the database will not require any instance recovery procedures.

A transactional shutdown prevents clients from losing work, and at the same time, does not require all users to log off.

Shutting Down with the ABORT Clause

You can shut down a database instantaneously by aborting the database instance. If possible, perform this type of shutdown *only* in the following situations:

The database or one of its applications is functioning irregularly *and* none of the other types of shutdown works.

- You need to shut down the database instantaneously (for example, if you know a power shutdown is going to occur in one minute).
- You experience problems when starting a database instance.

When you must do a database shutdown by aborting transactions and user connections, issue the `SHUTDOWN` command with the `ABORT` clause:

```
SHUTDOWN ABORT
```

An aborted database shutdown proceeds with the following conditions:

- No new connections are allowed, nor are new transactions allowed to be started, after the statement is issued.
- Current client SQL statements being processed by Oracle Database are immediately terminated.
- Uncommitted transactions are not rolled back.

- Oracle Database does not wait for users currently connected to the database to disconnect. The database implicitly disconnects all connected users.

The next startup of the database *will* require instance recovery procedures.

Shutdown Timeout

Shutdown modes that wait for users to disconnect or for transactions to complete have a limit on the amount of time that they wait. If all events blocking the shutdown do not occur within one hour, the shutdown command cancels with the following message: `ORA-01013: user requested cancel of current operation`.

Quiescing a Database

Occasionally you might want to put a database in a state that allows only DBA transactions, queries, fetches, or PL/SQL statements. Such a state is referred to as a **quiesced state**, in the sense that no ongoing non-DBA transactions, queries, fetches, or PL/SQL statements are running in the system.

> **Note:** In this discussion of quiesce database, a DBA is defined as user `SYS` or `SYSTEM`. Other users, including those with the `DBA` role, are not allowed to issue the `ALTER SYSTEM QUIESCE DATABASE` statement or proceed after the database is quiesced.

The quiesced state lets administrators perform actions that cannot safely be done otherwise. These actions include:

- Actions that fail if concurrent user transactions access the same object--for example, changing the schema of a database table or adding a column to an existing table where a no-wait lock is required.
- Actions whose undesirable intermediate effect can be seen by concurrent user transactions--for example, a multistep procedure for reorganizing a table when the table is first exported, then dropped, and finally imported. A concurrent user who attempts to access the table after it was dropped, but before import, would not have an accurate view of the situation.

Without the ability to quiesce the database, you would need to shut down the database and reopen it in restricted mode. This is a serious restriction, especially for systems requiring 24 x 7 availability. Quiescing a database is much a smaller restriction, because it eliminates the disruption to users and the downtime associated with shutting down and restarting the database.

When the database is in the quiesced state, it is through the facilities of the Database Resource Manager that non-DBA sessions are prevented from becoming active. Therefore, while this statement is in effect, any attempt to change the current resource plan will be queued until after the system is unquiesced. See Chapter 25, "Managing Resource Allocation with Oracle Database Resource Manager" for more information about the Database Resource Manager.

Placing a Database into a Quiesced State

To place a database into a quiesced state, issue the following statement:

```
ALTER SYSTEM QUIESCE RESTRICTED;
```

Non-DBA active sessions will continue until they become inactive. An active session is one that is currently inside of a transaction, a query, a fetch, or a PL/SQL statement; or a session that is currently holding any shared resources (for example, enqueues). No inactive sessions are allowed to become active. For example, If a user issues a SQL query in an attempt to force an inactive session to become active, the query will appear to be hung. When the database is later unquiesced, the session is resumed, and the blocked action is processed.

Once all non-DBA sessions become inactive, the `ALTER SYSTEM QUIESCE RESTRICTED` statement completes, and the database is in a quiesced state. In an Oracle Real Application Clusters environment, this statement affects all instances, not just the one that issues the statement.

The `ALTER SYSTEM QUIESCE RESTRICTED` statement may wait a long time for active sessions to become inactive. You can determine the sessions that are blocking the quiesce operation by querying the `V$BLOCKING_QUIESCE` view. This view returns only a single column: `SID` (Session ID). You can join it with `V$SESSION` to get more information about the session, as shown in the following example:

```
select bl.sid, user, osuser, type, program
from v$blocking_quiesce bl, v$session se
where bl.sid = se.sid;
```

See *Oracle Database Reference* for details on these view.

If you interrupt the request to quiesce the database, or if your session terminates abnormally before all active sessions are quiesced, then Oracle Database automatically reverses any partial effects of the statement.

For queries that are carried out by successive multiple Oracle Call Interface (OCI) fetches, the `ALTER SYSTEM QUIESCE RESTRICTED` statement does not wait for all fetches to finish. It only waits for the current fetch to finish.

For both dedicated and shared server connections, all non-DBA logins after this statement is issued are queued by the Database Resource Manager, and are not allowed to proceed. To the user, it appears as if the login is hung. The login will resume when the database is unquiesced.

The database remains in the quiesced state even if the session that issued the statement exits. A DBA must log in to the database to issue the statement that specifically unquiesces the database.

Note: You cannot perform a cold backup when the database is in the quiesced state, because Oracle Database background processes may still perform updates for internal purposes even while the database is quiesced. In addition, the file headers of online datafiles continue to appear to be accessible. They do not look the same as if a clean shutdown had been performed. However, you can still take online backups while the database is in a quiesced state.

Restoring the System to Normal Operation

The following statement restores the database to normal operation:

```
ALTER SYSTEM UNQUIESCE;
```

All non-DBA activity is allowed to proceed. In an Oracle Real Application Clusters environment, this statement is not required to be issued from the same session, or even the same instance, as that which quiesced the database. If the session issuing the

ALTER SYSTEM UNQUIESCE statement terminates abnormally, then the Oracle Database server ensures that the unquiesce operation completes.

Viewing the Quiesce State of an Instance

You can query the ACTIVE_STATE column of the V$INSTANCE view to see the current state of an instance. The column values has one of these values:

- NORMAL: Normal unquiesced state.
- QUIESCING: Being quiesced, but some non-DBA sessions are still active.
- QUIESCED: Quiesced; no non-DBA sessions are active or allowed.

Suspending and Resuming a Database

The ALTER SYSTEM SUSPEND statement halts all input and output (I/O) to datafiles (file header and file data) and control files. The suspended state lets you back up a database without I/O interference. When the database is suspended all preexisting I/O operations are allowed to complete and any new database accesses are placed in a queued state.

The suspend command is not specific to an instance. In an Oracle Real Application Clusters environment, when you issue the suspend command on one system, internal locking mechanisms propagate the halt request across instances, thereby quiescing all active instances in a given cluster. However, if someone starts a new instance another instance is being suspended, the new instance will not be suspended.

Use the ALTER SYSTEM RESUME statement to resume normal database operations. The SUSPEND and RESUME commands can be issued from different instances. For example, if instances 1, 2, and 3 are running, and you issue an ALTER SYSTEM SUSPEND statement from instance 1, then you can issue a RESUME statement from instance 1, 2, or 3 with the same effect.

The suspend/resume feature is useful in systems that allow you to mirror a disk or file and then split the mirror, providing an alternative backup and restore solution. If you use a system that is unable to split a mirrored disk from an existing database while writes are occurring, then you can use the suspend/resume feature to facilitate the split.

The suspend/resume feature is not a suitable substitute for normal shutdown operations, because copies of a suspended database can contain uncommitted updates.

Caution: Do not use the ALTER SYSTEM SUSPEND statement as a substitute for placing a tablespace in hot backup mode. Precede any database suspend operation by an ALTER TABLESPACE BEGIN BACKUP statement.

The following statements illustrate ALTER SYSTEM SUSPEND/RESUME usage. The V$INSTANCE view is queried to confirm database status.

```
SQL> ALTER SYSTEM SUSPEND;
System altered
SQL> SELECT DATABASE_STATUS FROM V$INSTANCE;
DATABASE_STATUS
---------
SUSPENDED
```

```
SQL> ALTER SYSTEM RESUME;
System altered
SQL> SELECT DATABASE_STATUS FROM V$INSTANCE;
DATABASE_STATUS
---------
ACTIVE
```

See Also: *Oracle Database Backup and Recovery User's Guide* for details about backing up a database using the database suspend/resume feature

4 Managing Processes

This chapter describes how to manage and monitor the processes of an Oracle Database instance and contains the following topics:

About Dedicated and Shared Server Processes

Oracle Database creates server processes to handle the requests of user processes connected to an instance. A server process can be either of the following:

- A **dedicated server process**, which services only one user process
- A **shared server process**, which can service multiple user processes

Your database is always enabled to allow dedicated server processes, but you must specifically configure and enable **shared server** by setting one or more initialization parameters.

Dedicated Server Processes

Figure 4–1, "Oracle Database Dedicated Server Processes" illustrates how dedicated server processes work. In this diagram two user processes are connected to the database through dedicated server processes.

In general, it is better to be connected through a **dispatcher** and use a shared server process. This is illustrated in Figure 4–2, "Oracle Database Shared Server Processes". A shared server process can be more efficient because it keeps the number of processes required for the running instance low.

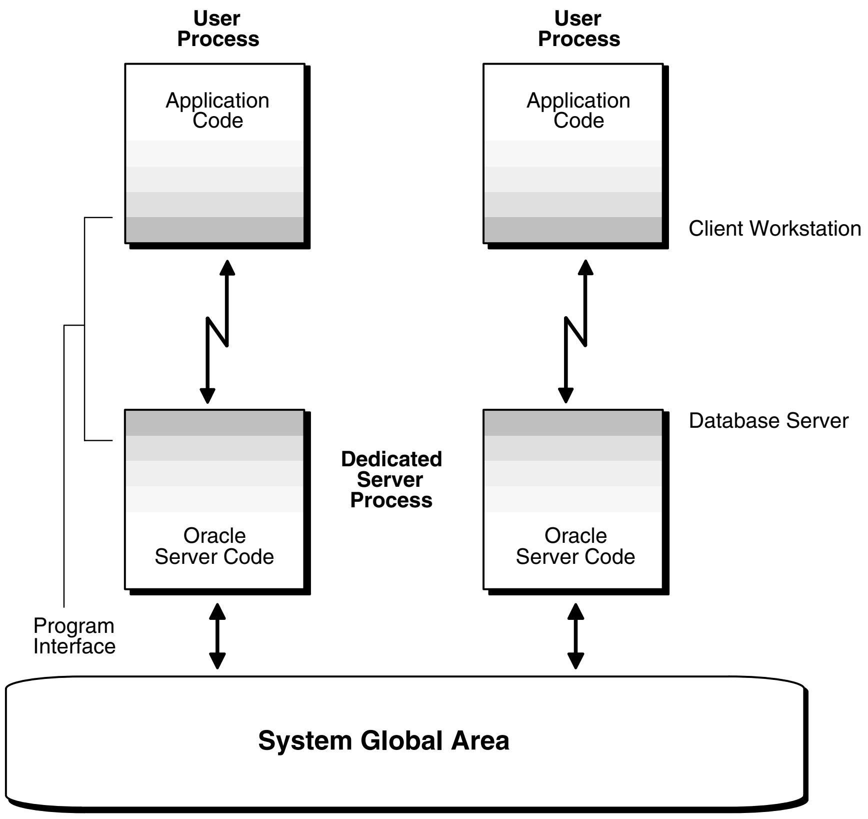
In the following situations, however, users and administrators should explicitly connect to an instance using a dedicated server process:

- To submit a batch job (for example, when a job can allow little or no idle time for the server process)
- To use Recovery Manager (RMAN) to back up, restore, or recover a database

To request a dedicated server connection when Oracle Database is configured for shared server, users must connect using a net service name that is configured to use a dedicated server. Specifically, the net service name value should include the `SERVER=DEDICATED` clause in the connect descriptor.

> **See Also:** *Oracle Database Net Services Administrator's Guide* for more information about requesting a dedicated server connection

Figure 4–1 Oracle Database Dedicated Server Processes

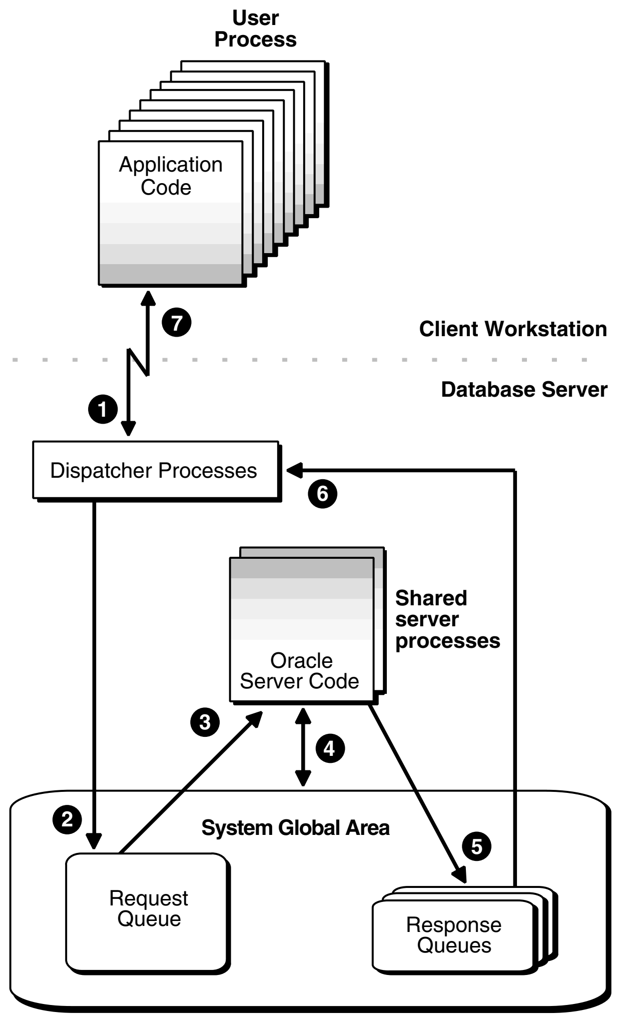


Shared Server Processes

Consider an order entry system with dedicated server processes. A customer phones the order desk and places an order, and the clerk taking the call enters the order into the database. For most of the transaction, the clerk is on the telephone talking to the customer. A server process is not needed during this time, so the server process dedicated to the clerk's user process remains idle. The system is slower for other clerks entering orders, because the idle server process is holding system resources.

Shared server architecture eliminates the need for a dedicated server process for each connection (see Figure 4–2).

Figure 4–2 Oracle Database Shared Server Processes



In a shared server configuration, client user processes connect to a dispatcher. The dispatcher can support multiple client connections concurrently. Each client connection is bound to a **virtual circuit**, which is a piece of shared memory used by the dispatcher for client database connection requests and replies. The dispatcher places a virtual circuit on a common queue when a request arrives.

An idle shared server process picks up the virtual circuit from the common queue, services the request, and relinquishes the virtual circuit before attempting to retrieve another virtual circuit from the common queue. This approach enables a small pool of server processes to serve a large number of clients. A significant advantage of shared server architecture over the dedicated server model is the reduction of system resources, enabling the support of an increased number of users.

For even better resource management, shared server can be configured for **connection pooling**. Connection pooling lets a dispatcher support more users by enabling the database server to time-out protocol connections and to use those connections to service an active session. Further, shared server can be configured for **session multiplexing**, which combines multiple sessions for transmission over a single network connection in order to conserve the operating system's resources.

Shared server architecture requires Oracle Net Services. User processes targeting the shared server must connect through Oracle Net Services, even if they are on the same machine as the Oracle Database instance.

> **See Also:** *Oracle Database Net Services Administrator's Guide* for more detailed information about shared server, including features such as connection pooling and session multiplexing

About Database Resident Connection Pooling

Database Resident Connection Pooling (DRCP) provides a connection pool in the database server for typical Web application usage scenarios where the application acquires a database connection, works on it for a relatively short duration, and then releases it. DRCP pools "dedicated" servers, which is the equivalent of a server foreground and a database session combined and henceforth are referred to as the "pooled" servers.

DRCP complements middle-tier connection pools that share connections between threads in a middle-tier process. In addition, DRCP enables sharing of database connections across middle-tier processes on the same middle-tier host and even across middle-tier hosts. This results in significant reduction in key database resources needed to support a large number of client connections, thereby reducing the database tier memory footprint and boosting the scalability of both middle-tier and database tiers. Having a pool of readily available servers also has the additional benefit of reducing the cost of creating and tearing down client connections.

DRCP is especially relevant for architectures with multi-process single threaded application servers (such as PHP/Apache) that cannot perform middle-tier connection pooling. The database can still scale to tens of thousands of simultaneous connections with DRCP.

> **See Also:**
>
> - *Oracle Call Interface Programmer's Guide*
> - *Oracle Database Concepts*

When To Use Database Resident Connection Pooling

Database resident connection pooling is useful when multiple clients access the database and when any of the following apply:

- A large number of client connections need to be supported with minimum memory usage.
- The client applications are similar and can share or reuse sessions.

  Applications are similar if they connect with the same database credentials and use the same schema.
- The client applications acquire a database connection, work on it for a relatively short duration, and then release it.
- Session affinity is not required across client requests.
- There are multiple processes and multiple hosts on the client side.

Advantages of Database Resident Connection Pooling

Using database resident connection pooling provides the following advantages:

- Enables resource sharing among multiple middle-tier client applications.

- Improves scalability of databases and applications by reducing resource usage.

Differences Between Dedicated Servers, Shared Servers, and Database Resident Connection Pooling

Table 4–1 lists the differences between dedicated servers, shared servers, and database resident connection pooling.

Table 4–1 Differences Between Dedicated Servers, Shared Servers, and Database Resident Connection Pooling

Dedicated Servers	Shared Servers	Database Resident Connection Pooling
When a client request is received, a new server process and a session are created for the client.	When the first request is received from a client, the Dispatcher process places this request on a common queue. The request is picked up by an available shared server process. The Dispatcher process then manages the communication between the client and the shared server process.	When the first request is received from a client, the Connection Broker picks an available pooled server and hands off the client connection to the pooled server. If no pooled servers are available, the Connection Broker creates one. If the pool has reached its maximum size, the client request is placed on the wait queue until a pooled server is available.
Releasing database resources involves terminating the session and server process.	Releasing database resources involves terminating the session.	Releasing database resources involves releasing the pooled server to the pool.
Memory requirement is proportional to the number of server processes and sessions. There is one server and one session for each client.	Memory requirement is proportional to the sum of the shared servers and sessions. There is one session for each client.	Memory requirement is proportional to the number of pooled servers and their sessions. There is one session for each pooled server.
Session memory is allocated from the PGA.	Session memory is allocated from the SGA.	Session memory is allocated from the PGA.

Example of Memory Usage for Dedicated Server, Shared Server, and Database Resident Connection Pooling

Consider an application in which the memory required for each session is 400 KB and the memory required for each server process is 4 MB. The pool size is 100 and the number of shared servers used is 100.

If there are 5000 client connections, the memory used by each configuration is as follows:

- Dedicated Server

  Memory used = 5000 X (400 KB + 4 MB) = 22 GB

- Shared Server

  Memory used = 5000 X 400 KB + 100 X 4 MB = 2.5 GB

  Out of the 2.5 GB, 2 GB is allocated from the SGA.

- Database Resident Connection Pooling

  Memory used = 100 X (400 KB + 4 MB) + (5000 X 35KB)= 615 MB

Restrictions on Using Database Resident Connection Pooling

You cannot perform the following activities with pooled servers:

- Shut down the database.
- Stop the database resident connection pool.
- Change the password for the connected user.
- Use shared database links to connect to a database resident connection pool that is on a different instance.
- Use all Advanced Security Option (ASO) options such as encryption, certificates, and so on.
- Use migratable sessions on the server side directly by using the OCI_MIGRATE option or indirectly via OCIConnectionPool.

DDL statements that pertain to database users in the pool need to be performed carefully, as the pre-DDL sessions in the pool can still be given to clients post-DDL. For example, while dropping users, ensure that there are no sessions of that user in the pool and no connections to the Broker that were authenticated as that user.

Sessions with explicit roles enabled, that are released to the pool, can be later handed out to connections (of the same user) that need the default logon role. Avoid releasing sessions with explicit roles, and instead terminate them.

Configuring Oracle Database for Shared Server

Shared memory resources are preconfigured to allow the enabling of shared server at run time. You need not configure it by specifying parameters in your initialization parameter file, but you can do so if that better suits your environment. You can start dispatchers and shared server processes (shared servers) dynamically using the `ALTER SYSTEM` statement.

This section discusses how to enable shared server and how to set or alter shared server initialization parameters. It contains the following topics:

- Initialization Parameters for Shared Server
- Enabling Shared Server
- Configuring Dispatchers
- Shared Server Data Dictionary Views

> **See Also:** *Oracle Database SQL Language Reference* for further information about the `ALTER SYSTEM` statement

Initialization Parameters for Shared Server

The following initialization parameters control shared server operation:

- `SHARED_SERVERS`: Specifies the initial number of shared servers to start and the minimum number of shared servers to keep. This is the only required parameter for using shared servers.
- `MAX_SHARED_SERVERS`: Specifies the maximum number of shared servers that can run simultaneously.
- `SHARED_SERVER_SESSIONS`: Specifies the total number of shared server user sessions that can run simultaneously. Setting this parameter enables you to reserve user sessions for dedicated servers.

- DISPATCHERS: Configures dispatcher processes in the shared server architecture.
- MAX_DISPATCHERS: Specifies the maximum number of dispatcher processes that can run simultaneously. This parameter can be ignored for now. It will only be useful in a future release when the number of dispatchers is auto-tuned according to the number of concurrent connections.
- CIRCUITS: Specifies the total number of virtual circuits that are available for inbound and outbound network sessions.

See Also: *Oracle Database Reference* for more information about these initialization parameters

Enabling Shared Server

Shared server is enabled by setting the SHARED_SERVERS initialization parameter to a value greater than 0. The other shared server initialization parameters need not be set. Because shared server requires at least one dispatcher in order to work, a dispatcher is brought up even if no dispatcher has been configured. Dispatchers are discussed in "Configuring Dispatchers" on page 4-9.

Shared server can be started dynamically by setting the SHARED_SERVERS parameter to a nonzero value with the ALTER SYSTEM statement, or SHARED_SERVERS can be included at database startup in the initialization parameter file. If SHARED_SERVERS is not included in the initialization parameter file, or is included but is set to 0, then shared server is not enabled at database startup.

Note: For backward compatibility, if SHARED_SERVERS is not included in the initialization parameter file at database startup, but DISPATCHERS is included and it specifies at least one dispatcher, shared server is enabled. In this case, the default for SHARED_SERVERS is 1.

However, if neither SHARED_SERVERS nor DISPATCHERS is included in the initialization file, you cannot start shared server after the instance is brought up by just altering the DISPATCHERS parameter. You must specifically alter SHARED_SERVERS to a nonzero value to start shared server.

Determining a Value for SHARED_SERVERS

The SHARED_SERVERS initialization parameter specifies the minimum number of shared servers that you want created when the instance is started. After instance startup, Oracle Database can dynamically adjust the number of shared servers based on how busy existing shared servers are and the length of the request queue.

In typical systems, the number of shared servers stabilizes at a ratio of one shared server for every ten connections. For OLTP applications, when the rate of requests is low, or when the ratio of server usage to request is low, the connections-to-servers ratio could be higher. In contrast, in applications where the rate of requests is high or the server usage-to-request ratio is high, the connections-to-server ratio could be lower.

The PMON (process monitor) background process cannot terminate shared servers below the value specified by SHARED_SERVERS. Therefore, you can use this parameter to stabilize the load and minimize strain on the system by preventing PMON from terminating and then restarting shared servers because of coincidental fluctuations in load.

If you know the average load on your system, you can set SHARED_SERVERS to an optimal value. The following example shows how you can use this parameter:

Assume a database is being used by a telemarketing center staffed by 1000 agents. On average, each agent spends 90% of the time talking to customers and only 10% of the time looking up and updating records. To keep the shared servers from being terminated as agents talk to customers and then spawned again as agents access the database, a DBA specifies that the optimal number of shared servers is 100.

However, not all work shifts are staffed at the same level. On the night shift, only 200 agents are needed. Since SHARED_SERVERS is a dynamic parameter, a DBA reduces the number of shared servers to 20 at night, thus allowing resources to be freed up for other tasks such as batch jobs.

Decreasing the Number of Shared Server Processes

You can decrease the minimum number of shared servers that must be kept active by dynamically setting the SHARED_SERVERS parameter to a lower value. Thereafter, until the number of shared servers is decreased to the value of the SHARED_SERVERS parameter, any shared servers that become inactive are marked by PMON for termination.

The following statement reduces the number of shared servers:

```
ALTER SYSTEM SET SHARED_SERVERS = 5;
```

Setting SHARED_SERVERS to 0 disables shared server. For more information, please refer to "Disabling Shared Servers" on page 4-14.

Limiting the Number of Shared Server Processes

The MAX_SHARED_SERVERS parameter specifies the maximum number of shared servers that can be automatically created by PMON. It has no default value. If no value is specified, then PMON starts as many shared servers as is required by the load, subject to these limitations:

- The process limit (set by the PROCESSES initialization parameter)
- A minimum number of free process slots (at least one-eighth of the total process slots, or two slots if PROCESSES is set to less than 24)
- System resources

Note: On Windows NT, take care when setting MAX_SHARED_SERVERS to a high value, because each server is a thread in a common process.

The value of SHARED_SERVERS overrides the value of MAX_SHARED_SERVERS. Therefore, you can force PMON to start more shared servers than the MAX_SHARED_SERVERS value by setting SHARED_SERVERS to a value higher than MAX_SHARED_SERVERS. You can subsequently place a new upper limit on the number of shared servers by dynamically altering the MAX_SHARED_SERVERS to a value higher than SHARED_SERVERS.

The primary reason to limit the number of shared servers is to reserve resources, such as memory and CPU time, for other processes. For example, consider the case of the telemarketing center discussed previously:

The DBA wants to reserve two thirds of the resources for batch jobs at night. He sets MAX_SHARED_SERVERS to less than one third of the maximum number of processes

(PROCESSES). By doing so, the DBA ensures that even if all agents happen to access the database at the same time, batch jobs can connect to dedicated servers without having to wait for the shared servers to be brought down after processing agents' requests.

Another reason to limit the number of shared servers is to prevent the concurrent run of too many server processes from slowing down the system due to heavy swapping, although PROCESSES can serve as the upper bound for this rather than MAX_SHARED_SERVERS.

Still other reasons to limit the number of shared servers are testing, debugging, performance analysis, and tuning. For example, to see how many shared servers are needed to efficiently support a certain user community, you can vary MAX_SHARED_SERVERS from a very small number upward until no delay in response time is noticed by the users.

Limiting the Number of Shared Server Sessions

The SHARED_SERVER_SESSIONS initialization parameter specifies the maximum number of concurrent shared server user sessions. Setting this parameter, which is a dynamic parameter, lets you reserve database sessions for dedicated servers. This in turn ensures that administrative tasks that require dedicated servers, such as backing up or recovering the database, are not preempted by shared server sessions.

This parameter has no default value. If it is not specified, the system can create shared server sessions as needed, limited by the SESSIONS initialization parameter.

Protecting Shared Memory

The CIRCUITS parameter sets a maximum limit on the number of virtual circuits that can be created in shared memory. This parameter has no default. If it is not specified, then the system can create circuits as needed, limited by the DISPATCHERS initialization parameter and system resources.

Configuring Dispatchers

The DISPATCHERS initialization parameter configures dispatcher processes in the shared server architecture. At least one dispatcher process is required for shared server to work.If you do not specify a dispatcher, but you enable shared server by setting SHARED_SERVER to a nonzero value, then by default Oracle Database creates one dispatcher for the TCP protocol. The equivalent DISPATCHERS explicit setting of the initialization parameter for this configuration is:

```
dispatchers="(PROTOCOL=tcp)"
```

You can configure more dispatchers, using the DISPATCHERS initialization parameter, if either of the following conditions apply:

- You need to configure a protocol other than TCP/IP. You configure a protocol address with one of the following attributes of the DISPATCHERS parameter:
  - ADDRESS
  - DESCRIPTION
  - PROTOCOL
- You want to configure one or more of the optional dispatcher attributes:
  - DISPATCHERS
  - CONNECTIONS

- SESSIONS
- TICKS
- LISTENER
- MULTIPLEX
- POOL
- SERVICE

Note: Database Configuration Assistant helps you configure this parameter.

DISPATCHERS Initialization Parameter Attributes

This section provides brief descriptions of the attributes that can be specified with the `DISPATCHERS` initialization parameter.

A protocol address is required and is specified using one or more of the following attributes:

Attribute	Description
`ADDRESS`	Specify the network protocol address of the endpoint on which the dispatchers listen.
`DESCRIPTION`	Specify the network description of the endpoint on which the dispatchers listen, including the network protocol address. The syntax is as follows: `(DESCRIPTION=(ADDRESS=...))`
`PROTOCOL`	Specify the network protocol for which the dispatcher generates a listening endpoint. For example: `(PROTOCOL=tcp)` See the *Oracle Database Net Services Reference* for further information about protocol address syntax.

The following attribute specifies how many dispatchers this configuration should have. It is optional and defaults to 1.

Attribute	Description
`DISPATCHERS`	Specify the initial number of dispatchers to start.

The following attributes tell the instance about the network attributes of each dispatcher of this configuration. They are all optional.

Attribute	Description
`CONNECTIONS`	Specify the maximum number of network connections to allow for each dispatcher.
`SESSIONS`	Specify the maximum number of network sessions to allow for each dispatcher.
`TICKS`	Specify the duration of a TICK in seconds. A TICK is a unit of time in terms of which the connection pool timeout can be specified. Used for connection pooling.

Attribute	Description
LISTENER	Specify an alias name for the listeners with which the PMON process registers dispatcher information. Set the alias to a name that is resolved through a naming method.
MULTIPLEX	Used to enable the Oracle Connection Manager session multiplexing feature.
POOL	Used to enable connection pooling.
SERVICE	Specify the service names the dispatchers register with the listeners.

You can specify either an entire attribute name a substring consisting of at least the first three characters. For example, you can specify `SESSIONS=3`, `SES=3`, `SESS=3`, or `SESSI=3`, and so forth.

> **See Also:** *Oracle Database Reference* for more detailed descriptions of the attributes of the `DISPATCHERS` initialization parameter

Determining the Number of Dispatchers

Once you know the number of possible connections for each process for the operating system, calculate the initial number of dispatchers to create during instance startup, for each network protocol, using the following formula:

```
Number of dispatchers =
   CEIL ( max. concurrent sessions / connections for each dispatcher )
```

`CEIL` returns the result roundest up to the next whole integer.

For example, assume a system that can support 970 connections for each process, and that has:

- A maximum of 4000 sessions concurrently connected through TCP/IP and
- A maximum of 2,500 sessions concurrently connected through TCP/IP with SSL

The `DISPATCHERS` attribute for TCP/IP should be set to a minimum of five dispatchers (4000 / 970), and for TCP/IP with SSL three dispatchers (2500 / 970:

```
DISPATCHERS='(PROT=tcp)(DISP=5)', '(PROT-tcps)(DISP=3)'
```

Depending on performance, you may need to adjust the number of dispatchers.

Setting the Initial Number of Dispatchers

You can specify multiple dispatcher configurations by setting `DISPATCHERS` to a comma separated list of strings, or by specifying multiple `DISPATCHERS` parameters in the initialization file. If you specify `DISPATCHERS` multiple times, the lines must be adjacent to each other in the initialization parameter file. Internally, Oracle Database assigns an `INDEX` value (beginning with zero) to each `DISPATCHERS` parameter. You can later refer to that `DISPATCHERS` parameter in an `ALTER SYSTEM` statement by its index number.

Some examples of setting the `DISPATCHERS` initialization parameter follow.

Example: Typical This is a typical example of setting the `DISPATCHERS` initialization parameter.

```
DISPATCHERS="(PROTOCOL=TCP)(DISPATCHERS=2)"
```

Example: Forcing the IP Address Used for Dispatchers The following hypothetical example will create two dispatchers that will listen on the specified IP address. The address must be a valid IP address for the host that the instance is on. (The host may be configured with multiple IP addresses.)

```
DISPATCHERS="(ADDRESS=(PROTOCOL=TCP)(HOST=144.25.16.201))(DISPATCHERS=2)"
```

Example: Forcing the Port Used by Dispatchers To force the dispatchers to use a specific port as the listening endpoint, add the `PORT` attribute as follows:

```
DISPATCHERS="(ADDRESS=(PROTOCOL=TCP)(PORT=5000))"
DISPATCHERS="(ADDRESS=(PROTOCOL=TCP)(PORT=5001))"
```

Altering the Number of Dispatchers

You can control the number of dispatcher processes in the instance. Unlike the number of shared servers, the number of dispatchers does not change automatically. You change the number of dispatchers explicitly with the `ALTER SYSTEM` statement. In this release of Oracle Database, you can increase the number of dispatchers to more than the limit specified by the `MAX_DISPATCHERS` parameter. It is planned that `MAX_DISPATCHERS` will be taken into consideration in a future release.

Monitor the following views to determine the load on the dispatcher processes:

- `V$QUEUE`
- `V$DISPATCHER`
- `V$DISPATCHER_RATE`

> **See Also:** *Oracle Database Performance Tuning Guide* for information about monitoring these views to determine dispatcher load and performance

If these views indicate that the load on the dispatcher processes is consistently high, then performance may be improved by starting additional dispatcher processes to route user requests. In contrast, if the load on dispatchers is consistently low, reducing the number of dispatchers may improve performance.

To dynamically alter the number of dispatchers when the instance is running, use the `ALTER SYSTEM` statement to modify the `DISPATCHERS` attribute setting for an existing dispatcher configuration. You can also add new dispatcher configurations to start dispatchers with different network attributes.

When you reduce the number of dispatchers for a particular dispatcher configuration, the dispatchers are not immediately removed. Rather, as users disconnect, Oracle Database terminates dispatchers down to the limit you specify in `DISPATCHERS`,

For example, suppose the instance was started with this `DISPATCHERS` setting in the initialization parameter file:

```
DISPATCHERS='(PROT=tcp)(DISP=2)', '(PROT=tcps)(DISP=2)'
```

To increase the number of dispatchers for the TCP/IP protocol from 2 to 3, and decrease the number of dispatchers for the TCP/IP with SSL protocol from 2 to 1, you can issue the following statement:

```
ALTER SYSTEM SET DISPATCHERS = '(INDEX=0)(DISP=3)', '(INDEX=1)(DISP=1)';
```

or

```
ALTER SYSTEM SET DISPATCHERS = '(PROT=tcp)(DISP=3)', '(PROT-tcps)(DISP=1)';
```

Note: You need not specify (`DISP=1`). It is optional because 1 is the default value for the `DISPATCHERS` parameter.

If fewer than three dispatcher processes currently exist for TCP/IP, the database creates new ones. If more than one dispatcher process currently exists for TCP/IP with SSL, then the database terminates the extra ones as the connected users disconnect.

Suppose that instead of changing the number of dispatcher processes for the TCP/IP protocol, you want to add another TCP/IP dispatcher that supports connection pooling. You can do so by entering the following statement:

```
ALTER SYSTEM SET DISPATCHERS = '(INDEX=2)(PROT=tcp)(POOL=on)';
```

The `INDEX` attribute is needed to add the new dispatcher configuration. If you omit (`INDEX=2`) in the preceding statement, then the TCP/IP dispatcher configuration at INDEX 0 will be changed to support connection pooling, and the number of dispatchers for that configuration will be reduced to 1, which is the default when the number of dispatchers (attribute `DISPATCHERS`) is not specified.

Notes on Altering Dispatchers

- The `INDEX` keyword can be used to identify which dispatcher configuration to modify. If you do not specify `INDEX`, then the first dispatcher configuration matching the `DESCRIPTION`, `ADDRESS`, or `PROTOCOL` specified will be modified. If no match is found among the existing dispatcher configurations, then a new dispatcher will be added.
- The `INDEX` value can range from 0 to *n*-1, where *n* is the current number of dispatcher configurations. If your `ALTER SYSTEM` statement specifies an `INDEX` value equal to *n*, where *n* is the current number of dispatcher configurations, a new dispatcher configuration will be added.
- To see the values of the current dispatcher configurations--that is, the number of dispatchers, whether connection pooling is on, and so forth--query the `V$DISPATCHER_CONFIG` dynamic performance view. To see which dispatcher configuration a dispatcher is associated with, query the `CONF_INDX` column of the `V$DISPATCHER` view.
- When you change the `DESCRIPTION`, `ADDRESS`, `PROTOCOL`, `CONNECTIONS`, `TICKS`, `MULTIPLEX`, and `POOL` attributes of a dispatcher configuration, the change does not take effect for existing dispatchers but only for new dispatchers. Therefore, in order for the change to be effective for all dispatchers associated with a configuration, you must forcibly kill existing dispatchers after altering the `DISPATCHERS` parameter, and let the database start new ones in their place with the newly specified properties.

  The attributes `LISTENER` and `SERVICES` are not subject to the same constraint. They apply to existing dispatchers associated with the modified configuration. Attribute `SESSIONS` applies to existing dispatchers only if its value is reduced. However, if its value is increased, it is applied only to newly started dispatchers.

Shutting Down Specific Dispatcher Processes

With the `ALTER SYSTEM` statement, you leave it up to the database to determine which dispatchers to shut down to reduce the number of dispatchers. Alternatively, it is possible to shut down specific dispatcher processes. To identify the name of the specific dispatcher process to shut down, use the `V$DISPATCHER` dynamic performance view.

```
SELECT NAME, NETWORK FROM V$DISPATCHER;
```

Each dispatcher is uniquely identified by a name of the form D*nnn*.

To shut down dispatcher `D002`, issue the following statement:

```
ALTER SYSTEM SHUTDOWN IMMEDIATE 'D002';
```

The `IMMEDIATE` keyword stops the dispatcher from accepting new connections and the database immediately terminates all existing connections through that dispatcher. After all sessions are cleaned up, the dispatcher process shuts down. If `IMMEDIATE` were not specified, the dispatcher would wait until all of its users disconnected and all of its connections terminated before shutting down.

Disabling Shared Servers

You disable shared server by setting `SHARED_SERVERS` to 0. No new client can connect in shared mode. However, when you set `SHARED_SERVERS` to 0, Oracle Database retains some shared servers until all shared server connections are closed. The number of shared servers retained is either the number specified by the preceding setting of `SHARED_SERVERS` or the value of the `MAX_SHARED_SERVERS` parameter, whichever is smaller. If both `SHARED_SERVERS` and `MAX_SHARED_SERVERS` are set to 0, then all shared servers will terminate and requests from remaining shared server clients will be queued until the value of `SHARED_SERVERS` or `MAX_SHARED_SERVERS` is raised again.

To terminate dispatchers once all shared server clients disconnect, enter this statement:

```
ALTER SYSTEM SET DISPATCHERS = '';
```

Shared Server Data Dictionary Views

The following views are useful for obtaining information about your shared server configuration and for monitoring performance.

View	Description
`V$DISPATCHER`	Provides information on the dispatcher processes, including name, network address, status, various usage statistics, and index number.
`V$DISPATCHER_CONFIG`	Provides configuration information about the dispatchers.
`V$DISPATCHER_RATE`	Provides rate statistics for the dispatcher processes.
`V$QUEUE`	Contains information on the shared server message queues.
`V$SHARED_SERVER`	Contains information on the shared servers.
`V$CIRCUIT`	Contains information about virtual circuits, which are user connections to the database through dispatchers and servers.
`V$SHARED_SERVER_MONITOR`	Contains information for tuning shared server.
`V$SGA`	Contains size information about various system global area (SGA) groups. May be useful when tuning shared server.
`V$SGASTAT`	Contains detailed statistical information about the SGA, useful for tuning.
`V$SHARED_POOL_RESERVED`	Lists statistics to help tune the reserved pool and space within the shared pool.

See Also:

- *Oracle Database Reference* for detailed descriptions of these views
- *Oracle Database Performance Tuning Guide* for specific information about monitoring and tuning shared server

Configuring Database Resident Connection Pooling

The database server is preconfigured to allow database resident connection pooling. However, you must explicitly enable this feature by starting the connection pool.

This section contains the following topics:

- Enabling Database Resident Connection Pooling
- Configuring the Connection Pool for Database Resident Connection Pooling
- Data Dictionary Views for Database Resident Connection Pooling

Enabling Database Resident Connection Pooling

Oracle Database includes a default connection pool called SYS_DEFAULT_CONNECTION_POOL. By default, this pool is created, but not started. To enable database resident connection pooling, you must explicitly start the connection pool.

To enable database resident connection pooling:

1. Start the database resident connection pool, as described in "Starting the Database Resident Connection Pool" on page 4-15.
2. Route the client connection requests to the connection pool, as described in "Routing Client Connection Requests to the Connection Pool" on page 4-15.

Starting the Database Resident Connection Pool

To start the connection pool, use the following steps:

1. Start SQL*Plus and connect to the database as the SYS user.
2. Issue the following command:

   ```
   SQL> EXECUTE DBMS_CONNECTION_POOL.START_POOL();
   ```

Once started, the connection pool remains in this state until it is explicitly stopped. The connection pool is automatically restarted when the database instance is restarted if the pool was active at the time of instance shutdown.

In an Oracle Real Application Clusters (RAC) environment, you can use any instance to manage the connection pool. Any changes you make to the pool configuration are applicable on all Oracle RAC instances.

Routing Client Connection Requests to the Connection Pool

In the client application, the connect string must specify the connect type as POOLED.

The following example shows an easy connect string that enables clients to connect to a database resident connection pool:

```
oraclehost.company.com:1521/books.company.com:POOLED
```

The following example shows a TNS connect descriptor that enables clients to connect to a database resident connection pool:

```
(DESCRIPTION=(ADDRESS=(PROTOCOL=tcp) (HOST=myhost)
       (PORT=1521))(CONNECT_DATA=(SERVICE_NAME=sales)
       (SERVER=POOLED)))
```

Disabling Database Resident Connection Pooling

To disable database resident connection pooling, you must explicitly stop the connection pool. Use the following steps:

1. Start SQL*Plus and connect to the database as the SYS user.
2. Issue the following command:

```
SQL> EXECUTE DBMS_CONNECTION_POOL.STOP_POOL();
```

See Also: *Oracle Database PL/SQL Packages and Types Reference* for more information on the DBMS_CONNECTION_POOL package.

Note: The operation of disabling the database resident connection pool can be completed only when all client requests that have been handed off to a server are completed.

Configuring the Connection Pool for Database Resident Connection Pooling

The connection pool is configured using default parameter values. You can use the procedures in the DBMS_CONNECTION_POOL package to configure the connection pool according to your usage. In an Oracle Real Application Clusters (RAC) environment, the configuration parameters are applicable to each Oracle RAC instance.

Table 4–2 lists the parameters that you can configure for the connection pool.

Table 4–2 Configuration Parameters for Database Resident Connection Pooling

Parameter Name	Description
MINSIZE	The minimum number of pooled servers in the pool. The default value is 4.
MAXSIZE	The maximum number of pooled servers in the pool. The default value is 40.
INCRSIZE	The number of pooled servers by which the pool is incremented if servers are unavailable when a client application request is received. The default value is 3.
SESSION_CACHED_CURSORS	The number of session cursors to cache in each pooled server session. The default value is 20.
INACTIVITY_TIMEOUT	The maximum time, in seconds, the pooled server can stay idle in the pool. After this time, the server is terminated. The default value is 300. This parameter does not apply if the pool is at MINSIZE.
MAX_THINK_TIME	The maximum time of inactivity, in seconds, for a client after it obtains a pooled server from the pool. After obtaining a pooled server from the pool, if the client application does not issue a database call for the time specified by MAX_THINK_TIME, the pooled server is freed and the client connection is terminated. The default value is 30.

Table 4–2 (Cont.) Configuration Parameters for Database Resident Connection Pooling

Parameter Name	Description
`MAX_USE_SESSION`	The number of times a pooled server can be taken and released to the pool. The default value is 5000.
`MAX_LIFETIME_SESSION`	The time, in seconds, to live for a pooled server in the pool. The default value is 3600.
`NUM_CBROK`	The number of Connection Brokers that are created to handle client requests. The default value is 1. Creating multiple Connection Broker processes helps distribute the load of client connection requests if there are a large number of client applications.
`MAXCONN_CBROK`	The maximum number of connections that each Connection Broker can handle. The default value is 40000. But if the maximum connections allowed by the platform on which the database is installed is lesser than the default value, this value overrides the value set using `MAXCONN_CBROK`. Set the per-process file descriptor limit of the operating system sufficiently high so that it supports the number of connections specified by `MAXCONN_CBROK`.

Using the CONFIGURE_POOL Procedure

The `CONFIGURE_POOL` procedure of the `DBMS_CONNECTION_POOL` package enables you to configure the connection pool with advanced options. This procedure is usually used when you need to modify all the parameters of the connection pool.

Using the ALTER_PARAM Procedure

The `ALTER_PARAM` procedure of the `DBMS_CONNECTION_POOL` package enables you to alter a specific configuration parameter without affecting other parameters.

For example, the following command changes the minimum number of pooled servers used:

```
SQL> EXECUTE DBMS_CONNECTION_POOL.ALTER_PARAM ('','MINSIZE','10');
```

The following example, changes the maximum number of connections that each connection broker can handle to 50000.

```
SQL> EXECUTE DBMS_CONNECTION_POOL.ALTER_PARAM ('','MAXCONN_CBROK','50000');
```

Before you execute this command, ensure that the maximum number of connections allowed by the platform on which your database is installed is not less than the value you set for `MAXCONN_CBROK`.

For example, in Linux, the following entry in the `/etc/security/limits.conf` file indicates that the maximum number of connections allowed for the user `test_user` is 30000.

```
test_user HARD NOFILE 30000
```

To set the maximum number of connections that each connection broker can allow to 50000, first change the value in the `limits.conf` file to a value not less than 50000.

Restoring the Connection Pool Default Settings

If you have made changes to the connection pool parameters, but you want to revert to the default pool settings, use the `RESTORE_DEFAULT` procedure of the

DBMS_CONNECTION_POOL package. The command to restore the connection pool to its default settings is:

```
SQL> EXECUTE DBMS_CONNECTION_POOL.RESTORE_DEFAULTS();
```

See Also: *Oracle Database PL/SQL Packages and Types Reference* for more information on the DBMS_CONNECTION_POOL package.

Data Dictionary Views for Database Resident Connection Pooling

Table 4–3 lists the data dictionary views that provide information about database resident connection pooling. Use these views to obtain information about your connection pool and to monitor the performance of database resident connection pooling.

Table 4–3 Data Dictionary Views for Database Resident Connection Pooling

View	Description
DBA_CPOOL_INFO	Contains information about the connection pool such as the pool status, the maximum and minimum number of connections, and timeout for idle sessions.
V$CPOOL_STATS	Contains pool statistics such as the number of session requests, number of times a session that matches the request was found in the pool, and total wait time for a session request.
V$CPOOL_CC_STATS	Contains connection class level statistics for the pool.

See Also: *Oracle Database Reference* for more information about these views.

About Oracle Database Background Processes

To maximize performance and accommodate many users, a multiprocess Oracle Database system uses **background processes**. Background processes consolidate functions that would otherwise be handled by multiple database programs running for each user process. Background processes asynchronously perform I/O and monitor other Oracle Database processes to provide increased parallelism for better performance and reliability.

Table 4–4 describes the basic Oracle Database background processes, many of which are discussed in more detail elsewhere in this book. The use of additional database server features or options can cause more background processes to be present. For example, when you use Advanced Queuing, the queue monitor (QMN*n*) background process is present. When you specify the FILE_MAPPING initialization parameter for mapping datafiles to physical devices on a storage subsystem, then the FMON process is present.

Table 4–4 Oracle Database Background Processes

Process Name	Description
Database writer (DBW*n*)	The database writer writes modified blocks from the database buffer cache to the datafiles. Oracle Database allows a maximum of 20 database writer processes (DBW0-DBW9 and DBWa-DBWj). The `DB_WRITER_PROCESSES` initialization parameter specifies the number of DBW*n* processes. The database selects an appropriate default setting for this initialization parameter or adjusts a user-specified setting based on the number of CPUs and the number of processor groups. For more information about setting the `DB_WRITER_PROCESSES` initialization parameter, see the *Oracle Database Performance Tuning Guide*.
Log writer (LGWR)	The log writer process writes redo log entries to disk. Redo log entries are generated in the redo log buffer of the system global area (SGA). LGWR writes the redo log entries sequentially into a redo log file. If the database has a multiplexed redo log, then LGWR writes the redo log entries to a group of redo log files. See Chapter 10, "Managing the Redo Log" for information about the log writer process.
Checkpoint (CKPT)	At specific times, all modified database buffers in the system global area are written to the datafiles by DBW*n*. This event is called a checkpoint. The checkpoint process is responsible for signalling DBW*n* at checkpoints and updating all the datafiles and control files of the database to indicate the most recent checkpoint.
System monitor (SMON)	The system monitor performs recovery when a failed instance starts up again. In an Oracle Real Application Clusters database, the SMON process of one instance can perform instance recovery for other instances that have failed. SMON also cleans up temporary segments that are no longer in use and recovers dead transactions skipped during system failure and instance recovery because of file-read or offline errors. These transactions are eventually recovered by SMON when the tablespace or file is brought back online.
Process monitor (PMON)	The process monitor performs process recovery when a user process fails. PMON is responsible for cleaning up the cache and freeing resources that the process was using. PMON also checks on the dispatcher processes (described later in this table) and server processes and restarts them if they have failed.
Archiver (ARC*n*)	One or more archiver processes copy the redo log files to archival storage when they are full or a log switch occurs. Archiver processes are the subject of Chapter 11, "Managing Archived Redo Logs".
Recoverer (RECO)	The recoverer process is used to resolve distributed transactions that are pending because of a network or system failure in a distributed database. At timed intervals, the local RECO attempts to connect to remote databases and automatically complete the commit or rollback of the local portion of any pending distributed transactions. For information about this process and how to start it, see Chapter 33, "Managing Distributed Transactions".
Dispatcher (D*nnn*)	Dispatchers are optional background processes, present only when the shared server configuration is used. Shared server was discussed previously in "Configuring Oracle Database for Shared Server" on page 4-6.
Global Cache Service (LMS)	In an Oracle Real Application Clusters environment, this process manages resources and provides inter-instance resource control.

See Also: *Oracle Database Concepts* for more information about Oracle Database background processes

Managing Processes for Parallel SQL Execution

Note: The parallel execution feature described in this section is available with the Oracle Database Enterprise Edition.

This section describes how to manage parallel processing of SQL statements. In this configuration Oracle Database can divide the work of processing an SQL statement among multiple parallel processes.

The execution of many SQL statements can be parallelized. The **degree of parallelism** is the number of parallel execution servers that can be associated with a single operation. The degree of parallelism is determined by any of the following:

- A `PARALLEL` clause in a statement
- For objects referred to in a query, the `PARALLEL` clause that was used when the object was created or altered
- A parallel hint inserted into the statement
- A default determined by the database

An example of using parallel SQL execution is contained in "Parallelizing Table Creation" on page 18-11.

The following topics are contained in this section:

- About Parallel Execution Servers
- Altering Parallel Execution for a Session

See Also:

- *Oracle Database Concepts* for a description of parallel execution
- *Oracle Database Performance Tuning Guide* for information about using parallel hints

About Parallel Execution Servers

When an instance starts up, Oracle Database creates a pool of parallel execution servers which are available for any parallel operation. A process called the **parallel execution coordinator** dispatches the execution of a pool of **parallel execution servers** and coordinates the sending of results from all of these parallel execution servers back to the user.

The parallel execution servers are enabled by default, because by default the value for `PARALLEL_MAX_SERVERS` initialization parameter is set >0. The processes are available for use by the various Oracle Database features that are capable of exploiting parallelism. Related initialization parameters are tuned by the database for the majority of users, but you can alter them as needed to suit your environment. For ease of tuning, some parameters can be altered dynamically.

Parallelism can be used by a number of features, including transaction recovery, replication, and SQL execution. In the case of parallel SQL execution, the topic discussed in this book, parallel server processes remain associated with a statement throughout its execution phase. When the statement is completely processed, these processes become available to process other statements.

See Also: *Oracle Database Data Warehousing Guide* for more information about using and tuning parallel execution, including parallel SQL execution

Altering Parallel Execution for a Session

You control parallel SQL execution for a session using the `ALTER SESSION` statement.

Disabling Parallel SQL Execution

You disable parallel SQL execution with an `ALTER SESSION DISABLE PARALLEL DML|DDL|QUERY` statement. All subsequent DML (`INSERT`, `UPDATE`, `DELETE`), DDL (`CREATE`, `ALTER`), or query (`SELECT`) operations are executed serially after such a statement is issued. They will be executed serially regardless of any `PARALLEL` clause associated with the statement or parallel attribute associated with the table or indexes involved.

The following statement disables parallel DDL operations:

```
ALTER SESSION DISABLE PARALLEL DDL;
```

Enabling Parallel SQL Execution

You enable parallel SQL execution with an `ALTER SESSION ENABLE PARALLEL DML|DDL|QUERY` statement. Subsequently, when a `PARALLEL` clause or parallel hint is associated with a statement, those DML, DDL, or query statements will execute in parallel. By default, parallel execution is enabled for DDL and query statements.

A DML statement can be parallelized only if you specifically issue an `ALTER SESSION` statement to enable parallel DML:

```
ALTER SESSION ENABLE PARALLEL DML;
```

Forcing Parallel SQL Execution

You can force parallel execution of all subsequent DML, DDL, or query statements for which parallelization is possible with the `ALTER SESSION FORCE PARALLEL DML|DDL|QUERY` statement. Additionally you can force a specific degree of parallelism to be in effect, overriding any `PARALLEL` clause associated with subsequent statements. If you do not specify a degree of parallelism in this statement, the default degree of parallelism is used. However, a degree of parallelism specified in a statement through a hint will override the degree being forced.

The following statement forces parallel execution of subsequent statements and sets the overriding degree of parallelism to 5:

```
ALTER SESSION FORCE PARALLEL DDL PARALLEL 5;
```

Managing Processes for External Procedures

External procedures are procedures written in one language that are called from another program in a different language. An example is a PL/SQL program calling one or more C routines that are required to perform special-purpose processing.

These callable routines are stored in a dynamic link library (DLL), or a libunit in the case of a Java class method, and are registered with the base language. Oracle Database provides a special-purpose interface, the **call specification** (call spec), that enables users to call external procedures from other languages.

To call an external procedure, an application alerts a network listener process, which in turn starts an external procedure agent. The default name of the agent is `extproc`, and this agent must reside on the same computer as the database server. Using the network connection established by the listener, the application passes to the external procedure agent the name of the DLL or libunit, the name of the external procedure, and any relevant parameters. The external procedure agent then loads, DLL or libunit, runs the external procedure, and passes back to the application any values returned by the external procedure.

To control access to DLLs, the database administrator grants execute privileges on the appropriate DLLs to application developers. The application developers write the external procedures and grant execute privilege on specific external procedures to other users.

Note: The external library (DLL file) must be statically linked. In other words, it must not reference any external symbols from other external libraries (DLL files). Oracle Database does not resolve such symbols, so they can cause your external procedure to fail.

The environment for calling external procedures, consisting of `tnsnames.ora` and `listener.ora` entries, is configured by default during the installation of your database. You may need to perform additional network configuration steps for a higher level of security. These steps are documented in the *Oracle Database Net Services Administrator's Guide*.

See Also: *Oracle Database Advanced Application Developer's Guide* for information about external procedures

Terminating Sessions

Sometimes it is necessary to terminate current user sessions. For example, you might want to perform an administrative operation and need to terminate all non-administrative sessions. This section describes the various aspects of terminating sessions, and contains the following topics:

- Identifying Which Session to Terminate
- Terminating an Active Session
- Terminating an Inactive Session

When a session is terminated, any active transactions of the session are rolled back, and resources held by the session (such as locks and memory areas) are immediately released and available to other sessions.

You terminate a current session using the SQL statement `ALTER SYSTEM KILL SESSION`. The following statement terminates the session whose system identifier is 7 and serial number is 15:

```
ALTER SYSTEM KILL SESSION '7,15';
```

Identifying Which Session to Terminate

To identify which session to terminate, specify the session index number and serial number. To identify the system identifier (SID) and serial number of a session, query the `V$SESSION` dynamic performance view. For example, the following query identifies all sessions for the user `jward`:

```
SELECT SID, SERIAL#, STATUS
  FROM V$SESSION
  WHERE USERNAME = 'JWARD';

SID    SERIAL#    STATUS
-----  ---------  --------
    7         15  ACTIVE
   12         63  INACTIVE
```

A session is `ACTIVE` when it is making a SQL call to Oracle Database. A session is `INACTIVE` if it is not making a SQL call to the database.

> **See Also:** *Oracle Database Reference* for a description of the status values for a session

Terminating an Active Session

If a user session is processing a transaction (`ACTIVE` status) when you terminate the session, the transaction is rolled back and the user immediately receives the following message:

```
ORA-00028: your session has been killed
```

If, after receiving the `ORA-00028` message, a user submits additional statements before reconnecting to the database, Oracle Database returns the following message:

```
ORA-01012: not logged on
```

An active session cannot be interrupted when it is performing network I/O or rolling back a transaction. Such a session cannot be terminated until the operation completes. In this case, the session holds all resources until it is terminated. Additionally, the session that issues the `ALTER SYSTEM` statement to terminate a session waits up to 60 seconds for the session to be terminated. If the operation that cannot be interrupted continues past one minute, the issuer of the `ALTER SYSTEM` statement receives a message indicating that the session has been marked to be terminated. A session marked to be terminated is indicated in `V$SESSION` with a status of `KILLED` and a server that is something other than `PSEUDO`.

Terminating an Inactive Session

If the session is not making a SQL call to Oracle Database (is `INACTIVE`) when it is terminated, the `ORA-00028` message is not returned immediately. The message is not returned until the user subsequently attempts to use the terminated session.

When an inactive session has been terminated, the `STATUS` of the session in the `V$SESSION` view is `KILLED`. The row for the terminated session is removed from `V$SESSION` after the user attempts to use the session again and receives the `ORA-00028` message.

In the following example, an inactive session is terminated. First, `V$SESSION` is queried to identify the `SID` and `SERIAL#` of the session, and then the session is terminated.

```
SELECT SID,SERIAL#,STATUS,SERVER
   FROM V$SESSION
   WHERE USERNAME = 'JWARD';

SID    SERIAL#   STATUS     SERVER
-----  --------  ---------  ---------
    7        15  INACTIVE   DEDICATED
   12        63  INACTIVE   DEDICATED
2 rows selected.

ALTER SYSTEM KILL SESSION '7,15';
Statement processed.

SELECT SID, SERIAL#, STATUS, SERVER
   FROM V$SESSION
   WHERE USERNAME = 'JWARD';
```

```
SID    SERIAL#   STATUS     SERVER
-----  --------  ---------  ---------
    7        15  KILLED     PSEUDO
   12        63  INACTIVE   DEDICATED
2 rows selected.
```

Process and Session Data Dictionary Views

The following are the data dictionary views that can help you manage processes and sessions.

View	Description
`V$PROCESS`	Contains information about the currently active processes
`V$SESSION`	Lists session information for each current session
`V$SESS_IO`	Contains I/O statistics for each user session
`V$SESSION_LONGOPS`	Displays the status of various operations that run for longer than 6 seconds (in absolute time). These operations currently include many backup and recovery functions, statistics gathering, and query execution. More operations are added for every Oracle Database release.
`V$SESSION_WAIT`	Displays the current or last wait for each session
`V$SESSION_WAIT_HISTORY`	Lists the last ten wait events for each active session
`V$WAIT_CHAINS`	Displays information about blocked sessions
`V$SYSSTAT`	Contains session statistics
`V$RESOURCE_LIMIT`	Provides information about current and maximum global resource utilization for some system resources
`V$SQLAREA`	Contains statistics about shared SQL areas. Contains one row for each SQL string. Provides statistics about SQL statements that are in memory, parsed, and ready for execution

5 Managing Memory

This chapter describes how to manage memory allocation in an Oracle Database instance. It discusses the database initialization parameters that affect the sizes of the various memory components, and how to set them. The following topics are discussed:

About Memory Management

Memory management involves maintaining optimal sizes for the Oracle Database instance memory structures as demands on the database change. The memory structures that must be managed are the system global area (SGA) and the instance program global area (instance PGA).

Oracle Database supports various memory management methods, which are chosen by initialization parameter settings. Oracle recommends that you enable the method known as *automatic memory management*.

Automatic Memory Management

Beginning with Release 11*g*, Oracle Database can manage the SGA memory and instance PGA memory completely automatically. You designate only the total memory size to be used by the instance, and Oracle Database dynamically exchanges memory between the SGA and the instance PGA as needed to meet processing demands. This capability is referred to as *automatic memory management*. With this memory management method, the database also dynamically tunes the sizes of the individual SGA components and the sizes of the individual PGAs.

Manual Memory Management

If you prefer to exercise more direct control over the sizes of individual memory components, you can disable automatic memory management and configure the database for manual memory management. There are a few different methods available for manual memory management. Some of these methods retain some degree of automation. The methods therefore vary in the amount of effort and knowledge required by the DBA. These methods are:

- Automatic shared memory management - for the SGA

- Manual shared memory management - for the SGA
- Automatic PGA memory management - for the instance PGA
- Manual PGA memory management - for the instance PGA

These memory management methods are described later in this chapter.

Note: The easiest way to manage memory is to use the graphical user interface of Oracle Enterprise Manager.

To manage memory with Enterprise Manager:

1. Do one of the following:

   - If you are using Oracle Enterprise Manager Database Control, access the Database Home page. See *Oracle Database 2 Day DBA* for instructions.

   - If you are using Oracle Enterprise Manager Grid Control, go to the desired database target. The Database Home page is displayed.
2. At the top of the page, click **Server** to display the Server page.
3. In the Database Configuration section, click **Memory Advisors**.

See Also: *Oracle Database Concepts* for an introduction to the various automatic and manual methods of managing memory.

Memory Architecture Overview

The basic memory structures associated with Oracle Database include:

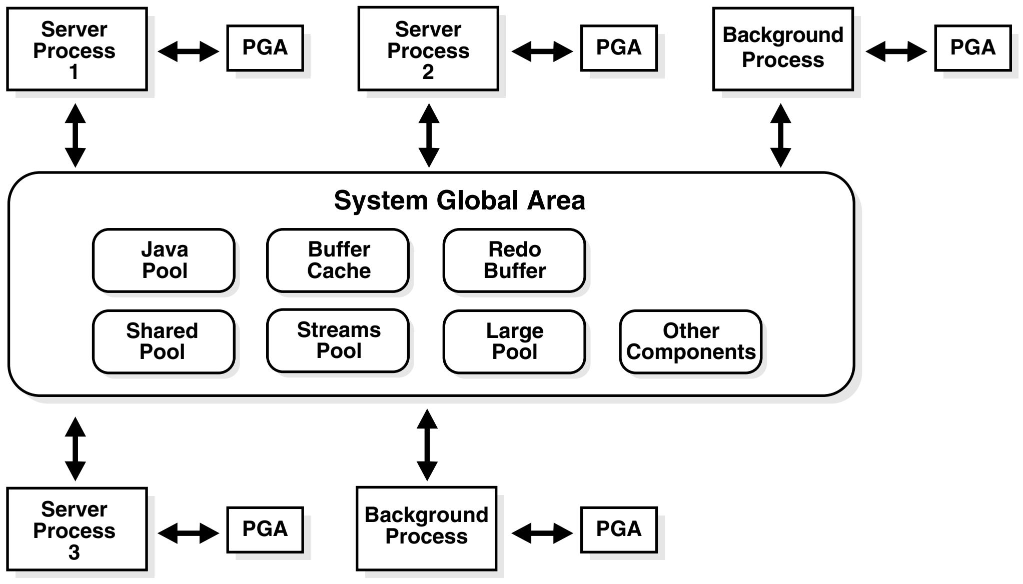
- System Global Area (SGA)

  The SGA is a group of shared memory structures, known as *SGA components*, that contain data and control information for one Oracle Database instance. The SGA is shared by all server and background processes. Examples of data stored in the SGA include cached data blocks and shared SQL areas.
- Program Global Area (PGA)

  A PGA is a memory region that contains data and control information for a server process. It is nonshared memory created by Oracle Database when a server process is started. Access to the PGA is exclusive to the server process. There is one PGA for each server process. Background processes also allocate their own PGAs. The total PGA memory allocated for all background and server processes attached to an Oracle Database instance is referred to as the **total instance PGA memory**, and the collection of all individual PGAs is referred to as the **total instance PGA**, or just **instance PGA**.

Figure 5–1 illustrates the relationships among these memory structures.

Figure 5–1 Oracle Database Memory Structures



See Also: *Oracle Database Concepts* for more information on memory architecture in an Oracle Database instance.

Using Automatic Memory Management

This section provides background information on the automatic memory management feature of Oracle Database, and includes instructions for enabling this feature. The following topics are covered:

- About Automatic Memory Management
- Enabling Automatic Memory Management
- Monitoring and Tuning Automatic Memory Management

About Automatic Memory Management

The simplest way to manage instance memory is to allow the Oracle Database instance to automatically manage and tune it for you. To do so (on most platforms), you set only a *target* memory size initialization parameter (`MEMORY_TARGET`) and optionally a *maximum* memory size initialization parameter (`MEMORY_MAX_TARGET`). The instance then tunes to the target memory size, redistributing memory as needed between the system global area (SGA) and the instance program global area (instance PGA). Because the target memory initialization parameter is dynamic, you can change the target memory size at any time without restarting the database. The maximum memory size serves as an upper limit so that you cannot accidentally set the target memory size too high, and so that enough memory is set aside for the Oracle Database instance in case you do want to increase total instance memory in the future. Because certain SGA components either cannot easily shrink or must remain at a minimum size, the instance also prevents you from setting the target memory size too low.

If you create your database with Database Configuration Assistant (DBCA) and choose the basic installation option, automatic memory management is enabled. If you choose advanced installation, Database Configuration Assistant (DBCA) enables you to select automatic memory management.

Note: You cannot enable automatic memory management if the LOCK_SGA initialization parameter is TRUE. See *Oracle Database Reference* for information about this parameter.

See Also:

- "Platforms That Support Automatic Memory Management" on page 5-21

Enabling Automatic Memory Management

If you did not enable automatic memory management upon database creation (either by selecting the proper options in DBCA or by setting the appropriate initialization parameters for the CREATE DATABASE SQL statement), you can enable it at a later time. Enabling automatic memory management involves a shutdown and restart of the database.

To enable automatic memory management

1. Start SQL*Plus and connect to the database as SYSDBA.

   See "Database Administrator Security and Privileges" on page 1-9 and "Database Administrator Authentication" on page 1-11 for instructions.

2. Calculate the minimum value for MEMORY_TARGET as follows:

   a. Determine the current sizes of SGA_TARGET and PGA_AGGREGATE_TARGET by entering the following SQL*Plus command:

   ```
   SHOW PARAMETER TARGET
   ```

   SQL*Plus displays the values of all initialization parameters with the string TARGET in the parameter name.

   ```
   NAME                           TYPE        VALUE
   ------------------------------ ----------- ----------------
   archive_lag_target             integer     0
   db_flashback_retention_target  integer     1440
   fast_start_io_target           integer     0
   fast_start_mttr_target         integer     0
   memory_max_target              big integer 0
   memory_target                  big integer 0
   pga_aggregate_target           big integer 90M
   sga_target                     big integer 272M
   ```

   b. Run the following query to determine the maximum instance PGA allocated since the database was started:

   ```
   select value from v$pgastat where name='maximum PGA allocated';
   ```

   c. Compute the maximum value between the query result from step 2b and PGA_AGGREGATE_TARGET. Add SGA_TARGET to this value.

   ```
   memory_target = sga_target + max(pga_aggregate_target, maximum PGA
   allocated)
   ```

   For example, if SGA_TARGET is 272M and PGA_AGGREGATE_TARGET is 90M as shown above, and if the maximum PGA allocated is determined to be 120M, then MEMORY_TARGET should be at least 392M (272M + 120M).

3. Choose the value for `MEMORY_TARGET` that you want to use.

   This can be the minimum value that you computed in step 2, or you can choose to use a larger value if you have enough physical memory available.

4. For the `MEMORY_MAX_TARGET` initialization parameter, decide on a maximum amount of memory that you would want to allocate to the database for the foreseeable future. That is, determine the maximum value for the sum of the SGA and instance PGA sizes. This number can be larger than or the same as the `MEMORY_TARGET` value that you chose in the previous step.

5. Do one of the following:

   - If you started your Oracle Database instance with a server parameter file, which is the default if you created the database with the Database Configuration Assistant (DBCA), enter the following command:

     ```
     ALTER SYSTEM SET MEMORY_MAX_TARGET = nM SCOPE = SPFILE;
     ```

     where *n* is the value that you computed in Step 4.

     The `SCOPE = SPFILE` clause sets the value only in the server parameter file, and not for the running instance. You must include this `SCOPE` clause because `MEMORY_MAX_TARGET` is not a dynamic initialization parameter.

   - If you started your instance with a text initialization parameter file, manually edit the file so that it contains the following statements:

     ```
     memory_max_target = nM
     memory_target = mM
     ```

     where *n* is the value that you determined in Step 4, and *m* is the value that you determined in step 3.

     Note: In a text initialization parameter file, if you omit the line for `MEMORY_MAX_TARGET` and include a value for `MEMORY_TARGET`, the database automatically sets `MEMORY_MAX_TARGET` to the value of `MEMORY_TARGET`. If you omit the line for `MEMORY_TARGET` and include a value for `MEMORY_MAX_TARGET`, the `MEMORY_TARGET` parameter defaults to zero. After startup, you can then dynamically change `MEMORY_TARGET` to a nonzero value, provided that it does not exceed the value of `MEMORY_MAX_TARGET`.

6. Shut down and restart the database.

   See Chapter 3, "Starting Up and Shutting Down" on page 3-1 for instructions.

7. If you started your Oracle Database instance with a server parameter file, enter the following commands:

   ```
   ALTER SYSTEM SET MEMORY_TARGET = nM;
   ALTER SYSTEM SET SGA_TARGET = 0;
   ALTER SYSTEM SET PGA_AGGREGATE_TARGET = 0;
   ```

   where *n* is the value that you determined in step 3.

Note: The preceding steps instruct you to set SGA_TARGET and PGA_AGGREGATE_TARGET to zero so that the sizes of the SGA and instance PGA are tuned up and down as required, without restrictions. You can omit the statements that set these parameter values to zero and leave either or both of the values as positive numbers. In this case, the values act as minimum values for the sizes of the SGA or instance PGA.

See Also:

- "About Automatic Memory Management" on page 5-3
- "Memory Architecture Overview" on page 5-2
- *Oracle Database SQL Language Reference* for information on the ALTER SYSTEM SQL statement

Monitoring and Tuning Automatic Memory Management

The dynamic performance view V$MEMORY_DYNAMIC_COMPONENTS shows the current sizes of all dynamically tuned memory components, including the total sizes of the SGA and instance PGA.

The view V$MEMORY_TARGET_ADVICE provides tuning advice for the MEMORY_TARGET initialization parameter.

```
SQL>  select * from v$memory_target_advice order by memory_size;

MEMORY_SIZE MEMORY_SIZE_FACTOR ESTD_DB_TIME ESTD_DB_TIME_FACTOR    VERSION
----------- ------------------ ------------ ------------------- ----------
        180                 .5          458               1.344          0
        270                .75          367              1.0761          0
        360                  1          341                   1          0
        450               1.25          335               .9817          0
        540                1.5          335               .9817          0
        630               1.75          335               .9817          0
        720                  2          335               .9817          0
```

The row with the MEMORY_SIZE_FACTOR of 1 shows the current size of memory, as set by the MEMORY_TARGET initialization parameter, and the amount of DB time required to complete the current workload. In previous and subsequent rows, the results show a number of alternative MEMORY_TARGET sizes. For each alternative size, the database shows the size factor (the multiple of the current size), and the estimated DB time to complete the current workload if the MEMORY_TARGET parameter were changed to the alternative size. Notice that for a total memory size smaller than the current MEMORY_TARGET size, estimated DB time increases. Notice also that in this example, there is nothing to be gained by increasing total memory size beyond 450MB. However, this situation might change if a complete workload has not yet been run.

Enterprise Manager provides an easy-to-use graphical memory advisor to help you select an optimal size for MEMORY_TARGET. See *Oracle Database 2 Day DBA* for details.

See Also:

- *Oracle Database Reference* for more information about these dynamic performance views
- *Oracle Database Performance Tuning Guide* for a definition of DB time.

Configuring Memory Manually

If you prefer to exercise more direct control over the sizes of individual memory components, you can disable automatic memory management and configure the database for manual memory management. There are two different manual memory management methods for the SGA, and two for the instance PGA.

The two manual memory management methods for the SGA vary in the amount of effort and knowledge required by the DBA. With *automatic shared memory management*, you set target and maximum sizes for the SGA. The database then tunes the total size of the SGA to your designated target, and dynamically tunes the sizes of many SGA components. With *manual shared memory management*, you set the sizes of several individual SGA components, thereby determining the overall SGA size. You then manually tune these individual SGA components on an ongoing basis.

For the instance PGA, there is *automatic PGA memory management*, in which you set a target size for the instance PGA. The database then tunes the size of the instance PGA to your target, and dynamically tunes the sizes of individual PGAs. There is also *manual PGA memory management*, in which you set maximum work area size for each type of SQL operator (such as sort or hash-join). This memory management method, although supported, is not recommended.

The following sections provide details on all of these manual memory management methods:

- Using Automatic Shared Memory Management
- Using Manual Shared Memory Management
- Using Automatic PGA Memory Management
- Using Manual PGA Memory Management

See Also: *Oracle Database Concepts* for an overview of Oracle Database memory management methods.

Using Automatic Shared Memory Management

This section contains the following topics:

- About Automatic Shared Memory Management
- Components and Granules in the SGA
- Setting Maximum SGA Size
- Setting SGA Target Size
- Enabling Automatic Shared Memory Management
- Automatic Shared Memory Management Advanced Topics

See Also:

- *Oracle Database Performance Tuning Guide* for information about tuning the components of the SGA

About Automatic Shared Memory Management

Automatic Shared Memory Management simplifies SGA memory management. You specify the total amount of SGA memory available to an instance using the `SGA_TARGET` initialization parameter and Oracle Database automatically distributes this memory among the various SGA components to ensure the most effective memory utilization.

When automatic shared memory management is enabled, the sizes of the different SGA components are flexible and can adapt to the needs of a workload without requiring any additional configuration. The database automatically distributes the available memory among the various components as required, allowing the system to maximize the use of all available SGA memory.

Oracle Database remembers the sizes of the automatically tuned components across instance shutdowns if you are using a server parameter file (`SPFILE`). As a result, the system does need to learn the characteristics of the workload again each time an instance is started. It can begin with information from the past instance and continue evaluating workload where it left off at the last shutdown.

Components and Granules in the SGA

The SGA comprises a number of memory **components**, which are pools of memory used to satisfy a particular class of memory allocation requests. Examples of memory components include the shared pool (used to allocate memory for SQL and PL/SQL execution), the java pool (used for java objects and other java execution memory), and the buffer cache (used for caching disk blocks). All SGA components allocate and deallocate space in units of **granules**. Oracle Database tracks SGA memory use in internal numbers of granules for each SGA component.

The memory for dynamic components in the SGA is allocated in the unit of granules. Granule size is determined by total SGA size. Generally speaking, on most platforms, if the total SGA size is equal to or less than 1 GB, then granule size is 4 MB. For SGAs larger than 1 GB, granule size is 16 MB. Some platform dependencies may arise. For example, on 32-bit Windows NT, the granule size is 8 MB for SGAs larger than 1 GB. Consult your operating system specific documentation for more details.

You can query the `V$SGAINFO` view to see the granule size that is being used by an instance. The same granule size is used for all components in the SGA.

If you specify a size for a component that is not a multiple of granule size, Oracle Database rounds the specified size up to the nearest multiple. For example, if the granule size is 4 MB and you specify `DB_CACHE_SIZE` as 10 MB, the database actually allocates 12 MB.

Setting Maximum SGA Size

The `SGA_MAX_SIZE` initialization parameter specifies the maximum size of the System Global Area for the lifetime of the instance. You can dynamically alter the initialization parameters affecting the size of the buffer caches, shared pool, large pool, Java pool, and streams pool but only to the extent that the sum of these sizes and the sizes of the other components of the SGA (fixed SGA, variable SGA, and redo log buffers) does not exceed the value specified by `SGA_MAX_SIZE`.

If you do not specify `SGA_MAX_SIZE`, then Oracle Database selects a default value that is the sum of all components specified or defaulted at initialization time. If you do specify `SGA_MAX_SIZE`, and at the time the database is initialized the value is less than the sum of the memory allocated for all components, either explicitly in the parameter file or by default, then the database ignores the setting for `SGA_MAX_SIZE` and chooses a correct value for this parameter.

Setting SGA Target Size

You enable the automatic shared memory management feature by setting the `SGA_TARGET` parameter to a nonzero value. This parameter in effect replaces the parameters that control the memory allocated for a specific set of individual components, which are now automatically and dynamically resized (tuned) as needed.

Note: The STATISTICS_LEVEL initialization parameter must be set to TYPICAL (the default) or ALL for automatic shared memory management to function.

The SGA_TARGET initialization parameter reflects the total size of the SGA. Table 5–1 lists the SGA components for which SGA_TARGET includes memory—the **automatically sized SGA components**—and the initialization parameters corresponding to those components.

Table 5–1 Automatically Sized SGA Components and Corresponding Parameters

SGA Component	Initialization Parameter
Fixed SGA and other internal allocations needed by the Oracle Database instance	N/A
The shared pool	SHARED_POOL_SIZE
The large pool	LARGE_POOL_SIZE
The Java pool	JAVA_POOL_SIZE
The buffer cache	DB_CACHE_SIZE
The Streams pool	STREAMS_POOL_SIZE

The parameters listed in Table 5–2, if they are set, take their memory from SGA_TARGET, leaving what is available for the components listed in Table 5–1.

Table 5–2 Manually Sized SGA Components that Use SGA_TARGET Space

SGA Component	Initialization Parameter
The log buffer	LOG_BUFFER
The keep and recycle buffer caches	DB_KEEP_CACHE_SIZE DB_RECYCLE_CACHE_SIZE
Nonstandard block size buffer caches	DB_*n*K_CACHE_SIZE

In addition to setting SGA_TARGET to a nonzero value, you must set the value of all automatically sized SGA components to zero to enable full automatic tuning of these components.

Alternatively, you can set one or more of the automatically sized SGA components to a nonzero value, which is then used as the minimum setting for that component during SGA tuning. This is discussed in detail later in this section.

Note: An easier way to enable automatic shared memory management is to use Oracle Enterprise Manager (EM). When you enable automatic shared memory management and set the Total SGA Size, EM automatically generates the ALTER SYSTEM statements to set SGA_TARGET to the specified size and to set all automatically sized SGA components to zero.

If you use SQL*Plus to set SGA_TARGET, you must then set the automatically sized SGA components to zero or to a minimum value.

SGA and Virtual Memory For optimal performance in most systems, the entire SGA should fit in real memory. If it does not, and if virtual memory is used to store parts of it, then overall database system performance can decrease dramatically. The reason for this is that portions of the SGA are paged (written to and read from disk) by the operating system.

See your operating system documentation for instructions for monitoring paging activity. You can also view paging activity from the Performance property page of the Host page of Enterprise Manager.

Monitoring and Tuning SGA Target Size The `V$SGAINFO` view provides information on the current tuned sizes of various SGA components.

The `V$SGA_TARGET_ADVICE` view provides information that helps you decide on a value for `SGA_TARGET`.

```
SQL> select * from v$sga_target_advice order by sga_size;

  SGA_SIZE SGA_SIZE_FACTOR ESTD_DB_TIME ESTD_DB_TIME_FACTOR ESTD_PHYSICAL_READS
---------- --------------- ------------ ------------------- -------------------
       290              .5       448176              1.6578             1636103
       435             .75       339336              1.2552             1636103
       580               1       270344                   1             1201780
       725            1.25       239038               .8842              907584
       870             1.5       211517               .7824              513881
      1015            1.75       201866               .7467              513881
      1160               2       200703               .7424              513881
```

The information in this view is similar to that provided in the `V$MEMORY_TARGET_ADVICE` view for automatic memory management. See "Monitoring and Tuning Automatic Memory Management" on page 5-6 for an explanation of that view.

Enterprise Manager provides an easy-to-use graphical memory advisor to help you select an optimal size for `SGA_TARGET`. See *Oracle Database 2 Day DBA* for details.

> **See Also:** *Oracle Database Reference* for more information about these dynamic performance views

Enabling Automatic Shared Memory Management

The procedure for enabling automatic shared memory management (ASMM) differs depending on whether you are changing to ASMM from manual shared memory management or from automatic memory management.

To change to ASMM from manual shared memory management:

1. Run the following query to obtain a value for `SGA_TARGET`:

   ```
   SELECT (
      (SELECT SUM(value) FROM V$SGA) -
      (SELECT CURRENT_SIZE FROM V$SGA_DYNAMIC_FREE_MEMORY)
      ) "SGA_TARGET"
   FROM DUAL;
   ```

2. Set the value of `SGA_TARGET`, either by editing the text initialization parameter file and restarting the database, or by issuing the following statement:

   ```
   ALTER SYSTEM SET SGA_TARGET=value [SCOPE={SPFILE|MEMORY|BOTH}]
   ```

   where *value* is the value computed in step 1 or is some value between the sum of all SGA component sizes and `SGA_MAX_SIZE`. For more information on the

ALTER SYSTEM statement and its SCOPE clause, see *Oracle Database SQL Language Reference*.

3. Do one of the following:
   - For more complete automatic tuning, set the values of the automatically sized SGA components listed in Table 5–1 to zero. Do this by editing the text initialization parameter file or by issuing ALTER SYSTEM statements.
   - To control the minimum size of one or more automatically sized SGA components, set those component sizes to the desired value. (See the next section for details.) Set the values of the other automatically sized SGA components to zero. Do this by editing the text initialization parameter file or by issuing ALTER SYSTEM statements.

To change to ASMM from automatic memory management:

1. Set the MEMORY_TARGET initialization parameter to 0.

   ```
   ALTER SYSTEM SET MEMORY_TARGET = 0;
   ```

   The database sets SGA_TARGET based on current SGA memory allocation.

2. Do one of the following:
   - For more complete automatic tuning, set the values of the automatically sized SGA components listed in Table 5–1 to zero. Do this by editing the text initialization parameter file or by issuing ALTER SYSTEM statements.
   - To control the minimum size of one or more automatically sized SGA components, set those component sizes to the desired value. (See the next section for details.) Set the values of the other automatically sized SGA components to zero. Do this by editing the text initialization parameter file or by issuing ALTER SYSTEM statements.

Example For example, suppose you currently have the following configuration of parameters for an instance configured for manual shared memory management and with SGA_MAX_SIZE set to 1200M:

- SHARED_POOL_SIZE = 200M
- DB_CACHE_SIZE = 500M
- LARGE_POOL_SIZE=200M

Also assume the following query results:

Query	Result
SELECT SUM(value) FROM V$SGA	1200M
SELECT CURRENT_SIZE FROM V$SGA_DYNAMIC_FREE_MEMORY	208M

You can take advantage of automatic shared memory management by setting Total SGA Size to 992M in Oracle Enterprise Manager, or by issuing the following statements:

```
ALTER SYSTEM SET SGA_TARGET = 992M;
ALTER SYSTEM SET SHARED_POOL_SIZE = 0;
ALTER SYSTEM SET LARGE_POOL_SIZE = 0;
ALTER SYSTEM SET JAVA_POOL_SIZE = 0;
ALTER SYSTEM SET DB_CACHE_SIZE = 0;
```

```
ALTER SYSTEM SET STREAMS_POOL_SIZE = 0;
```

where 992M = 1200M minus 208M.

Automatic Shared Memory Management Advanced Topics

This section provides a closer look at automatic shared memory management. It includes the following topics:

- Setting Minimums for Automatically Sized SGA Components
- Automatic Tuning and the Shared Pool
- Dynamic Modification of SGA_TARGET
- Modifying Parameters for Automatically Sized Components
- Modifying Parameters for Manually Sized Components

Setting Minimums for Automatically Sized SGA Components You can exercise some control over the size of the automatically sized SGA components by specifying minimum values for the parameters corresponding to these components. Doing so can be useful if you know that an application cannot function properly without a minimum amount of memory in specific components. You specify the minimum amount of SGA space for a component by setting a value for its corresponding initialization parameter.

Manually limiting the minimum size of one or more automatically sized components reduces the total amount of memory available for dynamic adjustment. This reduction in turn limits the ability of the system to adapt to workload changes. Therefore, this practice is not recommended except in exceptional cases. The default automatic management behavior maximizes both system performance and the use of available resources.

Automatic Tuning and the Shared Pool When the automatic shared memory management feature is enabled, the internal tuning algorithm tries to determine an optimal size for the shared pool based on the workload. It usually converges on this value by increasing in small increments over time. However, the internal tuning algorithm typically does not attempt to shrink the shared pool, because the presence of open cursors, pinned PL/SQL packages, and other SQL execution state in the shared pool make it impossible to find granules that can be freed. Therefore, the tuning algorithm only tries to increase the shared pool in conservative increments, starting from a conservative size and stabilizing the shared pool at a size that produces the optimal performance benefit.

Dynamic Modification of SGA_TARGET The `SGA_TARGET` parameter can be dynamically increased up to the value specified for the `SGA_MAX_SIZE` parameter, and it can also be reduced. If you reduce the value of `SGA_TARGET`, the system identifies one or more automatically tuned components for which to release memory. You can reduce `SGA_TARGET` until one or more automatically tuned components reach their minimum size. Oracle Database determines the minimum allowable value for `SGA_TARGET` taking into account several factors, including values set for the automatically sized components, manually sized components that use `SGA_TARGET` space, and number of CPUs.

The change in the amount of physical memory consumed when `SGA_TARGET` is modified depends on the operating system. On some UNIX platforms that do not support dynamic shared memory, the physical memory in use by the SGA is equal to the value of the `SGA_MAX_SIZE` parameter. On such platforms, there is no real benefit in setting SGA_TARGET to a value smaller than SGA_MAX_SIZE. Therefore, setting SGA_MAX_SIZE on those platforms is not recommended.

On other platforms, such as Solaris and Windows, the physical memory consumed by the SGA is equal to the value of SGA_TARGET.

For example, suppose you have an environment with the following configuration:

- SGA_MAX_SIZE = 1024M
- SGA_TARGET = 512M
- DB_8K_CACHE_SIZE = 128M

In this example, the value of SGA_TARGET can be resized up to 1024M and can also be reduced until one or more of the automatically sized components reaches its minimum size. The exact value depends on environmental factors such as the number of CPUs on the system. However, the value of DB_8K_CACHE_SIZE remains fixed at all times at 128M

Note: When enabling automatic shared memory management, it is best to set SGA_TARGET to the desired nonzero value before starting the database. Dynamically modifying SGA_TARGET from zero to a nonzero value may not achieve the desired results because the shared pool may not be able to shrink. After startup, you can dynamically tune SGA_TARGET up or down as required.

Modifying Parameters for Automatically Sized Components When SGA_TARGET is not set, the automatic shared memory management feature is not enabled. Therefore the rules governing resize for all component parameters are the same as in earlier releases. However, when automatic shared memory management is enabled, the manually specified sizes of automatically sized components serve as a lower bound for the size of the components. You can modify this limit dynamically by changing the values of the corresponding parameters.

If the specified lower limit for the size of a given SGA component is less than its current size, there is no immediate change in the size of that component. The new setting only limits the automatic tuning algorithm to that reduced minimum size in the future. For example, consider the following configuration:

- SGA_TARGET = 512M
- LARGE_POOL_SIZE = 256M
- Current actual large pool size = 284M

In this example, if you increase the value of LARGE_POOL_SIZE to a value greater than the actual current size of the component, the system expands the component to accommodate the increased minimum size. For example, if you increase the value of LARGE_POOL_SIZE to 300M, then the system increases the large pool incrementally until it reaches 300M. This resizing occurs at the expense of one or more automatically tuned components.

If you decrease the value of LARGE_POOL_SIZE to 200, there is no immediate change in the size of that component. The new setting only limits the reduction of the large pool size to 200 M in the future.

Modifying Parameters for Manually Sized Components Parameters for manually sized components can be dynamically altered as well. However, rather than setting a minimum size, the value of the parameter specifies the precise size of the corresponding component. When you increase the size of a manually sized component, extra memory is taken away from one or more automatically sized components. When you decrease the size of a manually sized component, the memory that is released is given to the automatically sized components.

For example, consider this configuration:

- `SGA_TARGET` = 512M
- `DB_8K_CACHE_SIZE` = 128M

In this example, increasing `DB_8K_CACHE_SIZE` by 16 M to 144M means that the 16M is taken away from the automatically sized components. Likewise, reducing `DB_8K_CACHE_SIZE` by 16M to 112M means that the 16M is given to the automatically sized components.

Using Manual Shared Memory Management

If you decide not to use automatic memory management or automatic shared memory management, you must manually configure several SGA component sizes, and then monitor and tune these sizes on an ongoing basis as the database workload changes. This section provides guidelines on setting the parameters that control the sizes of these SGA components.

If you create your database with DBCA and choose manual shared memory management, DBCA provides fields where you must enter sizes for the buffer cache, shared pool, large pool, and Java pool. It then sets the corresponding initialization parameters in the server parameter file (`SPFILE`) that it creates. If you instead create the database with the `CREATE DATABASE` SQL statement and a text initialization parameter file, you can do one of the following:

- Provide values for the initialization parameters that set SGA component sizes.
- Omit SGA component size parameters from the text initialization file. Oracle Database chooses reasonable defaults for any component whose size you do not set.

This section contains the following topics:

- Enabling Manual Shared Memory Management
- Setting the Buffer Cache Initialization Parameters
- Specifying the Shared Pool Size
- Specifying the Large Pool Size
- Specifying the Java Pool Size
- Specifying the Streams Pool Size
- Specifying the Result Cache Maximum Size
- Specifying Miscellaneous SGA Initialization Parameters

Enabling Manual Shared Memory Management

There is no initialization parameter that in itself enables manual shared memory management. You effectively enable manual shared memory management by disabling both automatic memory management and automatic shared memory management.

To enable manual shared memory management:

1. Set the `MEMORY_TARGET` initialization parameter to 0.

2. Set the `SGA_TARGET` initialization parameter to 0.

You must then set values for the various SGA components, as described in the following sections.

Setting the Buffer Cache Initialization Parameters

The buffer cache initialization parameters determine the size of the buffer cache component of the SGA. You use them to specify the sizes of caches for the various block sizes used by the database. These initialization parameters are all dynamic.

The size of a buffer cache affects performance. Larger cache sizes generally reduce the number of disk reads and writes. However, a large cache may take up too much memory and induce memory paging or swapping.

Oracle Database supports multiple block sizes in a database. If you create tablespaces with non-standard block sizes, you must configure non-standard block size buffers to accommodate these tablespaces. The standard block size is used for the `SYSTEM` tablespace. You specify the standard block size by setting the initialization parameter `DB_BLOCK_SIZE`. Legitimate values are from 2K to 32K.

If you intend to use multiple block sizes in your database, you must have the `DB_CACHE_SIZE` and at least one `DB_nK_CACHE_SIZE` parameter set. Oracle Database assigns an appropriate default value to the `DB_CACHE_SIZE` parameter, but the `DB_nK_CACHE_SIZE` parameters default to 0, and no additional block size caches are configured.

The sizes and numbers of non-standard block size buffers are specified by the following parameters:

```
DB_2K_CACHE_SIZE
DB_4K_CACHE_SIZE
DB_8K_CACHE_SIZE
DB_16K_CACHE_SIZE
DB_32K_CACHE_SIZE
```

Each parameter specifies the size of the cache for the corresponding block size.

Note: Platform-specific restrictions regarding the maximum block size apply, so some of these sizes might not be allowed on some platforms.

See Also: "Specifying Nonstandard Block Sizes for Tablespaces" on page 12-14

Example of Setting Block and Cache Sizes

```
DB_BLOCK_SIZE=4096
DB_CACHE_SIZE=1024M
DB_2K_CACHE_SIZE=256M
DB_8K_CACHE_SIZE=512M
```

In the preceding example, the parameter `DB_BLOCK_SIZE` sets the standard block size of the database to 4K. The size of the cache of standard block size buffers is 1024MB. Additionally, 2K and 8K caches are also configured, with sizes of 256MB and 512MB, respectively.

Note: The DB_*n*K_CACHE_SIZE parameters cannot be used to size the cache for the standard block size. If the value of DB_BLOCK_SIZE is *n*K, it is invalid to set DB_*n*K_CACHE_SIZE. The size of the cache for the standard block size is always determined from the value of DB_CACHE_SIZE.

The cache has a limited size, so not all the data on disk can fit in the cache. When the cache is full, subsequent cache misses cause Oracle Database to write dirty data already in the cache to disk to make room for the new data. (If a buffer is not dirty, it does not need to be written to disk before a new block can be read into the buffer.) Subsequent access to any data that was written to disk and then overwritten results in additional cache misses.

The size of the cache affects the likelihood that a request for data results in a cache hit. If the cache is large, it is more likely to contain the data that is requested. Increasing the size of a cache increases the percentage of data requests that result in cache hits.

You can change the size of the buffer cache while the instance is running, without having to shut down the database. Do this with the ALTER SYSTEM statement.

Use the fixed view V$BUFFER_POOL to track the sizes of the different cache components and any pending resize operations.

Multiple Buffer Pools You can configure the database buffer cache with separate buffer pools that either keep data in the buffer cache or make the buffers available for new data immediately after using the data blocks. Particular schema objects (tables, clusters, indexes, and partitions) can then be assigned to the appropriate buffer pool to control the way their data blocks age out of the cache.

- The KEEP buffer pool retains the schema object's data blocks in memory.
- The RECYCLE buffer pool eliminates data blocks from memory as soon as they are no longer needed.
- The DEFAULT buffer pool contains data blocks from schema objects that are not assigned to any buffer pool, as well as schema objects that are explicitly assigned to the DEFAULT pool.

The initialization parameters that configure the KEEP and RECYCLE buffer pools are DB_KEEP_CACHE_SIZE and DB_RECYCLE_CACHE_SIZE.

Note: Multiple buffer pools are only available for the standard block size. Non-standard block size caches have a single DEFAULT pool.

See Also:

- *Oracle Database Performance Tuning Guide* for information about tuning the buffer cache and for more information about multiple buffer pools

Specifying the Shared Pool Size

The SHARED_POOL_SIZE initialization parameter is a dynamic parameter that lets you specify or adjust the size of the shared pool component of the SGA. Oracle Database selects an appropriate default value.

In releases before Oracle Database 10*g* Release 1, the amount of shared pool memory that was allocated was equal to the value of the SHARED_POOL_SIZE initialization parameter plus the amount of internal SGA overhead computed during instance startup. The internal SGA overhead refers to memory that is allocated by Oracle Database during startup, based on the values of several other initialization parameters. This memory is used to maintain state for different server components in the SGA. For example, if the SHARED_POOL_SIZE parameter is set to 64MB and the internal SGA overhead is computed to be 12MB, the real size of the shared pool is 64+12=76MB, although the value of the SHARED_POOL_SIZE parameter is still displayed as 64MB.

Starting with Oracle Database 10*g* Release 1, the size of the internal SGA overhead is included in the user-specified value of SHARED_POOL_SIZE. If you are not using automatic memory management or automatic shared memory management, the amount of shared pool memory that is allocated at startup is equal to the value of the SHARED_POOL_SIZE initialization parameter, rounded up to a multiple of the granule size. You must therefore set this parameter so that it includes the internal SGA overhead in addition to the desired value for shared pool size. In the previous example, if the SHARED_POOL_SIZE parameter is set to 64MB at startup, then the available shared pool after startup is 64-12=52MB, assuming the value of internal SGA overhead remains unchanged. In order to maintain an effective value of 64MB for shared pool memory after startup, you must set the SHARED_POOL_SIZE parameter to 64+12=76MB.

When migrating from a release that is earlier than Oracle Database 10*g* Release 1, the Oracle Database 11*g* migration utilities recommend a new value for this parameter based on the value of internal SGA overhead in the pre-upgrade environment and based on the old value of this parameter. Beginning with Oracle Database 10*g*, the exact value of internal SGA overhead, also known as startup overhead in the shared pool, can be queried from the V$SGAINFO view. Also, in manual shared memory management mode, if the user-specified value of SHARED_POOL_SIZE is too small to accommodate even the requirements of internal SGA overhead, then Oracle Database generates an ORA-371 error during startup, with a suggested value to use for the SHARED_POOL_SIZE parameter.

When you use automatic shared memory management in Oracle Database 11*g*, the shared pool is automatically tuned, and an ORA-371 error would not be generated.

The Result Cache and Shared Pool Size The result cache takes its memory from the shared pool. Therefore, if you expect to increase the maximum size of the result cache, take this into consideration when sizing the shared pool.

See Also: "Specifying the Result Cache Maximum Size" on page 5-18

Specifying the Large Pool Size

The LARGE_POOL_SIZE initialization parameter is a dynamic parameter that lets you specify or adjust the size of the large pool component of the SGA. The large pool is an optional component of the SGA. You must specifically set the LARGE_POOL_SIZE parameter if you want to create a large pool. Configuring the large pool is discussed in *Oracle Database Performance Tuning Guide*.

Specifying the Java Pool Size

The JAVA_POOL_SIZE initialization parameter is a dynamic parameter that lets you specify or adjust the size of the java pool component of the SGA. Oracle Database selects an appropriate default value. Configuration of the java pool is discussed in *Oracle Database Java Developer's Guide*.

Specifying the Streams Pool Size

The STREAMS_POOL_SIZE initialization parameter is a dynamic parameter that lets you specify or adjust the size of the Streams Pool component of the SGA. If STREAMS_POOL_SIZE is set to 0, then the Oracle Streams product transfers memory from the buffer cache to the Streams Pool when it is needed. For details, see the discussion of the Streams Pool in *Oracle Streams Concepts and Administration*.

Specifying the Result Cache Maximum Size

The RESULT_CACHE_MAX_SIZE initialization parameter is a dynamic parameter that enables you to specify the maximum size of the result cache component of the SGA. Typically, there is no need to specify this parameter, because the default maximum size is chosen by the database based on total memory available to the SGA and on the memory management method currently in use. You can view the current default maximum size by displaying the value of the RESULT_CACHE_MAX_SIZE parameter. If you want to change this maximum size, you can set RESULT_CACHE_MAX_SIZE with an ALTER SYSTEM statement or you can specify this parameter in the text initialization parameter file. In each case, the value is rounded up to the nearest multiple of 32K.

If RESULT_CACHE_MAX_SIZE is 0 upon instance startup, the result cache is disabled. To reenable it you must set RESULT_CACHE_MAX_SIZE to a nonzero value (or remove this parameter from the text initialization parameter file to get the default maximum size) and then restart the database.

Note that after starting the database with the result cache disabled, if you use an ALTER SYSTEM statement to set RESULT_CACHE_MAX_SIZE to a nonzero value but do not restart the database, querying the value of the RESULT_CACHE_MAX_SIZE parameter returns a nonzero value even though the result cache is still disabled. The value of RESULT_CACHE_MAX_SIZE is therefore not the most reliable way to determine if the result cache is enabled. You can use the following query instead:

```
SELECT dbms_result_cache.status() FROM dual;

DBMS_RESULT_CACHE.STATUS()
---------------------------------------------
ENABLED
```

The result cache takes its memory from the shared pool, so if you increase the maximum result cache size, consider also increasing the shared pool size.

The view V$RESULT_CACHE_STATISTICS and the PL/SQL package procedure DBMS_RESULT_CACHE.MEMORY_REPORT display information to help you determine the amount of memory currently allocated to the result cache.

The PL/SQL package function DBMS_RESULT_CACHE.FLUSH clears the result cache and releases all the memory back to the shared pool.

See Also:

- *Oracle Database Performance Tuning Guide* for more information about the result cache
- *Oracle Database PL/SQL Packages and Types Reference* for more information about the `DBMS_RESULT_CACHE` package procedures and functions.
- *Oracle Database Reference* for more information about the `V$RESULT_CACHE_STATISTICS` view.
- *Oracle Real Application Clusters Administration and Deployment Guide* for information on setting `RESULT_CACHE_MAX_SIZE` for a cluster database.

Specifying Miscellaneous SGA Initialization Parameters

You can set a few additional initialization parameters to control how the SGA uses memory.

Physical Memory The `LOCK_SGA` parameter, when set to `TRUE`, locks the entire SGA into physical memory. This parameter cannot be used in conjunction with automatic memory management or automatic shared memory management.

SGA Starting Address The `SHARED_MEMORY_ADDRESS` and `HI_SHARED_MEMORY_ADDRESS` parameters specify the SGA's starting address at runtime. These parameters are rarely used. For 64-bit platforms, `HI_SHARED_MEMORY_ADDRESS` specifies the high order 32 bits of the 64-bit address.

Extended Buffer Cache Mechanism The `USE_INDIRECT_DATA_BUFFERS` parameter enables the use of the extended buffer cache mechanism for 32-bit platforms that can support more than 4 GB of physical memory. On platforms that do not support this much physical memory, this parameter is ignored. This parameter cannot be used in conjunction with automatic memory management or automatic shared memory management.

See Also:

- *Oracle Database Reference* for more information on these initialization parameters
- "Using Automatic Memory Management" on page 5-3
- "Using Automatic Shared Memory Management" on page 5-7

Using Automatic PGA Memory Management

By default, Oracle Database automatically and globally manages the total amount of memory dedicated to the instance PGA. You can control this amount by setting the initialization parameter `PGA_AGGREGATE_TARGET`. Oracle Database then tries to ensure that the total amount of PGA memory allocated across all database server processes and background processes never exceeds this target.

If you create your database with DBCA, you can specify a value for the total instance PGA. DBCA then sets the `PGA_AGGREGATE_TARGET` initialization parameters in the server parameter file (`SPFILE`) that it creates. If you do not specify the total instance PGA, DBCA chooses a reasonable default.

If you create the database with the `CREATE DATABASE` SQL statement and a text initialization parameter file, you can provide a value for `PGA_AGGREGATE_TARGET`. If you omit this parameter, the database chooses a default value.

With automatic PGA memory management, sizing of SQL work areas for all dedicated server sessions is automatic and all `*_AREA_SIZE` initialization parameters are ignored for these sessions. At any given time, the total amount of PGA memory available to active work areas on the instance is automatically derived from the parameter `PGA_AGGREGATE_TARGET`. This amount is set to the value of `PGA_AGGREGATE_TARGET` minus the PGA memory allocated for other purposes (for example, session memory). The resulting PGA memory is then allotted to individual active work areas based on their specific memory requirements.

There are dynamic performance views that provide PGA memory use statistics. Most of these statistics are enabled when `PGA_AGGREGATE_TARGET` is set.

- Statistics on allocation and use of work area memory can be viewed in the following dynamic performance views:

  ```
  V$SYSSTAT
  V$SESSTAT
  V$PGASTAT
  V$SQL_WORKAREA
  V$SQL_WORKAREA_ACTIVE
  ```

- The following three columns in the `V$PROCESS` view report the PGA memory allocated and used by an Oracle Database process:

  ```
  PGA_USED_MEM
  PGA_ALLOCATED_MEM
  PGA_MAX_MEM
  ```

Note: The automatic PGA memory management method applies to work areas allocated by both dedicated and shared server process. See *Oracle Database Concepts* for information about PGA memory allocation in dedicated and shared server modes.

See Also:

- *Oracle Database Reference* for information about views mentioned in this section
- *Oracle Database Performance Tuning Guide* for information about using these views

Using Manual PGA Memory Management

Oracle Database supports manual PGA memory management, in which you manually tune SQL work areas.

In releases earlier than Oracle Database 10*g*, the database administrator controlled the maximum size of SQL work areas by setting the following parameters: `SORT_AREA_SIZE`, `HASH_AREA_SIZE`, `BITMAP_MERGE_AREA_SIZE` and `CREATE_BITMAP_AREA_SIZE`. Setting these parameters is difficult, because the maximum work area size is ideally selected from the data input size and the total number of work areas active in the system. These two factors vary greatly from one work area to another and from one time to another. Thus, the various `*_AREA_SIZE` parameters are difficult to tune under the best of circumstances.

For this reason, Oracle strongly recommends that you leave automatic PGA memory management enabled.

If you decide to tune SQL work areas manually, you must set the `WORKAREA_SIZE_POLICY` initialization parameter to `MANUAL`.

Note: The initialization parameter `WORKAREA_SIZE_POLICY` is a session- and system-level parameter that can take only two values: `MANUAL` or `AUTO`. The default is `AUTO`. You can set `PGA_AGGREGATE_TARGET`, and then switch back and forth from auto to manual memory management mode. When `WORKAREA_SIZE_POLICY` is set to `AUTO`, your settings for `*_AREA_SIZE` parameters are ignored.

Memory Management Reference

This section contains the following reference topics for memory management:

- Platforms That Support Automatic Memory Management
- Memory Management Data Dictionary Views

Platforms That Support Automatic Memory Management

The following platforms support automatic memory management—the Oracle Database ability to automatically tune the sizes of the SGA and PGA, redistributing memory from one to the other on demand to optimize performance:

- Linux
- Solaris
- Windows
- HP-UX
- AIX

Memory Management Data Dictionary Views

The following dynamic performance views provide information on memory management:

View	Description
`V$SGA`	Displays summary information about the system global area (SGA).
`V$SGAINFO`	Displays size information about the SGA, including the sizes of different SGA components, the granule size, and free memory.
`V$SGASTAT`	Displays detailed information about how memory is allocated within the shared pool, large pool, Java pool, and Streams pool.

View	Description
V$PGASTAT	Displays PGA memory usage statistics as well as statistics about the automatic PGA memory manager when it is enabled (that is, when PGA_AGGREGATE_TARGET is set). Cumulative values in V$PGASTAT are accumulated since instance startup.
V$MEMORY_DYNAMIC_COMPONENTS	Displays information on the current size of all automatically tuned and static memory components, with the last operation (for example, grow or shrink) that occurred on each.
V$SGA_DYNAMIC_COMPONENTS	Displays the current sizes of all SGA components, and the last operation for each component.
V$SGA_DYNAMIC_FREE_MEMORY	Displays information about the amount of SGA memory available for future dynamic SGA resize operations.
V$MEMORY_CURRENT_RESIZE_OPS	Displays information about resize operations that are currently in progress. A resize operation is an enlargement or reduction of the SGA, the instance PGA, or a dynamic SGA component.
V$SGA_CURRENT_RESIZE_OPS	Displays information about dynamic SGA component resize operations that are currently in progress.
V$MEMORY_RESIZE_OPS	Displays information about the last 800 completed memory component resize operations, including automatic grow and shrink operations for SGA_TARGET and PGA_AGGREGATE_TARGET.
V$SGA_RESIZE_OPS	Displays information about the last 800 completed SGA component resize operations.
V$MEMORY_TARGET_ADVICE	Displays information that helps you tune MEMORY_TARGET if you enabled automatic memory management.
V$SGA_TARGET_ADVICE	Displays information that helps you tune SGA_TARGET.
V$PGA_TARGET_ADVICE	Displays information that helps you tune PGA_AGGREGATE_TARGET.

See Also: *Oracle Database Reference* for detailed information on memory management views.

6 Managing Users and Securing the Database

This chapter briefly discusses the creation and management of database users, with special attention to the importance of establishing security policies to protect your database, and provides cross-references to the appropriate security documentation.

The following topics are contained in this chapter:

The Importance of Establishing a Security Policy for Your Database

It is important to develop a security policy for every database. The security policy establishes methods for protecting your database from accidental or malicious destruction of data or damage to the database infrastructure.

Each database can have an administrator, referred to as the security administrator, who is responsible for implementing and maintaining the database security policy If the database system is small, the database administrator can have the responsibilities of the security administrator. However, if the database system is large, a designated person or group of people may have sole responsibility as security administrator.

For information about establishing security policies for your database, see *Oracle Database Security Guide*.

Managing Users and Resources

To connect to the database, each user must specify a valid user name that has been previously defined to the database. An account must have been established for the user, with information about the user being stored in the data dictionary.

When you create a database user (account), you specify the following attributes of the user:

- User name
- Authentication method
- Default tablespace
- Temporary tablespace

- Other tablespaces and quotas
- User profile

To learn how to create and manage users, see *Oracle Database Security Guide*.

Managing User Privileges and Roles

Privileges and roles are used to control user access to data and the types of SQL statements that can be executed. The table that follows describes the three types of privileges and roles:

Type	Description
System privilege	A system-defined privilege usually granted only by administrators. These privileges allow users to perform specific database operations.
Object privilege	A system-defined privilege that controls access to a specific object.
Role	A collection of privileges and other roles. Some system-defined roles exist, but most are created by administrators. Roles group together privileges and other roles, which facilitates the granting of multiple privileges and roles to users.

Privileges and roles can be granted to other users by users who have been granted the privilege to do so. The granting of roles and privileges starts at the administrator level. At database creation, the administrative user `SYS` is created and granted all system privileges and predefined Oracle Database roles. User `SYS` can then grant privileges and roles to other users, and also grant those users the right to grant specific privileges to others.

To learn how to administer privileges and roles for users, see *Oracle Database Security Guide*.

Auditing Database Use

You can monitor and record selected user database actions, including those performed by administrators. There are several reasons why you might want to implement database auditing. Complete background information and instructions for database auditing are found in *Oracle Database Security Guide*.

Predefined User Accounts

Oracle Database includes a number of predefined user accounts. The three types of predefined accounts are:

- Administrative accounts (`SYS`, `SYSTEM`, `SYSMAN`, and `DBSNMP`)

  `SYS` and `SYSTEM` are described in "Database Administrator Security and Privileges" on page 1-9. `SYSMAN` is used to perform Oracle Enterprise Manager administration tasks. The management agent of Enterprise Manager uses the `DBSNMP` account to monitor and manage the database. You must not delete these accounts.

- Sample schema accounts

These accounts are used for examples in Oracle Database documentation and instructional materials. Examples are `HR`, `SH`, and `OE`. You must unlock these accounts and reset their passwords before using them.

- Internal accounts.

  These accounts are created so that individual Oracle Database features or components can have their own schemas. You must not delete internal accounts, and you must not attempt to log in with them.

> **See Also:** *Oracle Database 2 Day + Security Guide* for a table of predefined accounts.

7 Monitoring Database Operations

It is important that you monitor the operation of your database on a regular basis. Doing so not only informs you of errors that have not yet come to your attention but also gives you a better understanding of the normal operation of your database. Being familiar with normal behavior in turn helps you recognize when something is wrong.

This chapter describes some of the options available to you for monitoring the operation of your database. It contains the following sections:

- Monitoring Errors and Alerts
- Monitoring Performance

Monitoring Errors and Alerts

The following sections explain how to monitor database errors and alerts. It contains the following topics:

- Monitoring Errors with Trace Files and the Alert Log
- Monitoring with Server-Generated Alerts

Note: The easiest and best way to monitor the database for errors and alerts is with the Database Home page in Enterprise Manager. This section provides alternate methods for monitoring, using data dictionary views, PL/SQL packages, and other command-line facilities.

Monitoring Errors with Trace Files and the Alert Log

Each server and background process can write to an associated **trace file**. When an internal error is detected by a process, it dumps information about the error to its trace file. Some of the information written to a trace file is intended for the database administrator, and other information is for Oracle Support Services. Trace file information is also used to tune applications and instances.

Note: Critical errors also create incidents and incident dumps in the Automatic Diagnostic Repository. See Chapter 8, "Managing Diagnostic Data" on page 8-1 for more information.

The **alert log** is a chronological log of messages and errors, and includes the following items:

- All internal errors (`ORA-600`), block corruption errors (`ORA-1578`), and deadlock errors (`ORA-60`) that occur
- Administrative operations, such as `CREATE`, `ALTER`, and `DROP` statements and `STARTUP`, `SHUTDOWN`, and `ARCHIVELOG` statements
- Messages and errors relating to the functions of shared server and dispatcher processes
- Errors occurring during the automatic refresh of a materialized view
- The values of all initialization parameters that had nondefault values at the time the database and instance start

Oracle Database uses the alert log to record these operations as an alternative to displaying the information on an operator's console (although some systems also display information on the console). If an operation is successful, a "completed" message is written in the alert log, along with a timestamp.

The alert log is maintained as both an XML-formatted file and a text-formatted file. You can view either format of the alert log with any text editor or you can use the ADRCI utility to view the XML-formatted version of the file with the XML tags stripped.

Check the alert log and trace files of an instance periodically to learn whether the background processes have encountered errors. For example, when the log writer process (LGWR) cannot write to a member of a log group, an error message indicating the nature of the problem is written to the LGWR trace file and the alert log. Such an error message means that a media or I/O problem has occurred and should be corrected immediately.

Oracle Database also writes values of initialization parameters to the alert log, in addition to other important statistics.

The alert log and all trace files for background and server processes are written to the Automatic Diagnostic Repository, the location of which is specified by the `DIAGNOSTIC_DEST` initialization parameter. The names of trace files are operating system specific, but each file usually includes the name of the process writing the file (such as LGWR and RECO).

See Also:

- Chapter 8, "Managing Diagnostic Data" on page 8-1 for information on the Automatic Diagnostic Repository.
- "Alert Log" on page 8-5 for additional information about the alert log.
- "Viewing the Alert Log" on page 8-18
- *Oracle Database Utilities* for information on the ADRCI utility.
- Your operating system specific Oracle documentation for information about the names of trace files

Controlling the Size of Trace Files

You can control the maximum size of all trace files (excluding the alert log) using the initialization parameter `MAX_DUMP_FILE_SIZE`, which limits the file to the specified number of operating system blocks. To control the size of an alert log, you must manually delete the file when you no longer need it. Otherwise the database continues to append to the file.

You can safely delete the alert log while the instance is running, although you should consider making an archived copy of it first. This archived copy could prove valuable if you should have a future problem that requires investigating the history of an instance.

Controlling When Oracle Database Writes to Trace Files

Background processes always write to a trace file when appropriate. In the case of the ARC*n* background process, it is possible, through an initialization parameter, to control the amount and type of trace information that is produced. This behavior is described in "Controlling Trace Output Generated by the Archivelog Process" on page 11-13. Other background processes do not have this flexibility.

Trace files are written on behalf of server processes whenever critical errors occur. Additionally, setting the initialization parameter `SQL_TRACE = TRUE` causes the SQL trace facility to generate performance statistics for the processing of all SQL statements for an instance and write them to the Automatic Diagnostic Repository.

Optionally, you can request that trace files be generated for server processes. Regardless of the current value of the `SQL_TRACE` initialization parameter, each session can enable or disable trace logging on behalf of the associated server process by using the SQL statement `ALTER SESSION SET SQL_TRACE`. This example enables the SQL trace facility for a specific session:

```
ALTER SESSION SET SQL_TRACE TRUE;
```

Use the `DBMS_SESSION` or the `DBMS_MONITOR` packages if you want to control SQL tracing for a session.

Caution: The SQL trace facility for server processes can cause significant system overhead resulting in severe performance impact, so you should enable this feature only when collecting statistics.

See Also:

- Chapter 8, "Managing Diagnostic Data" on page 8-1 for more information on how the database handles critical errors, otherwise known as "incidents."

Reading the Trace File for Shared Server Sessions

If shared server is enabled, each session using a dispatcher is routed to a shared server process, and trace information is written to the server trace file only if the session has enabled tracing (or if an error is encountered). Therefore, to track tracing for a specific session that connects using a dispatcher, you might have to explore several shared server trace files. To help you, Oracle provides a command line utility program, `trcsess`, which consolidates all trace information pertaining to a user session in one place and orders the information by time.

See Also: *Oracle Database Performance Tuning Guide* for information about using the SQL trace facility and using `TKPROF` and `trcsess` to interpret the generated trace files

Monitoring with Server-Generated Alerts

A server-generated alert is a notification from the Oracle Database server of an impending problem. The notification may contain suggestions for correcting the problem. Notifications are also provided when the problem condition has been cleared.

Alerts are automatically generated when a problem occurs or when data does not match expected values for metrics, such as the following:

- Physical Reads Per Second
- User Commits Per Second
- SQL Service Response Time

Server-generated alerts can be based on threshold levels or can issue simply because an event has occurred. Threshold-based alerts can be triggered at both threshold warning and critical levels. The value of these levels can be customer-defined or internal values, and some alerts have default threshold levels which you can change if appropriate. For example, by default a server-generated alert is generated for tablespace space usage when the percentage of space usage exceeds either the 85% warning or 97% critical threshold level. Examples of alerts not based on threshold levels are:

- `Snapshot Too Old`
- `Resumable Session Suspended`
- `Recovery Area Space Usage`

An alert message is sent to the predefined persistent queue `ALERT_QUE` owned by the user `SYS`. Oracle Enterprise Manager reads this queue and provides notifications about outstanding server alerts, and sometimes suggests actions for correcting the problem. The alerts are displayed on the Enterprise Manager Database Home page and can be configured to send email or pager notifications to selected administrators. If an alert cannot be written to the alert queue, a message about the alert is written to the Oracle Database alert log.

Background processes periodically flush the data to the Automatic Workload Repository to capture a history of metric values. The alert history table and `ALERT_QUE` are purged automatically by the system at regular intervals.

Setting and Retrieving Thresholds for Server-Generated Alerts

You can view and change threshold settings for the server alert metrics using the `SET_THRESHOLD` and `GET_THRESHOLD` procedures of the `DBMS_SERVER_ALERTS` PL/SQL package. Examples of using these procedures are provided in the following sections:

- Setting Threshold Levels
- Retrieving Threshold Information

Note: The most convenient way to set and retrieve threshold values is to use the graphical interface of Enterprise Manager. See *Oracle Database 2 Day DBA* for instructions.

See Also: *Oracle Database PL/SQL Packages and Types Reference* for information about the `DBMS_SERVER_ALERTS` package

Setting Threshold Levels The following example shows how to set thresholds with the `SET_THRESHOLD` procedure for CPU time for each user call for an instance:

```
DBMS_SERVER_ALERT.SET_THRESHOLD(
 DBMS_SERVER_ALERT.CPU_TIME_PER_CALL, DBMS_SERVER_ALERT.OPERATOR_GE, '8000',
 DBMS_SERVER_ALERT.OPERATOR_GE, '10000', 1, 2, 'inst1',
 DBMS_SERVER_ALERT.OBJECT_TYPE_SERVICE, 'main.regress.rdbms.dev.us.oracle.com');
```

In this example, a warning alert is issued when CPU time exceeds 8000 microseconds for each user call and a critical alert is issued when CPU time exceeds 10,000 microseconds for each user call. The arguments include:

- `CPU_TIME_PER_CALL` specifies the metric identifier. For a list of support metrics, see *Oracle Database PL/SQL Packages and Types Reference*.
- The observation period is set to 1 minute. This period specifies the number of minutes that the condition must deviate from the threshold value before the alert is issued.
- The number of consecutive occurrences is set to 2. This number specifies how many times the metric value must violate the threshold values before the alert is generated.
- The name of the instance is set to `inst1`.
- The constant `DBMS_ALERT.OBJECT_TYPE_SERVICE` specifies the object type on which the threshold is set. In this example, the service name is `main.regress.rdbms.dev.us.oracle.com`.

Retrieving Threshold Information To retrieve threshold values, use the `GET_THRESHOLD` procedure. For example:

```
DECLARE
 warning_operator         BINARY_INTEGER;
 warning_value            VARCHAR2(60);
 critical_operator        BINARY_INTEGER;
 critical_value           VARCHAR2(60);
 observation_period       BINARY_INTEGER;
 consecutive_occurrences  BINARY_INTEGER;
BEGIN
 DBMS_SERVER_ALERT.GET_THRESHOLD(
 DBMS_SERVER_ALERT.CPU_TIME_PER_CALL, warning_operator, warning_value,
    critical_operator, critical_value, observation_period,
    consecutive_occurrences, 'inst1',
 DBMS_SERVER_ALERT.OBJECT_TYPE_SERVICE, 'main.regress.rdbms.dev.us.oracle.com');
 DBMS_OUTPUT.PUT_LINE('Warning operator:       ' || warning_operator);
 DBMS_OUTPUT.PUT_LINE('Warning value:          ' || warning_value);
 DBMS_OUTPUT.PUT_LINE('Critical operator:      ' || critical_operator);
 DBMS_OUTPUT.PUT_LINE('Critical value:         ' || critical_value);
 DBMS_OUTPUT.PUT_LINE('Observation_period:     ' || observation_period);
 DBMS_OUTPUT.PUT_LINE('Consecutive occurrences:' || consecutive_occurrences);
END;
/
```

You can also check specific threshold settings with the `DBA_THRESHOLDS` view. For example:

```
SELECT metrics_name, warning_value, critical_value, consecutive_occurrences
   FROM DBA_THRESHOLDS
   WHERE metrics_name LIKE '%CPU Time%';
```

Viewing Server-Generated Alerts

The easiest way to view server-generated alerts is by accessing the Database Home page of Enterprise Manager. The following discussion presents other methods of viewing these alerts.

If you use your own tool rather than Enterprise Manager to display alerts, you must subscribe to the `ALERT_QUE`, read the `ALERT_QUE`, and display an alert notification after setting the threshold levels for an alert. To create an agent and subscribe the agent to the `ALERT_QUE`, use the `CREATE_AQ_AGENT` and `ADD_SUBSCRIBER` procedures of the `DBMS_AQADM` package.

Next you must associate a database user with the subscribing agent, because only a user associated with the subscribing agent can access queued messages in the secure `ALERT_QUE`. You must also assign the enqueue privilege to the user. Use the `ENABLE_DB_ACCESS` and `GRANT_QUEUE_PRIVILEGE` procedures of the `DBMS_AQADM` package.

Optionally, you can register with the `DBMS_AQ.REGISTER` procedure to receive an asynchronous notification when an alert is enqueued to `ALERT_QUE`. The notification can be in the form of email, HTTP post, or PL/SQL procedure.

To read an alert message, you can use the `DBMS_AQ.DEQUEUE` procedure or `OCIAQDeq` call. After the message has been dequeued, use the `DBMS_SERVER_ALERT.EXPAND_MESSAGE` procedure to expand the text of the message.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for information about the `DBMS_AQ`, and `DBMS_AQADM` packages

Server-Generated Alerts Data Dictionary Views

The following data dictionary views provide information about server-generated alerts.

View	Description
`DBA_THRESHOLDS`	Lists the threshold settings defined for the instance
`DBA_OUTSTANDING_ALERTS`	Describes the outstanding alerts in the database
`DBA_ALERT_HISTORY`	Lists a history of alerts that have been cleared
`V$ALERT_TYPES`	Provides information such as group and type for each alert
`V$METRICNAME`	Contains the names, identifiers, and other information about the system metrics
`V$METRIC`	Contains system-level metric values
`V$METRIC_HISTORY`	Contains a history of system-level metric values

> **See Also:** *Oracle Database Reference* for information on static data dictionary views and dynamic performance views

Monitoring Performance

Monitoring database performance is covered in detail in *Oracle Database Performance Tuning Guide*. Here are some additional topics with details that are not covered in that guide:

- Monitoring Locks
- Monitoring Wait Events

- Performance Monitoring Data Dictionary Views

Monitoring Locks

Locks are mechanisms that prevent destructive interaction between transactions accessing the same resource. The resources can be either user objects, such as tables and rows, or system objects not visible to users, such as shared data structures in memory and data dictionary rows. Oracle Database automatically obtains and manages necessary locks when executing SQL statements, so you need not be concerned with such details. However, the database also lets you lock data manually.

A deadlock can occur when two or more users are waiting for data locked by each other. Deadlocks prevent some transactions from continuing to work. Oracle Database automatically detects deadlock situations and resolves them by rolling back one of the statements involved in the deadlock, thereby releasing one set of the conflicting row locks.

Oracle Database is designed to avoid deadlocks, and they are not common. Most often they occur when transactions explicitly override the default locking of the database. Deadlocks can affect the performance of your database, so Oracle provides some scripts and views that enable you to monitor locks.

The `utllockt.sql` script displays, in a tree fashion, the sessions in the system that are waiting for locks and the locks that they are waiting for. The location of this script file is operating system dependent.

A second script, `catblock.sql`, creates the lock views that `utllockt.sql` needs, so you must run it before running `utllockt.sql`.

See Also:

- "Performance Monitoring Data Dictionary Views" on page 7-7
- *Oracle Database Concepts* contains more information about locks.

Monitoring Wait Events

Wait events are statistics that are incremented by a server process to indicate that it had to wait for an event to complete before being able to continue processing. A session could wait for a variety of reasons, including waiting for more input, waiting for the operating system to complete a service such as a disk write, or it could wait for a lock or latch.

When a session is waiting for resources, it is not doing any useful work. A large number of waits is a source of concern. Wait event data reveals various symptoms of problems that might be affecting performance, such as latch contention, buffer contention, and I/O contention.

Oracle provides several views that display wait event statistics. A discussion of these views and their role in instance tuning is contained in *Oracle Database Performance Tuning Guide*.

Performance Monitoring Data Dictionary Views

This section lists some of the data dictionary views that you can use to monitor an Oracle Database instance. These views are general in their scope. Other views, more specific to a process, are discussed in the section of this book where the process is described.

View	Description
`V$LOCK`	Lists the locks currently held by Oracle Database and outstanding requests for a lock or latch
`DBA_BLOCKERS`	Displays a session if it is holding a lock on an object for which another session is waiting
`DBA_WAITERS`	Displays a session if it is waiting for a locked object
`DBA_DDL_LOCKS`	Lists all DDL locks held in the database and all outstanding requests for a DDL lock
`DBA_DML_LOCKS`	Lists all DML locks held in the database and all outstanding requests for a DML lock
`DBA_LOCK`	Lists all locks or latches held in the database and all outstanding requests for a lock or latch
`DBA_LOCK_INTERNAL`	Displays a row for each lock or latch that is being held, and one row for each outstanding request for a lock or latch
`V$LOCKED_OBJECT`	Lists all locks acquired by every transaction on the system
`V$SESSION_WAIT`	Lists the resources or events for which active sessions are waiting
`V$SYSSTAT`	Contains session statistics
`V$RESOURCE_LIMIT`	Provides information about current and maximum global resource utilization for some system resources
`V$SQLAREA`	Contains statistics about shared SQL area and contains one row for each SQL string. Also provides statistics about SQL statements that are in memory, parsed, and ready for execution
`V$LATCH`	Contains statistics for nonparent latches and summary statistics for parent latches

See Also: *Oracle Database Reference* for detailed descriptions of these views

8 Managing Diagnostic Data

Beginning with Release 11*g*, Oracle Database includes an advanced fault diagnosability infrastructure for collecting and managing diagnostic data. **Diagnostic data** includes the trace files, dumps, and core files that are also present in previous releases, plus new types of diagnostic data that enable customers and Oracle Support to identify, investigate, track, and resolve problems quickly and effectively.

This chapter explains how to:

- View and manage diagnostic data generated by the database if a critical error or data corruption occurs.
- Investigate critical errors and data corruptions, and gather additional diagnostic data.
- Use an automated mechanism to upload first-failure diagnostic data to Oracle Support.
- Resolve some critical errors and data corruptions with Oracle advisors and other self-service facilities.

The following topics are covered:

- About the Oracle Database Fault Diagnosability Infrastructure
- Investigating, Reporting, and Resolving a Problem
- Viewing Problems with the Enterprise Manager Support Workbench
- Creating a User-Reported Problem
- Viewing the Alert Log
- Finding Trace Files
- Running Health Checks with Health Monitor
- Repairing SQL Failures with the SQL Repair Advisor
- Repairing Data Corruptions with the Data Recovery Advisor
- Creating, Editing, and Uploading Custom Incident Packages

About the Oracle Database Fault Diagnosability Infrastructure

This section contains background information on the Oracle Database fault diagnosability infrastructure. It contains the following topics:

- Fault Diagnosability Infrastructure Overview
- About Incidents and Problems

- Fault Diagnosability Infrastructure Components
- Structure, Contents, and Location of the Automatic Diagnostic Repository

Fault Diagnosability Infrastructure Overview

The fault diagnosability infrastructure aids in preventing, detecting, diagnosing, and resolving problems. The problems that are targeted in particular are critical errors such as those caused by database code bugs, metadata corruption, and customer data corruption.

When a critical error occurs, it is assigned an incident number, and diagnostic data for the error (such as trace files) are immediately captured and tagged with this number. The data is then stored in the Automatic Diagnostic Repository (ADR)—a file-based repository outside the database—where it can later be retrieved by incident number and analyzed.

The goals of the fault diagnosability infrastructure are the following:

- First-failure diagnosis
- Problem prevention
- Limiting damage and interruptions after a problem is detected
- Reducing problem diagnostic time
- Reducing problem resolution time
- Simplifying customer interaction with Oracle Support

The keys to achieving these goals are the following technologies:

- **Automatic capture of diagnostic data upon first failure**—For critical errors, the ability to capture error information at first-failure greatly increases the chance of a quick problem resolution and reduced downtime. An always-on memory-based tracing system proactively collects diagnostic data from many database components, and can help isolate root causes of problems. Such proactive diagnostic data is similar to the data collected by airplane "black box" flight recorders. When a problem is detected, alerts are generated and the fault diagnosability infrastructure is activated to capture and store diagnostic data. The data is stored in a repository that is outside the database (and therefore available when the database is down), and is easily accessible with command line utilities and Enterprise Manager.
- **Standardized trace formats**—Standardizing trace formats across all database components enables DBAs and Oracle Support personnel to use a single set of tools for problem analysis. Problems are more easily diagnosed, and downtime is reduced.
- **Health checks**—Upon detecting a critical error, the fault diagnosability infrastructure can run one or more health checks to perform deeper analysis of a critical error. Health check results are then added to the other diagnostic data collected for the error. Individual health checks look for data block corruptions, undo and redo corruption, data dictionary corruption, and more. As a DBA, you can manually invoke these health checks, either on a regular basis or as required.
- **Incident packaging service (IPS) and incident packages**—The IPS enables you to automatically and easily gather the diagnostic data—traces, dumps, health check reports, and more—pertaining to a critical error and package the data into a zip file for transmission to Oracle Support. Because all diagnostic data relating to a critical error are tagged with that error's incident number, you do not have to

search through trace files and other files to determine the files that are required for analysis; the incident packaging service identifies the required files automatically and adds them to the zip file. Before creating the zip file, the IPS first collects diagnostic data into an intermediate logical structure called an incident package (package). Packages are stored in the Automatic Diagnostic Repository. If you choose to, you can access this intermediate logical structure, view and modify its contents, add or remove additional diagnostic data at any time, and when you are ready, create the zip file from the package and upload it to Oracle Support.

- **Data Recovery Advisor**—The Data Recovery Advisor integrates with database health checks and RMAN to display data corruption problems, assess the extent of each problem (critical, high priority, low priority), describe the impact of a problem, recommend repair options, conduct a feasibility check of the customer-chosen option, and automate the repair process.
- **SQL Test Case Builder**—For many SQL-related problems, obtaining a reproducible test case is an important factor in problem resolution speed. The SQL Test Case Builder automates the sometimes difficult and time-consuming process of gathering as much information as possible about the problem and the environment in which it occurred. After quickly gathering this information, you can upload it to Oracle Support to enable support personnel to easily and accurately reproduce the problem.

See Also:

- *Oracle Database Performance Tuning Guide* for more information on SQL Test Case Builder

About Incidents and Problems

To facilitate diagnosis and resolution of critical errors, the fault diagnosability infrastructure introduces two concepts for Oracle Database: problems and incidents.

A **problem** is a critical error in the database. Critical errors manifest as internal errors, such as `ORA-00600`, or other severe errors, such as `ORA-07445` (operating system exception) or `ORA-04031` (out of memory in the shared pool). Problems are tracked in the ADR. Each problem has a *problem key*, which is a text string that describes the problem. It includes an error code (such as `ORA 600`) and in some cases, one or more error parameters.

An **incident** is a single occurrence of a problem. When a problem (critical error) occurs multiple times, an incident is created for each occurrence. Incidents are timestamped and tracked in the Automatic Diagnostic Repository (ADR). Each incident is identified by a numeric incident ID, which is unique within the ADR. When an incident occurs, the database:

- Makes an entry in the alert log.
- Sends an *incident alert* to Oracle Enterprise Manager (Enterprise Manager).
- Gathers first-failure diagnostic data about the incident in the form of dump files (incident dumps).
- Tags the incident dumps with the incident ID.
- Stores the incident dumps in an ADR subdirectory created for that incident.

Diagnosis and resolution of a critical error usually starts with an incident alert. The incident alert is displayed on the Enterprise Manager Database Home page. You can then view the problem and its associated incidents with Enterprise Manager or with the ADRCI command-line utility.

Incident Flood Control

It is conceivable that a problem could generate dozens or perhaps hundreds of incidents in a short period of time. This would generate too much diagnostic data, which would consume too much space in the ADR and could possibly slow down your efforts to diagnose and resolve the problem. For these reasons, the fault diagnosability infrastructure applies *flood control* to incident generation after certain thresholds are reached. A **flood-controlled incident** is an incident that generates an alert log entry, is recorded in the ADR, but does not generate incident dumps. Flood-controlled incidents provide a way of informing you that a critical error is ongoing, without overloading the system with diagnostic data. You can choose to view or hide flood-controlled incidents when viewing incidents with Enterprise Manager or ADRCI.

Threshold levels for incident flood control are predetermined and cannot be changed. They are defined as follows:

- After five incidents occur for the same problem key in one hour, subsequent incidents for this problem key are flood-controlled. Normal (non-flood-controlled) recording of incidents for that problem key begins again in the next hour.
- After 25 incidents occur for the same problem key in one day, subsequent incidents for this problem key are flood-controlled. Normal recording of incidents for that problem key begins again on the next day.

In addition, after 50 incidents for the same problem key occur in one hour, or 250 incidents for the same problem key occur in one day, subsequent incidents for this problem key are not recorded at all in the ADR. In these cases, the database writes a message to the alert log indicating that no further incidents will be recorded. As long as incidents continue to be generated for this problem key, this message is added to the alert log every ten minutes until the hour or the day expires. Upon expiration of the hour or day, normal recording of incidents for that problem key begins again.

See Also:

- "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16
- "Investigating, Reporting, and Resolving a Problem" on page 8-9
- "ADRCI Command-Line Utility" on page 8-6

Fault Diagnosability Infrastructure Components

The following are the key components of the fault diagnosability infrastructure:

- Automatic Diagnostic Repository (ADR)
- Alert Log
- Trace Files, Dumps, and Core Files
- Other ADR Contents
- Enterprise Manager Support Workbench
- ADRCI Command-Line Utility

Automatic Diagnostic Repository (ADR)

The ADR is a file-based repository for database diagnostic data such as traces, dumps, the alert log, health monitor reports, and more. It has a unified directory structure across multiple instances and multiple products. Beginning with Release 11*g*, the database, Automatic Storage Management (ASM), and other Oracle products or components store all diagnostic data in the ADR. Each instance of each product stores diagnostic data underneath its own home directory within the ADR. For example, in an Oracle Real Application Clusters environment with shared storage and ASM, each database instance and each ASM instance has an ADR home directory. ADR's unified directory structure, consistent diagnostic data formats across products and instances, and a unified set of tools enable customers and Oracle Support to correlate and analyze diagnostic data across multiple instances.

Note: Beginning with Release 11*g* of Oracle Database, because all diagnostic data, including the alert log, are stored in the ADR, the initialization parameters `BACKGROUND_DUMP_DEST` and `USER_DUMP_DEST` are deprecated. They are replaced by the initialization parameter `DIAGNOSTIC_DEST`, which identifies the location of the ADR.

See Also: "Structure, Contents, and Location of the Automatic Diagnostic Repository" on page 8-6 for more information on the `DIAGNOSTIC_DEST` parameter and on ADR homes.

Alert Log

The alert log is an XML file that is a chronological log of database messages and errors. It is stored in the ADR and includes messages about the following:

- Critical errors (incidents)
- Administrative operations, such as starting up or shutting down the database, recovering the database, creating or dropping a tablespace, and others.
- Errors during automatic refresh of a materialized view
- Other database events

You can view the alert log in text format (with the XML tags stripped) with Enterprise Manager and with the ADRCI utility. There is also a text-formatted version of the alert log stored in the ADR for backward compatibility. However, Oracle recommends that any parsing of the alert log contents be done with the XML-formatted version, because the text format is unstructured and may change from release to release.

See Also:

- "ADRCI Command-Line Utility" on page 8-6
- "Viewing the Alert Log" on page 8-18

Trace Files, Dumps, and Core Files

Trace files, dumps, and core files contain diagnostic data that are used to investigate problems. They are stored in the ADR.

Trace Files Each server and background process can write to an associated trace file. Trace files are updated periodically over the life of the process and can contain information on the process environment, status, activities, and errors. In addition, when a process detects a critical error, it writes information about the error to its trace file. The SQL trace facility also creates trace files, which provide performance information on individual SQL statements. You can enable SQL tracing for a session or an instance.

Trace file names are platform-dependent. Typically, database background process trace file names contain the Oracle SID, the background process name, and the operating system process number, while server process trace file names contain the Oracle SID, the string "ora", and the operating system process number. The file extension is `.trc`. An example of a server process trace file name is orcl_ora_344.trc. Trace files are sometimes accompanied by corresponding trace map (`.trm`) files, which contain structural information about trace files and are used for searching and navigation.

Oracle Database includes tools that help you analyze trace files. For more information on application tracing, SQL tracing, and tracing tools, see *Oracle Database Performance Tuning Guide*.

See Also: "Finding Trace Files" on page 8-19

Dumps A dump is a specific type of trace file. A dump is typically a one-time output of diagnostic data in response to an event (such as an incident), whereas a trace tends to be continuous output of diagnostic data. When an incident occurs, the database writes one or more dumps to the incident directory created for the incident. Incident dumps also contain the incident number in the file name.

Core Files A core file contains a memory dump, in an all-binary, port-specific format. Core file names include the string "core" and the operating system process ID. Core files are useful to Oracle Support engineers only. Core files are not found on all platforms.

Other ADR Contents

In addition to files mentioned in the previous sections, the ADR contains health monitor reports, data repair records, SQL test cases, incident packages, and more. These components are described later in the chapter.

Enterprise Manager Support Workbench

The Enterprise Manager Support Workbench (Support Workbench) is a facility that enables you to investigate, report, and in some cases, repair problems (critical errors), all with an easy-to-use graphical interface. The Support Workbench provides a self-service means for you to gather first-failure diagnostic data, obtain a support request number, and upload diagnostic data to Oracle Support with a minimum of effort and in a very short time, thereby reducing time-to-resolution for problems. The Support Workbench also recommends and provides easy access to Oracle advisors that help you repair SQL-related problems, data corruption problems, and more.

ADRCI Command-Line Utility

The ADR Command Interpreter (ADRCI) is a utility that enables you to investigate problems, view health check reports, and package and upload first-failure diagnostic data to Oracle Support, all within a command-line environment. ADRCI also enables you to view the names of the trace files in the ADR, and to view the alert log with XML tags stripped, with and without content filtering.

For more information on ADRCI, see *Oracle Database Utilities*.

Structure, Contents, and Location of the Automatic Diagnostic Repository

The Automatic Diagnostic Repository (ADR) is a directory structure that is stored outside of the database. It is therefore available for problem diagnosis when the database is down.

The ADR root directory is known as **ADR base**. Its location is set by the `DIAGNOSTIC_DEST` initialization parameter. If this parameter is omitted or left null, the database sets `DIAGNOSTIC_DEST` upon startup as follows:

- If environment variable `ORACLE_BASE` is set, `DIAGNOSTIC_DEST` is set to the directory designated by `ORACLE_BASE`.
- If environment variable `ORACLE_BASE` is not set, `DIAGNOSTIC_DEST` is set to *ORACLE_HOME*/log.

Within ADR base, there can be multiple ADR homes, where each ADR home is the root directory for all diagnostic data—traces, dumps, the alert log, and so on—for a particular instance of a particular Oracle product or component. For example, in an Oracle Real Application Clusters environment with ASM, each database instance and each ASM instance has an ADR home. All ADR homes share the same hierarchical directory structure.

The location of an ADR home is given by the following path, which starts at the ADR base directory:

```
diag/product_type/product_id/instance_id
```

Table 8–1 lists the values of the various path components for an Oracle Database instance.

Table 8–1 ADR Home Path Components for Oracle Database

Path Component	Value for Oracle Database
product_type	rdbms
product_id	*database name*
instance_id	*SID*

For example, for a database with a SID and database name both equal to orclbi, the ADR home would be in the following location:

```
ADR_base/diag/rdbms/orclbi/orclbi/
```

ADR Home Subdirectories

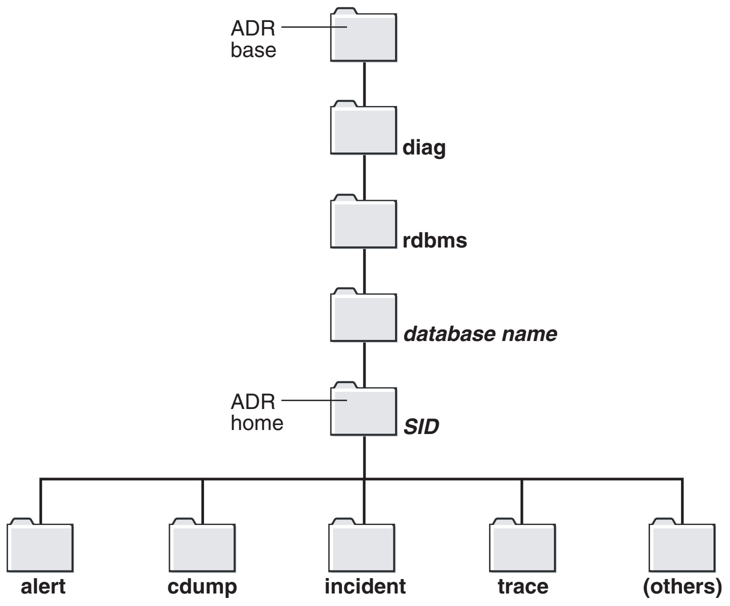
Within the ADR home directory are subdirectories where the database instance stores diagnostic data. Table 8–2 lists some of these subdirectories and their contents.

Table 8–2 ADR Home Subdirectories

Subdirectory Name	Contents
alert	The XML-formatted alert log
cdump	Core files
incident	Multiple subdirectories, where each subdirectory is named for a particular incident, and where each contains dumps pertaining only to that incident
trace	Background and server process trace files and SQL trace files
(others)	Other subdirectories of ADR home, which store incident packages, health monitor reports, and other information

Figure 8–1 illustrates the directory hierarchy of the ADR for an Oracle Database instance. Other ADR homes for other Oracle products or components (such as ASM or Oracle Net Services) can exist within this hierarchy, under the same ADR base.

Figure 8–1 ADR Directory Structure for an Oracle Database Instance



ADR in an Oracle Real Application Clusters Environment

In an Oracle Real Application Clusters (RAC) environment, each node can have ADR base on its own local storage, or ADR base can be set to a location on shared storage. The following are the advantages of the shared storage approach:

- You can use ADRCI to view aggregated diagnostic data from all instances on a single report.
- You can use the Data Recovery Advisor to help diagnose and repair corrupted data blocks, corrupted or missing files, and other data failures. (For Oracle RAC, the Data Recovery Advisor requires shared storage.)

  See *Oracle Database 2 Day DBA* for more information on the Data Recovery Advisor.

Viewing ADR Locations with the V$DIAG_INFO View

The `V$DIAG_INFO` view lists all important ADR locations.

```
SELECT * FROM V$DIAG_INFO;

INST_ID NAME                  VALUE
------- --------------------- -------------------------------------------------------------
      1 Diag Enabled          TRUE
      1 ADR Base              /u01/oracle
      1 ADR Home              /u01/oracle/diag/rdbms/orclbi/orclbi
      1 Diag Trace            /u01/oracle/diag/rdbms/orclbi/orclbi/trace
      1 Diag Alert            /u01/oracle/diag/rdbms/orclbi/orclbi/alert
      1 Diag Incident         /u01/oracle/diag/rdbms/orclbi/orclbi/incident
      1 Diag Cdump            /u01/oracle/diag/rdbms/orclbi/orclbi/cdump
      1 Health Monitor        /u01/oracle/diag/rdbms/orclbi/orclbi/hm
      1 Default Trace File    /u01/oracle/diag/rdbms/orclbi/orclbi/trace/orcl_ora_22769.trc
      1 Active Problem Count  8
```

```
1 Active Incident Count 20
```

The following table describes some of the information displayed by this view.

Table 8–3 Data in the V$DIAG_INFO View

Name	Description
ADR Base	Path of ADR base
ADR Home	Path of ADR home for the current database instance
Diag Trace	Location of background process trace files, server process trace files, SQL trace files, and the text-formatted version of the alert log
Diag Alert	Location of the XML-formatted version of the alert log
Default Trace File	Path to the trace file for the current session

Investigating, Reporting, and Resolving a Problem

This section describes how to use the Enterprise Manager Support Workbench (Support Workbench) to investigate and report a problem (critical error), and in some cases, resolve the problem. The section begins with a "roadmap" that summarizes the typical set of tasks that you must perform.

Note: The tasks described in this section are all Enterprise Manager–based. You can also accomplish all of these tasks (or their equivalents) with the `ADRCI` command-line utility, with PL/SQL packages such as `DBMS_HM` and `DBMS_SQLDIAG`, and with other software tools. See *Oracle Database Utilities* for more information on the `ADRCI` utility, and see *Oracle Database PL/SQL Packages and Types Reference* for information on PL/SQL packages.

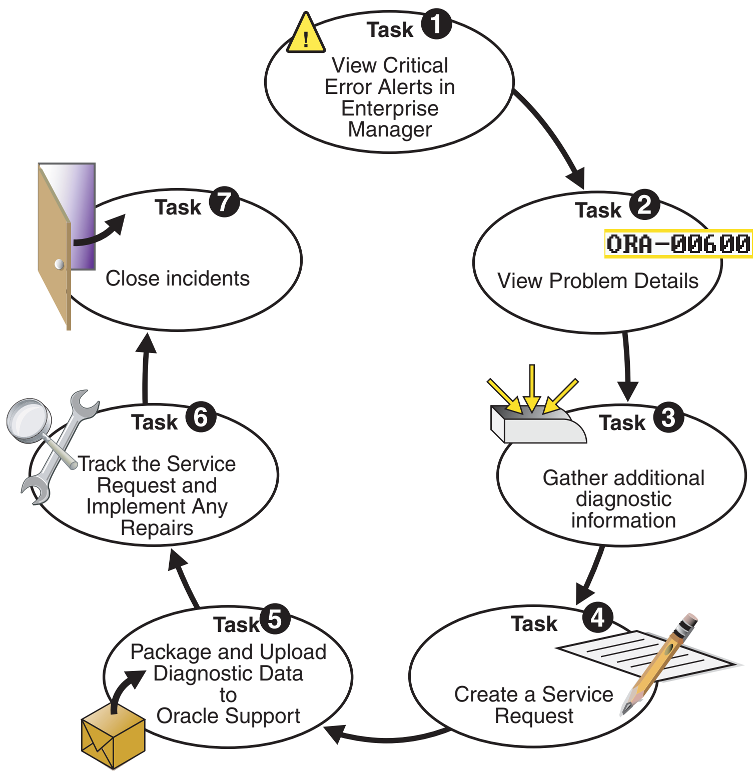
See Also: "About the Oracle Database Fault Diagnosability Infrastructure" on page 8-1 for more information on problems and their diagnostic data

Roadmap—Investigating, Reporting, and Resolving a Problem

You can begin investigating a problem by starting from the Support Workbench home page in Enterprise Manager. However, the more typical workflow begins with a critical error alert on the Database Home page. This section provides an overview of that workflow.

Figure 8–2 illustrates the tasks that you complete to investigate, report, and in some cases, resolve a problem.

Figure 8–2 Workflow for Investigating, Reporting, and Resolving a Problem


Task 1
View Critical Error Alerts in Enterprise Manager
Task 2
ORA-00600
View Problem Details
Task 3
Gather additional diagnostic information
Task 4
Create a Service Request
Task 5
Package and Upload Diagnostic Data to Oracle Support
Task 6
Track the Service Request and Implement Any Repairs
Task 7
Close incidents

The following are task descriptions. Subsequent sections provide details for each task.

- **Task 1 – View Critical Error Alerts in Enterprise Manager** on page 8-11

  Start by accessing the Database Home page in Enterprise Manager, and reviewing critical error alerts. Select an alert for which to view details, and then go to the Problem Details page.

- **Task 2 –View Problem Details** on page 8-12

  Examine the problem details and view a list of all incidents that were recorded for the problem. Display findings from any health checks that were automatically run.

- **Task 3 – (Optional) Gather Additional Diagnostic Information** on page 8-12

  Optionally run additional health checks or other diagnostics. For SQL-related errors, optionally invoke the SQL Test Case Builder, which gathers all required data related to a SQL problem and packages the information in a way that enables the problem to be reproduced at Oracle Support.

- **Task 4 – (Optional) Create a Service Request** on page 8-12

  Optionally create a service request with Oracle*MetaLink* and record the service request number with the problem information. If you skip this step, you can create a service request later, or the Support Workbench can create one for you.

- **Task 5 – Package and Upload Diagnostic Data to Oracle Support** on page 8-13

  Invoke a guided workflow (a *wizard*) that automatically packages the gathered diagnostic data for a problem and uploads the data to Oracle Support.

- **Task 6 – Track the Service Request and Implement Any Repairs** on page 8-14

  Optionally maintain an activity log for the service request in the Support Workbench. Run Oracle advisors to help repair SQL failures or corrupted data.

- **Task 7 – Close Incidents** on page 8-15

  Set status for one, some, or all incidents for the problem to Closed.

  > **See Also:** "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16

Task 1 – View Critical Error Alerts in Enterprise Manager

You begin the process of investigating problems (critical errors) by reviewing critical error alerts on the Database Home page.

To view critical error alerts:

1. Access the Database Home page in Enterprise Manager.

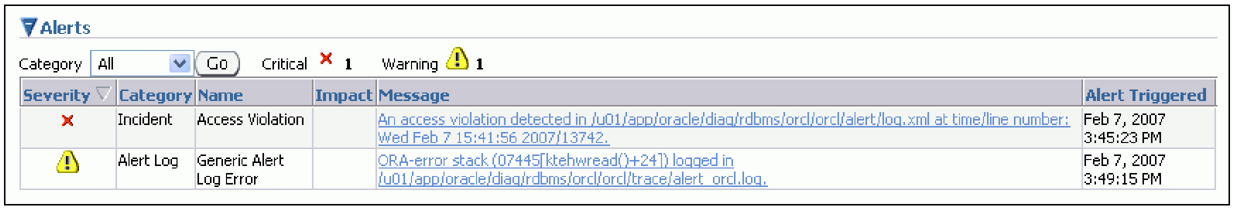
   For Oracle Enterprise Manager Database Control, see *Oracle Database 2 Day DBA* for instructions. For Oracle Enterprise Manager Grid Control, go to the desired database target.

2. In the Alerts section, examine the table of alerts.

   Critical error alerts are indicated by a red × in the Severity column, and the text "Incident" in the Category column.

   > **Note:** You may have to click the hide/show icon next to the Alerts heading to display the alerts table.

Figure 8–3 Alerts Table on the Database Home Page



Alerts

Category All Go Critical ✗ 1 Warning ⚠ 1

Severity	Category	Name	Impact	Message	Alert Triggered
✗	Incident	Access Violation		An access violation detected in /u01/app/oracle/diag/rdbms/orcl/orcl/alert/log.xml at time/line number: Wed Feb 7 15:41:56 2007/13742.	Feb 7, 2007 3:45:23 PM
⚠	Alert Log	Generic Alert Log Error		ORA-error stack (07445[ktehwread()+24]) logged in /u01/app/oracle/diag/rdbms/orcl/orcl/trace/alert_orcl.log.	Feb 7, 2007 3:49:15 PM

3. In the Message column, click the message of the critical error alert that you want investigate.

   The Incident page or Data Failure page appears. This page includes:

   - Problem information, including the number of incidents for the problem
   - A Performance and Critical Error graphical timeline for the 24-hour period in which the critical error occurred.
   - Alert details, including severity, timestamp, and message
   - Controls that enable you to clear the alert or record a comment about it.

4. Review the Performance and Critical Error graphical timeline, and note any time correlation between performance issues and the critical error. Optionally clear the alert or leave a comment about it.

5. Do one of the following:

   - If you want to view the details of the problem associated with the critical error alert that you are investigating, proceed with Task 2 –View Problem Details on page 8-12.

- If the graphical timeline shows a large number of different problems over the past 24 hours and you want to view a summary of all those problems, complete these steps:
  - Click **View All Problems**.

    The Support Workbench home page appears.
  - View problems and incidents as described in "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16.
  - Select a single problem and view problem details, as described in "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16.
  - Continue with either Task 3 – (Optional) Gather Additional Diagnostic Information on page 8-12 or Task 4 – (Optional) Create a Service Request on page 8-12.

Task 2 –View Problem Details

You continue your investigation with the Problem Details page.

To view problem details:

1. On the Incident page or Data Failure page, click **View Problem Details**.

   The Problem Details page appears, showing the Incidents subpage.
2. (Optional) To view incident details, select an incident, and then click **View**.

   The incident details page appears.
3. (Optional) On the Incident Details page, click **Checker Findings** to view the Checker Findings subpage.

   This page displays findings from any health checks that were automatically run when the critical error was detected.

   See Also: "Running Health Checks with Health Monitor" on page 8-19

Task 3 – (Optional) Gather Additional Diagnostic Information

You can perform the following activities to gather additional diagnostic information for a problem. This additional information is then automatically included in the diagnostic data uploaded to Oracle Support. If you are unsure as to whether or not to perform these activities, check with your Oracle Support representative.

- Manually invoke additional health checks

  See "Running Health Checks with Health Monitor" on page 8-19
- Invoke the SQL Test Case Builder

  See *Oracle Database Performance Tuning Guide* for instructions.

Task 4 – (Optional) Create a Service Request

At this point, you can create an Oracle Support service request and record the service request number with the problem information. If you choose to skip this task, the Support Workbench will automatically create a draft service request for you in Task 5.

To create a service request:

1. On the Problem Details page, in the Investigate and Resolve section, click **Go to Metalink**.

   The Oracle*MetaLink* Login and Registration page appears in a new browser window.

   > **Note:** See "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16 for instructions for returning to the Problem Details page if you are not already there.

2. Log in to Oracle*MetaLink* and create a service request in the usual manner.

   (Optional) Remember the service request number (SR#) for the next step.

3. (Optional) Return to the Problem Details page, and then do the following:

   a. In the Summary section, click the **Edit** button that is adjacent to the SR# label.

   b. In the window that opens, enter the SR#, and then click **OK**.

   The SR# is recorded in the Problem Details page. This is for your reference only.

Task 5 – Package and Upload Diagnostic Data to Oracle Support

For this task, you use the quick packaging process of the Support Workbench to package and upload the diagnostic information for the problem to Oracle Support. Quick packaging has a minimum of steps, organized in a guided workflow (a wizard). The wizard assists you with creating an incident package (package) for a single problem, creating a zip file from the package, and uploading the file. With quick packaging, you are not able to edit or otherwise customize the diagnostic information that is uploaded. However, quick packaging is the more direct, straightforward method to package and upload diagnostic data.

If you want to edit or remove sensitive data from the diagnostic information, enclose additional user files (such as application configuration files or scripts), or perform other customizations before uploading, you must use the custom packaging process, which is a more manual process and has more steps. See "Creating, Editing, and Uploading Custom Incident Packages" on page 8-29 for instructions. If you choose to follow those instructions instead of the instructions here in Task 5, continue with Task 6 – Track the Service Request and Implement Any Repairs on page 8-14 when you are finished.

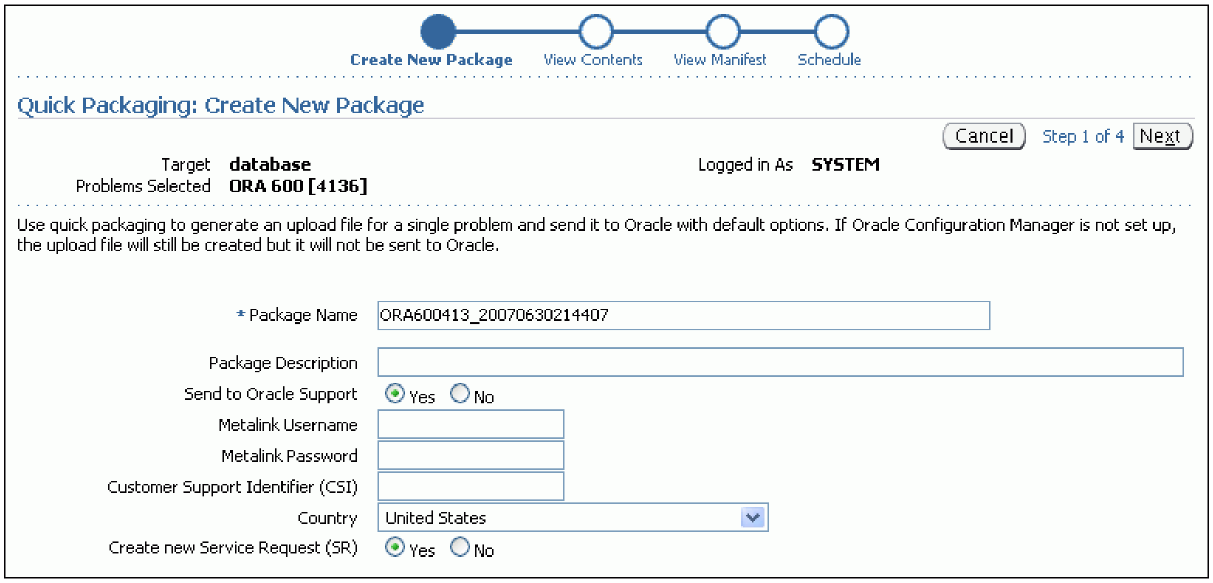
> **Note:** The Support Workbench uses Oracle Configuration Manager to upload the diagnostic data. If Oracle Configuration Manager is not installed or properly configured, the upload may fail. In this case, a message is displayed with a request that you upload the file to Oracle Support manually. You can upload manually with Oracle*MetaLink*.
>
> For more information about Oracle Configuration Manager, see *Oracle Configuration Manager Installation and Administration Guide*.

To package and upload diagnostic data to Oracle Support:

1. On the Problem Details page, in the Investigate and Resolve section, click **Quick Package**.

   The Create New Package page of the Quick Packaging wizard appears.

Note: See "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16 for instructions for returning to the Problem Details page if you are not already there.



Quick Packaging: Create New Package

Target	**database**
Problems Selected	**ORA 600 [4136]**
Logged in As	**SYSTEM**

Use quick packaging to generate an upload file for a single problem and send it to Oracle with default options. If Oracle Configuration Manager is not set up, the upload file will still be created but it will not be sent to Oracle.

* Package Name	ORA600413_20070630214407
Package Description	
Send to Oracle Support	[✓ Yes] No
Metalink Username	
Metalink Password	
Customer Support Identifier (CSI)	
Country	United States
Create new Service Request (SR)	[✓ Yes] No

2. Optionally enter a package name and description.
3. Fill in the remaining fields on the page. If you already created a service request for this problem, select **No** next to Create new Service Request (SR).

   If you select Yes, the Quick Packaging wizard creates a draft service request on your behalf. You must later log in to Oracle*MetaLink* and fill in the details of the service request.
4. Click **Next**, and then proceed with the remaining pages of the Quick Packaging wizard.

   When the Quick Packaging wizard is complete, the package that it creates remains available in the Support Workbench. You can then modify it with custom packaging operations (such as adding new incidents) and reupload at a later time. See "Viewing and Modifying Incident Packages" on page 8-35.

Task 6 – Track the Service Request and Implement Any Repairs

After uploading diagnostic information to Oracle Support, you might perform various activities to track the service request, to collect additional diagnostic information, and to implement repairs. Among these activities are the following:

- Adding an Oracle bug number to the problem information.

  To do so, on the Problem Details page, click the **Edit** button that is adjacent to the Bug# label. This is for your reference only.
- Adding comments to the problem activity log.

  You may want to do this to share problem status or history information with other DBAs in your organization. For example you could record the results of your conversations with Oracle Support. To add comments, complete the following steps:

1. Access the Problem Details page for the problem, as described in "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16.
2. Click **Activity Log** to display the Activity Log subpage.
3. In the Comment field, enter a comment, and then click **Add Comment**.

   Your comment is recorded in the activity log.

- As new incidents occur, adding them to the package and reuploading.

  For this activity, you must use the custom packaging method described in "Creating, Editing, and Uploading Custom Incident Packages" on page 8-29.

- Running health checks.

  See "Running Health Checks with Health Monitor" on page 8-19.

- Running a suggested Oracle advisor to implement repairs.

  Access the suggested advisor in one of the following ways:

  – **Problem Details page**—In the Self-Service tab of the Investigate and Resolve section

  – **Support Workbench home page**—on the Checker Findings subpage

  – **Incident Details page**—on the Checker Findings subpage

  Table 8–4 lists the advisors that help repair critical errors.

Table 8–4 Oracle Advisors that Help Repair Critical Errors

Advisor	Critical Errors Addressed	See
Data Recovery Advisor	Corrupted blocks, corrupted or missing files, and other data failures	"Repairing Data Corruptions with the Data Recovery Advisor" on page 8-27
SQL Repair Advisor	SQL statement failures	"Repairing SQL Failures with the SQL Repair Advisor" on page 8-25

See Also: "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16 for instructions for viewing the Checker Findings subpage of the Incident Details page

Task 7 – Close Incidents

When a particular incident is no longer of interest, you can close it. By default, closed incidents are not displayed on the Problem Details page.

All incidents, whether closed or not, are purged after 30 days. You can disable purging for an incident on the Incident Details page.

To close incidents:

1. Access the Support Workbench home page.

   See "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16 for instructions.

2. Select the desired problem, and then click **View**.

   The Problem Details page appears.

3. Select the incidents to close and then click **Close**.

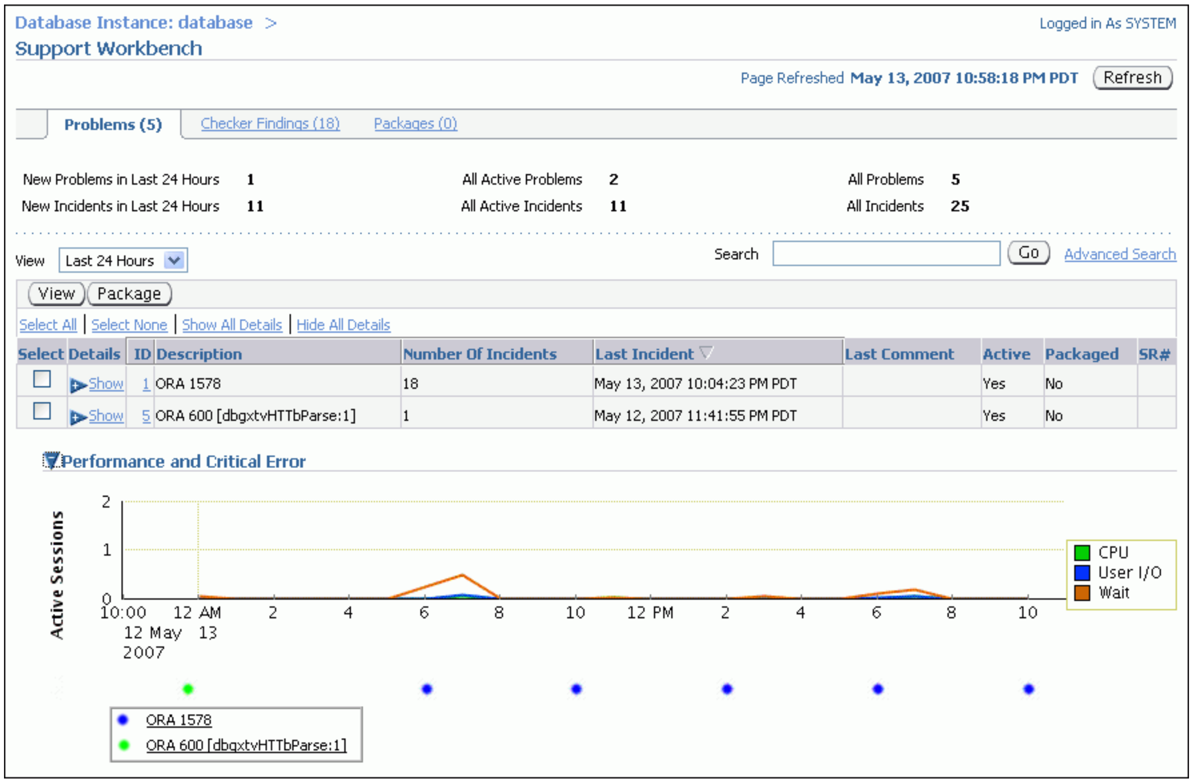
A confirmation page appears.

4. Enter an optional comment and click **OK**.

Viewing Problems with the Enterprise Manager Support Workbench

You use the Enterprise Manager Support Workbench home page (Figure 8–4 on page 8-16) to view all problems or only those within a specified time period.

Figure 8–4 Enterprise Manager Support Workbench Home Page



Database Instance: database >
Support Workbench
Logged in As SYSTEM

Page Refreshed **May 13, 2007 10:58:18 PM PDT** Refresh

Problems (5) Checker Findings (18) Packages (0)

New Problems in Last 24 Hours	**1**	All Active Problems	**2**	All Problems	**5**
New Incidents in Last 24 Hours	**11**	All Active Incidents	**11**	All Incidents	**25**

View: Last 24 Hours   Search [ ] Go Advanced Search

View Package

Select All | Select None | Show All Details | Hide All Details

Select	Details	ID	Description	Number Of Incidents	Last Incident	Last Comment	Active	Packaged	SR#
☐	Show	1	ORA 1578	18	May 13, 2007 10:04:23 PM PDT		Yes	No	
☐	Show	5	ORA 600 [dbgxtvHTTbParse:1]	1	May 12, 2007 11:41:55 PM PDT		Yes	No	

Performance and Critical Error

To access the Support Workbench home page:

1. Access the Database Home page in Enterprise Manager.

   See *Oracle Database 2 Day DBA* for the instructions for Oracle Enterprise Manager Database Control. For Oracle Enterprise Manager Grid Control, go to the desired database target.

2. Click **Software and Support** to view the Software and Support page.

3. In the Support section, click **Support Workbench**.

   The Support Workbench home page appears, showing the Problems subpage. By default the problems from the last 24 hours are displayed.

4. To view all problems, select **All** from the View list.

5. (Optional) If the Performance and Critical Error section is hidden, click the **Show/Hide** icon adjacent to the section heading to show the section.

   This section enables you to view any correlation between performance changes and incident occurrences.

6. (Optional) Under the Details column, click **Show** to display a list of all incidents for a problem, and then click an incident ID to display the Incident Details page.

To view details for a particular problem:

1. On the Support Workbench home page, select the problem, and then click **View**.

   The Problem Details page appears, showing the Incidents subpage. The incidents subpage shows all incidents that are open and that generated dumps—that is, that were not flood-controlled.

2. (Optional) To view both open and closed incidents, select **All Incidents** in the Status list. To view both normal and flood-controlled incidents, select **All Incidents** in the Data Dumped list.

3. (Optional) To view details for an incident, select the incident, and then click **View**.

   The Incident Details page appears.

4. (Optional) On the Incident Details page, to view checker findings for the incident, click **Checker Findings**.

5. (Optional) On the Incident Details page, to view the user actions that are available to you for the incident, click **Additional Diagnostics**. Each user action provides a way for you to gather additional diagnostics for the incident or its problem.

See Also: "Incident Flood Control" on page 8-4

Creating a User-Reported Problem

System-generated problems—critical errors generated internally to the database—are automatically added to the Automatic Diagnostic Repository (ADR) and tracked in the Support Workbench. From the Support Workbench, you can gather additional diagnostic data on these problems, upload diagnostic data to Oracle Support, and in some cases, resolve the problems, all with the easy-to-use workflow that is explained in "Investigating, Reporting, and Resolving a Problem" on page 8-9.

There may be a situation in which you want to manually add a problem that you noticed to the ADR so that you can put that problem through that same workflow. An example of such a situation might be a global database performance problem that was not diagnosed by Automatic Diagnostic Database Monitor (ADDM). The Support Workbench includes a mechanism for you to create and work with such a user-reported problem.

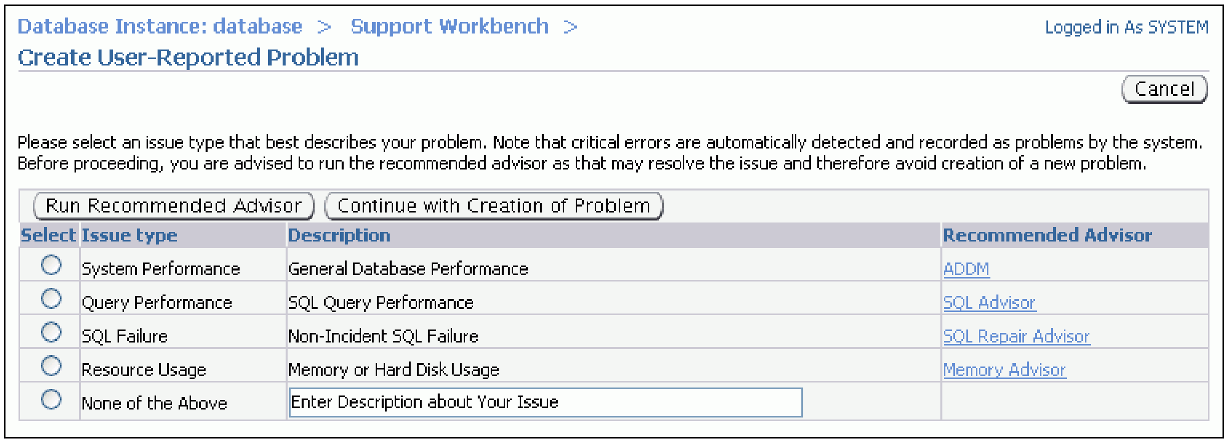
To create a user-reported problem:

1. Access the Support Workbench home page.

   See "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16 for instructions.

2. Under Related Links, click **Create User-Reported Problem**.

   The Create User-Reported Problem page appears.


Database Instance: database > Support Workbench >

Logged in As SYSTEM

Create User-Reported Problem

Cancel

Please select an issue type that best describes your problem. Note that critical errors are automatically detected and recorded as problems by the system. Before proceeding, you are advised to run the recommended advisor as that may resolve the issue and therefore avoid creation of a new problem.

Run Recommended Advisor | Continue with Creation of Problem

Select	Issue type	Description	Recommended Advisor
○	System Performance	General Database Performance	ADDM
○	Query Performance	SQL Query Performance	SQL Advisor
○	SQL Failure	Non-Incident SQL Failure	SQL Repair Advisor
○	Resource Usage	Memory or Hard Disk Usage	Memory Advisor
○	None of the Above	Enter Description about Your Issue	

3. If your problem matches one of the listed issue types, select the issue type, and then click **Run Recommended Advisor** to attempt to solve the problem with an Oracle advisor.
4. If the recommended advisor did not solve the problem, or if you did not run an advisor, do one of the following:
   - If your problem matches one of the listed issue types, select the issue type, and then click **Continue with Creation of Problem**.
   - If your problem does not match one of the listed issue types, select the issue type **None of the Above**, enter a description, and then click **Continue with Creation of Problem**.

   The Problem Details page appears.
5. Follow the instructions on the Problem Details page.

   See "Investigating, Reporting, and Resolving a Problem" on page 8-9 for more information.

   See Also: "About the Oracle Database Fault Diagnosability Infrastructure" on page 8-1 for more information on problems and the ADR

Viewing the Alert Log

You can view the alert log with a text editor, with Enterprise Manager, or with the ADRCI utility.

To view the alert log with Enterprise Manager:

1. Access the Database Home page in Enterprise Manager.

   For Oracle Enterprise Manager Database Control, see *Oracle Database 2 Day DBA* for instructions. For Oracle Enterprise Manager Grid Control, go to the desired database target.
2. Under Related Links, click **Alert Log Contents**.

   The View Alert Log Contents page appears.
3. Select the number of entries to view, and then click **Go**.

To view the alert log with a text editor:

1. Connect to the database with SQL*Plus or another query tool, such as SQL Developer.
2. Query the `V$DIAG_INFO` view as shown in "Viewing ADR Locations with the V$DIAG_INFO View" on page 8-8.
3. To view the text-only alert log, without the XML tags, complete these steps:
   a. In the `V$DIAG_INFO` query results, note the path that corresponds to the `Diag Trace` entry, and change directory to that path.
   b. Open file alert_*SID*.log with a text editor.
4. To view the XML-formatted alert log, complete these steps:
   a. In the `V$DIAG_INFO` query results, note the path that corresponds to the `Diag Alert` entry, and change directory to that path.
   b. Open the file log.xml with a text editor.

See Also: *Oracle Database Utilities* for information about using the ADRCI utility to view a text version of the alert log (with XML tags stripped) and to run queries against the alert log

Finding Trace Files

Trace files are stored in the Automatic Diagnostic Repository (ADR), in the `trace` directory under each ADR home. To help you locate individual trace files within this directory, you can use data dictionary views. For example, you can find the path to your current session's trace file or to the trace file for each Oracle process.

To find the trace file for your current session:

- Submit the following query:

```
SELECT VALUE FROM V$DIAG_INFO WHERE NAME = 'Default Trace File';
```

  The full path to the trace file is returned.

To find the trace files for Oracle Database processes:

- Submit the following query:

```
SELECT PID, PROGRAM, TRACEFILE FROM V$PROCESS;
```

See Also:

- "Structure, Contents, and Location of the Automatic Diagnostic Repository" on page 8-6
- The ADRCI `SHOW TRACEFILE` command in *Oracle Database Utilities*

Running Health Checks with Health Monitor

This section describes the Health Monitor and includes instructions on how to use it. The following topics are covered:

- About Health Monitor
- Running Health Checks Manually
- Viewing Checker Reports

- Health Monitor Views

About Health Monitor

Beginning with Release 11*g*, Oracle Database includes a framework called Health Monitor for running diagnostic checks on the database.

About Health Monitor Checks

Health Monitor checks (also known as checkers, health checks, or checks) examine various layers and components of the database. Health checks detect file corruptions, physical and logical block corruptions, undo and redo corruptions, data dictionary corruptions, and more. The health checks generate reports of their findings and, in many cases, recommendations for resolving problems. Health checks can be run in two ways:

- **Reactive—**The fault diagnosability infrastructure can run health checks automatically in response to a critical error.
- **Manual—**As a DBA, you can manually run health checks using either the `DBMS_HM` PL/SQL package or the Enterprise Manager interface. You can run checkers on a regular basis if desired, or Oracle Support may ask you to run a checker while working with you on a service request.

Health Monitor checks store findings, recommendations, and other information in the Automatic Diagnostic Repository (ADR).

See Also: "Automatic Diagnostic Repository (ADR)" on page 8-4

Types of Health Checks

Health monitor runs the following checks:

- **DB Structure Integrity Check—**This check verifies the integrity of database files and reports failures if these files are inaccessible, corrupt or inconsistent. If the database is in mount or open mode, this check examines the log files and data files listed in the control file. If the database is in `NOMOUNT` mode, only the control file is checked.
- **Data Block Integrity Check—**This check detects disk image block corruptions such as checksum failures, head/tail mismatch, and logical inconsistencies within the block. Most corruptions can be repaired using Block Media Recovery. Corrupted block information is also captured in the `V$DATABASE_BLOCK_CORRUPTION` view. This check does not detect inter-block or inter-segment corruption.
- **Redo Integrity Check—**This check scans the contents of the redo log for accessibility and corruption, as well as the archive logs, if available. The Redo Integrity Check reports failures such as archive log or redo corruption.
- **Undo Segment Integrity Check—**This check finds logical undo corruptions, which typically occur during rollback operations. After locating an undo corruption, this check uses PMON and SMON to try to recover the corrupted transaction. If this recovery fails, then Health Monitor stores information about the corruption in `V$CORRUPT_XID_LIST`. Most undo corruptions can be resolved by forcing a commit.

- **Transaction Integrity Check**—This check is identical to the Undo Segment Integrity Check except that it checks only one specific transaction. The transaction is passed to the check as an input parameter.
- **Dictionary Integrity Check**—This check examines the integrity of core dictionary objects, such as `tab$` and `col$`. It performs the following operations:
  - Verifies the contents of dictionary entries for each dictionary object.
  - Performs a cross-row level check, which verifies that logical constraints on rows in the dictionary are enforced.
  - Performs an object relationship check, which verifies that parent-child relationships between dictionary objects are enforced.

  The Dictionary Integrity Check operates on the following dictionary objects:

  `tab$`, `clu$`, `fet$`, `uet$`, `seg$`, `undo$`, `ts$`, `file$`, `obj$`, `ind$`, `icol$`, `col$`, `user$`, `con$`, `cdef$`, `ccol$`, `bootstrap$`, `objauth$`, `ugroup$`, `tsq$`, `syn$`, `view$`, `typed_view$`, `superobj$`, `seq$`, `lob$`, `coltype$`, `subcoltype$`, `ntab$`, `refcon$`, `opqtype$`, `dependency$`, `access$`, `viewcon$`, `icoldep$`, `dual$`, `sysauth$`, `objpriv$`, `defrole$`, and `ecol$`.

Health checks can run in two modes:

- **DB-online** mode means the check can be run while the database is open (that is, in `OPEN` mode or `MOUNT` mode).
- **DB-offline** mode means the check can be run when the instance is available but the database itself is closed (that is, in `NOMOUNT` mode).

All the health checks can be run in DB-online mode. Only the Redo Integrity Check and the DB Structure Integrity Check can be used in DB-offline mode.

Running Health Checks Manually

Health Monitor provides two ways to run health checks manually:

- By using the `DBMS_HM` PL/SQL package
- By using the Enterprise Manager interface, found on the Checkers subpage of the Advisor Central page

Running Health Checks Using the DBMS_HM PL/SQL Package

The `DBMS_HM` procedure for running a health check is called `RUN_CHECK`. To call `RUN_CHECK`, supply the name of the check and a name for the run, as follows:

```
BEGIN
    dbms_hm.run_check('Dictionary Integrity Check', 'my_run');
END;
```

To obtain a list of health check names, run the following query:

```
SELECT NAME FROM V$HM_CHECK WHERE INTERNAL_CHECK='N';

NAME
----------------------------------------------------------------
DB Structure Integrity Check
Data Block Integrity Check
Redo Integrity Check
Transaction Integrity Check
Undo Segment Integrity Check
Dictionary Integrity Check
```

Each health check can also accept a set of input parameters for controlling its execution. You can view these inputs using the `V$HM_CHECK_PARAM` view. See *Oracle Database PL/SQL Packages and Types Reference* for more information.

Running Health Checks Using Enterprise Manager

Enterprise Manager provides an interface for running Health Monitor checkers.

To run a Health Monitor Checker using Enterprise Manager:

1. On the Database Home page, in the Related Links section, click **Advisor Central**.
2. Click **Checkers** to view the Checkers subpage.
3. In the Checkers section, click the checker you want to run.
4. Enter values for each input parameter. These parameters are passed to the checker.
5. Click **Run**, confirm your parameters, and click **Run** again.

The list of input parameters for each checker is taken from the `V$HM_CHECK_PARAM` view.

Viewing Checker Reports

After a checker has run, you can view a report of its execution. The report contains findings, recommendations, and other information. You can view reports using Enterprise Manager, the ADRCI utility, or the `DBMS_HM` PL/SQL package. The following table indicates the report formats available with each viewing method.

Report Viewing Method	Report Formats Available
Enterprise Manager	HTML
`DBMS_HM` PL/SQL package	HTML, XML, and text
ADRCI utility	XML

Results of checker runs (findings, recommendations, and other information) are stored in the ADR, but reports are not generated immediately. When you request a report with the `DBMS_HM` PL/SQL package or with Enterprise Manager, if the report does not yet exist, it is first generated from the checker run data in the ADR, stored as a report file in XML format in the HM subdirectory of the ADR home for the current instance, and then displayed. If the report file already exists, it is just displayed. When using the ADRCI utility, you must first run a command to generate the report file if it does not exist, and then run another command to display its contents.

The preferred method to view checker reports is with Enterprise Manager. The following sections provide instructions for all methods:

- Viewing Reports Using Enterprise Manager
- Viewing Reports Using DBMS_HM
- Viewing Reports Using the ADRCI Utility

See Also: "Automatic Diagnostic Repository (ADR)" on page 8-4

Viewing Reports Using Enterprise Manager

You can also view Health Monitor reports and findings for a given checker run using Enterprise Manager.

To view run findings using Enterprise Manager

1. Access the Database Home page.

   For Oracle Enterprise Manager Database Control, see *Oracle Database 2 Day DBA* for instructions. For Oracle Enterprise Manager Grid Control, go to the desired database target.

2. In the Related Links section, click **Advisor Central**.
3. Click **Checkers** to view the Checkers subpage.
4. Click the run name for the checker run that you want to view.

   The Run Detail page appears, showing the findings for that checker run.

5. Click **Runs** to display the Runs subpage.

   Enterprise Manager displays more information about the checker run.

6. Click **View Report** to view the report for the checker run.

   The report is displayed in a new browser window.

Viewing Reports Using DBMS_HM

You can view Health Monitor checker reports with the `DBMS_HM` package function `GET_RUN_REPORT`. This function enables you to request HTML, XML, or text formatting. The default format is text, as shown in the following SQL*Plus example:

```
SET LONG 100000
SET LONGCHUNKSIZE 1000
SET PAGESIZE 1000
SET LINESIZE 512
SELECT DBMS_HM.GET_RUN_REPORT('HM_RUN_1061') FROM DUAL;

DBMS_HM.GET_RUN_REPORT('HM_RUN_1061')
-----------------------------------------------------------------------

 Run Name                     : HM_RUN_1061
 Run Id                       : 1061
 Check Name                   : Data Block Integrity Check
 Mode                         : REACTIVE
 Status                       : COMPLETED
 Start Time                   : 2007-05-12 22:11:02.032292 -07:00
 End Time                     : 2007-05-12 22:11:20.835135 -07:00
 Error Encountered            : 0
 Source Incident Id           : 7418
 Number of Incidents Created  : 0

Input Paramters for the Run
 BLC_DF_NUM=1
 BLC_BL_NUM=64349

Run Findings And Recommendations
 Finding
 Finding Name  : Media Block Corruption
 Finding ID    : 1065
 Type          : FAILURE
 Status        : OPEN
```

```
Priority      : HIGH
Message       : Block 64349 in datafile 1:
              '/ade/sfogel_emdb/oracle/dbs/t_db1.f' is media corrupt
Message       : Object BMRTEST1 owned by SYS might be unavailable
Finding
Finding Name  : Media Block Corruption
Finding ID    : 1071
Type          : FAILURE
Status        : OPEN
Priority      : HIGH
Message       : Block 64351 in datafile 1:
              '/ade/sfogel_emdb/oracle/dbs/t_db1.f' is media corrupt
Message       : Object BMRTEST2 owned by SYS might be unavailable
```

See Also: *Oracle Database PL/SQL Packages and Types Reference* for details on the `DBMS_HM` package.

Viewing Reports Using the ADRCI Utility

You can create and view Health Monitor checker reports using the ADRCI utility.

To create and view a checker report using ADRCI

1. Ensure that operating system environment variables (such as `ORACLE_HOME`) are set properly, and then enter the following command at the operating system command prompt:

   ```
   ADRCI
   ```

   The utility starts and displays the following prompt:

   ```
   adrci>>
   ```

   Optionally, you can change the current ADR home. Use the `SHOW HOMES` command to list all ADR homes, and the `SET HOMEPATH` command to change the current ADR home. See *Oracle Database Utilities* for more information.

2. Enter the following command:

   ```
   show hm_run
   ```

   This command lists all the checker runs (stored in `V$HM_RUN`) registered in the ADR repository.

3. Locate the checker run for which you want to create a report and note the checker run name. The `REPORT_FILE` field contains a filename if a report already exists for this checker run. Otherwise, generate the report with the following command:

   ```
   create report hm_run run_name
   ```

4. To view the report, enter the following command:

   ```
   show report hm_run run_name
   ```

See Also: "Automatic Diagnostic Repository (ADR)" on page 8-4

Health Monitor Views

Instead of requesting a checker report, you can view the results of a specific checker run by directly querying the ADR data from which reports are created. This data is available through the views V$HM_RUN, V$HM_FINDING, and V$HM_RECOMMENDATION.

The following example queries the V$HM_RUN view to determine a history of checker runs:

```
SELECT run_id, name, check_name, run_mode, src_incident FROM v$hm_run;

    RUN_ID NAME         CHECK_NAME                         RUN_MODE SRC_INCIDENT
---------- ------------ ---------------------------------- -------- ------------
         1 HM_RUN_1     DB Structure Integrity Check       REACTIVE            0
       101 HM_RUN_101   Transaction Integrity Check        REACTIVE         6073
       121 TXNCHK       Transaction Integrity Check        MANUAL              0
       181 HMR_tab$     Dictionary Integrity Check         MANUAL              0
         .
         .
         .
       981 Proct_ts$    Dictionary Integrity Check         MANUAL              0
      1041 HM_RUN_1041  DB Structure Integrity Check       REACTIVE            0
      1061 HM_RUN_1061  Data Block Integrity Check         REACTIVE         7418
```

The next example queries the V$HM_FINDING view to obtain finding details for the reactive data block check with RUN_ID 1061:

```
SELECT type, description FROM v$hm_finding WHERE run_id = 1061;

TYPE          DESCRIPTION
------------- -----------------------------------------
FAILURE       Block 64349 in datafile 1: '/ade/sfogel_e
              mdb/oracle/dbs/t_db1.f' is media corrupt

FAILURE       Block 64351 in datafile 1: '/ade/sfogel_e
              mdb/oracle/dbs/t_db1.f' is media corrupt
```

See Also:

- "Types of Health Checks" on page 8-20
- *Oracle Database Reference* for more information on the V$HM_* views

Repairing SQL Failures with the SQL Repair Advisor

In the rare case that a SQL statement fails with a critical error, you can run the SQL Repair Advisor to try to repair the failed statement.

This section covers the following topics:

- About the SQL Repair Advisor
- Running the SQL Repair Advisor
- Viewing, Disabling, or Removing a SQL Patch

About the SQL Repair Advisor

You run the SQL Repair Advisor after a SQL statement fails with a critical error. The advisor analyzes the statement and in many cases recommends a patch to repair the statement. If you implement the recommendation, the applied SQL patch circumvents the failure by causing the query optimizer to choose an alternate execution plan for future executions.

Running the SQL Repair Advisor

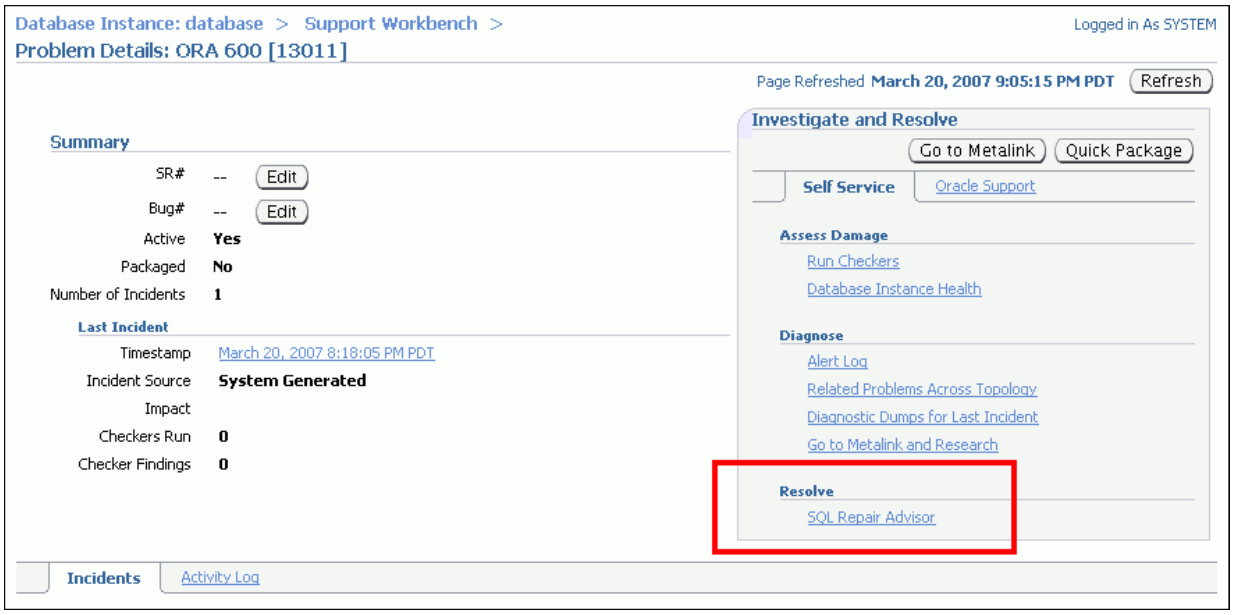
You run the SQL Repair Advisor from the Problem Details page of the Support Workbench. The instructions in this section assume that you were already notified of a critical error caused by your SQL statement and that you followed the workflow described in "Investigating, Reporting, and Resolving a Problem" on page 8-9.

To run the SQL Repair Advisor:

1. Access the Problem Details page for the problem that pertains to the failed SQL statement.

   See "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16 for instructions.

2. In the Investigate and Resolve section, under the Self Service tab, under the Resolve heading, click **SQL Repair Advisor**.



Database Instance: database > Support Workbench >

Logged in As SYSTEM

Problem Details: ORA 600 [13011]

Page Refreshed **March 20, 2007 9:05:15 PM PDT**

Summary

SR#	--
Bug#	--
Active	**Yes**
Packaged	**No**
Number of Incidents	**1**

Last Incident

Timestamp	March 20, 2007 8:18:05 PM PDT
Incident Source	**System Generated**
Impact	
Checkers Run	**0**
Checker Findings	**0**

Investigate and Resolve

Self Service | Oracle Support

Assess Damage
- Run Checkers
- Database Instance Health

Diagnose
- Alert Log
- Related Problems Across Topology
- Diagnostic Dumps for Last Incident
- Go to Metalink and Research

Resolve
- SQL Repair Advisor

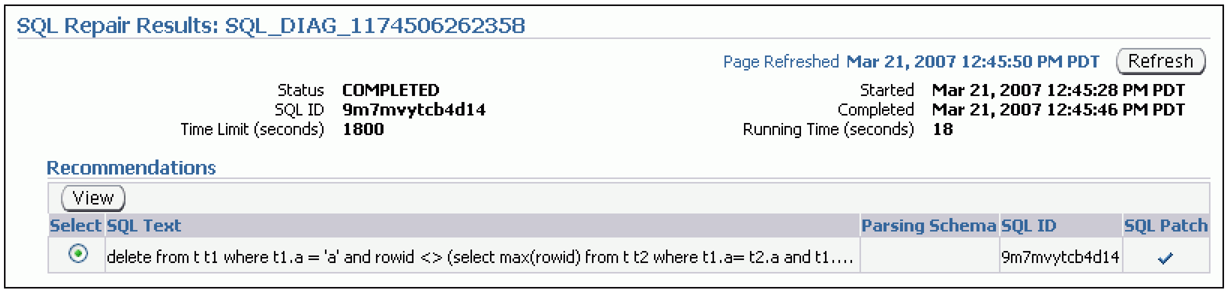
Incidents | Activity Log

   The SQL Repair Advisor page appears.

3. Enter an optional task name, set an optional time limit for the advisor task, and adjust settings to schedule the advisor to run either immediately or at a future date and time.

4. Click **Submit**.

   A "processing" page appears. After a short delay, the SQL Repair Results page appears.



SQL Repair Results: SQL_DIAG_1174506262358

Page Refreshed **Mar 21, 2007 12:45:50 PM PDT**

Status	**COMPLETED**	Started	**Mar 21, 2007 12:45:28 PM PDT**
SQL ID	**9m7mvytcb4d14**	Completed	**Mar 21, 2007 12:45:46 PM PDT**
Time Limit (seconds)	**1800**	Running Time (seconds)	**18**

Recommendations

Select	SQL Text	Parsing Schema	SQL ID	SQL Patch
●	delete from t t1 where t1.a = 'a' and rowid <> (select max(rowid) from t t2 where t1.a= t2.a and t1....		9m7mvytcb4d14	✓

A check mark in the SQL Patch column indicates that a recommendation is present. The absence of a check mark in this column means that the SQL Repair Advisor was unable to devise a patch for the SQL statement.

5. If a recommendation is present, click **View** to view the recommendation.

   The Repair Recommendations page appears, showing the recommended patch for the statement.

6. Click **Implement**.

   The SQL Repair Results page returns, showing a confirmation message.

7. (Optional) Click **Verify using SQL Worksheet** to run the statement in the SQL worksheet and verify that the patch successfully repaired the statement.

Viewing, Disabling, or Removing a SQL Patch

After you apply a SQL patch with the SQL Repair Advisor, you may want to view it to confirm its presence, disable it, or remove it. One reason to remove a patch is if you install a later release of Oracle Database that fixes the bug that caused the failure in the patched SQL statement.

To view, disable, or remove a SQL patch:

1. Access the Database Home page in Enterprise Manager.

   For Oracle Enterprise Manager Database Control, see *Oracle Database 2 Day DBA* for instructions. For Oracle Enterprise Manager Grid Control, go to the desired database target.

2. At the top of the page, click **Server** to display the Server page.

3. In the Query Optimizer section, click **SQL Plan Control**.

   The SQL Plan Control page appears. See the online help for information about this page.

4. At the top of the page, click **SQL Patch** to display the SQL Patch subpage.

   The SQL Patch subpage displays all SQL patches in the database.

5. Locate the desired patch by examining the associated SQL text.

   Click the SQL text to view the complete text of the statement.

6. To disable the patch, select it, and then click **Disable**.

   A confirmation message appears, and the patch status changes to `DISABLED`. You can later reenable the patch by selecting it and clicking **Enable**.

7. To remove the patch, select it, and then click **Drop**.

   A confirmation message appears.

See Also: "About the SQL Repair Advisor" on page 8-25

Repairing Data Corruptions with the Data Recovery Advisor

You use the Data Recovery Advisor to repair data block corruptions, undo corruptions, data dictionary corruptions, and more. The Data Recovery Advisor integrates with the Enterprise Manager Support Workbench (Support Workbench), with the Health Monitor, and with the RMAN utility to display data corruption problems, assess the extent of each problem (critical, high priority, low priority), describe the impact of a problem, recommend repair options, conduct a feasibility check of the customer-chosen option, and automate the repair process.

Oracle Database 2 Day DBA provides details on how to use the Data Recovery Advisor. This section describes the various ways to access the advisor from the Support Workbench.

The Data Recovery Advisor is automatically recommended by and accessible from the Support Workbench when you are viewing:

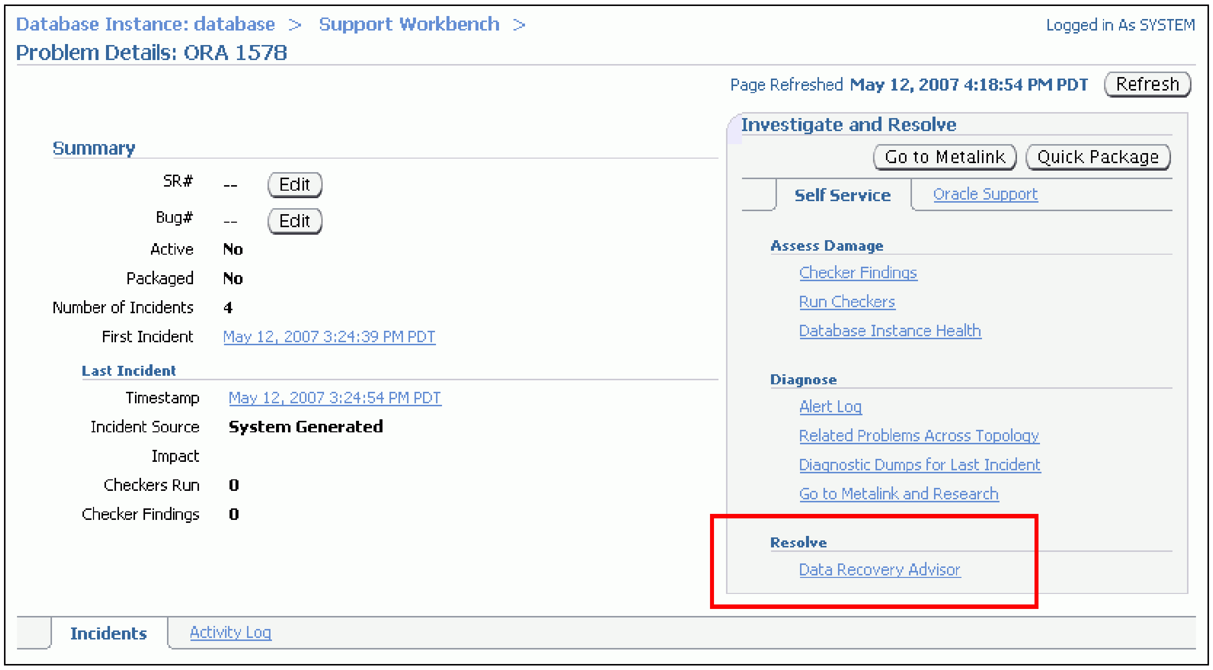
- Problem details for a problem that is related to a data corruption or other data failure.
- Health checker findings that are related to a data corruption or other data failure.

The Data Recovery Advisor is also available from the Advisor Central page. A link to this page can be found in the Related Links section of the Database Home page and of the Performance page.

Note: The Data Recovery Advisor is available only when you are connected as `SYSDBA`.

You access the Data Recovery Advisor from the Support Workbench in the following ways:

- From the Problem Details page



Database Instance: database > Support Workbench > Logged in As SYSTEM

Problem Details: ORA 1578

Page Refreshed **May 12, 2007 4:18:54 PM PDT** Refresh

Summary

SR#	--	Edit
Bug#	--	Edit
Active	**No**	
Packaged	**No**	
Number of Incidents	**4**	
First Incident	May 12, 2007 3:24:39 PM PDT	

Last Incident

Timestamp	May 12, 2007 3:24:54 PM PDT
Incident Source	**System Generated**
Impact	
Checkers Run	**0**
Checker Findings	**0**

Investigate and Resolve

Go to Metalink | Quick Package

Self Service | Oracle Support

Assess Damage
- Checker Findings
- Run Checkers
- Database Instance Health

Diagnose
- Alert Log
- Related Problems Across Topology
- Diagnostic Dumps for Last Incident
- Go to Metalink and Research

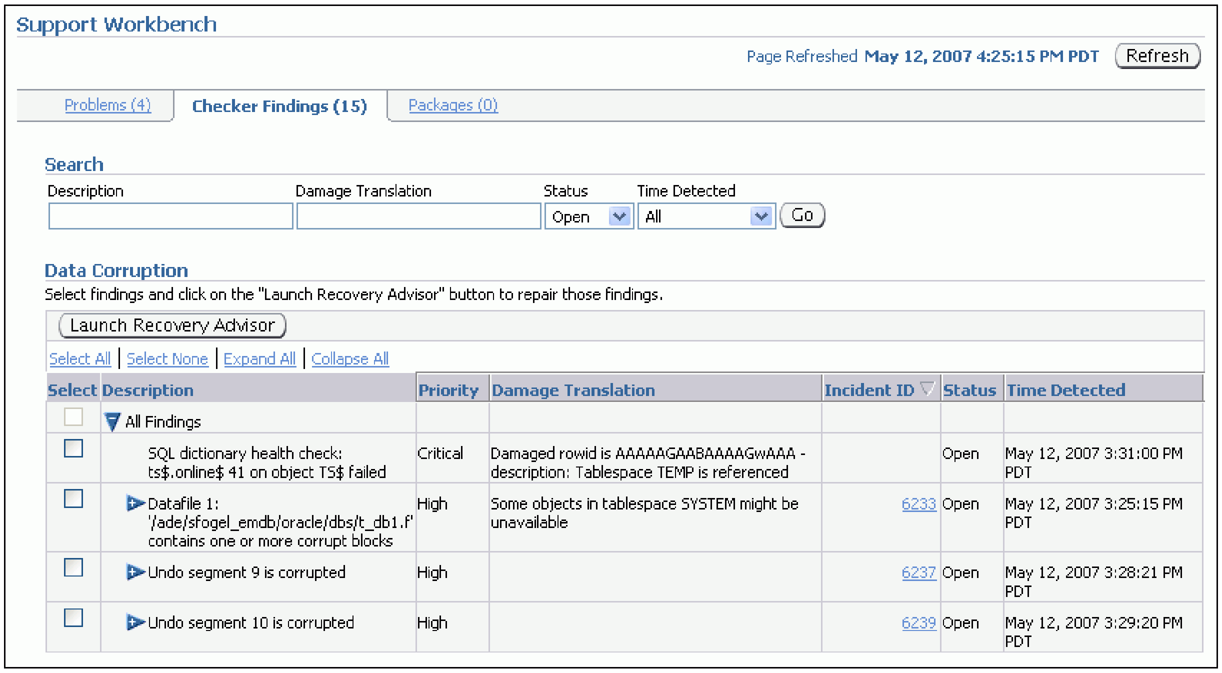
Resolve
- Data Recovery Advisor

Incidents | Activity Log

Click the **Data Recovery Advisor** link in the Investigate and Resolve section.

See "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16 for instructions on how to access this page.

- From the Checker Findings subpage of the Support Workbench home page



Description	Damage Translation	Status	Time Detected
		Open	All

Data Corruption

Select findings and click on the "Launch Recovery Advisor" button to repair those findings.

Select	Description	Priority	Damage Translation	Incident ID	Status	Time Detected
☐	All Findings					
☐	SQL dictionary health check: ts$.online$ 41 on object TS$ failed	Critical	Damaged rowid is AAAAAGAABAAAAGwAAA - description: Tablespace TEMP is referenced		Open	May 12, 2007 3:31:00 PM PDT
☐	Datafile 1: '/ade/sfogel_emdb/oracle/dbs/t_db1.f' contains one or more corrupt blocks	High	Some objects in tablespace SYSTEM might be unavailable	6233	Open	May 12, 2007 3:25:15 PM PDT
☐	Undo segment 9 is corrupted	High		6237	Open	May 12, 2007 3:28:21 PM PDT
☐	Undo segment 10 is corrupted	High		6239	Open	May 12, 2007 3:29:20 PM PDT

Select one or more data corruption findings and then click **Launch Recovery Advisor**.

See "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16 for instructions on how to access the Support Workbench home page.

See Also: *Oracle Database 2 Day DBA* for instructions for running the Data Recovery Advisor

Creating, Editing, and Uploading Custom Incident Packages

This section provides background information on incident packages, and explains how to create, modify, and upload customized packages with the Enterprise Manager Support Workbench (Support Workbench) custom packaging process. The following topics are covered:

- About Incident Packages
- Packaging and Uploading Problems with Custom Packaging
- Viewing and Modifying Incident Packages
- Setting Incident Packaging Preferences

See Also: "About the Oracle Database Fault Diagnosability Infrastructure" on page 8-1

About Incident Packages

For the customized approach to uploading diagnostic data to Oracle Support, you first collect the data into an intermediate logical structure called an incident package (package). A **package** is a collection of metadata that is stored in the Automatic Diagnostic Repository (ADR) and that points to diagnostic data files and other files both in and out of the ADR. When you create a package, you select one or more problems to add to the package. The Support Workbench then automatically adds to the package the problem information, incident information, and diagnostic data (such as trace files and dumps) associated with the selected problems. Because a problem can have many incidents (many occurrences of the same problem), by default only the first three and last three incidents for each problem are added to the package, excluding any incidents that are over 90 days old. You can change these default numbers on the Incident Packaging Configuration page of the Support Workbench.

After the package is created, you can add any type of external file to the package, remove selected files from the package, or edit selected files in the package to remove sensitive data. As you add and remove package contents, only the package metadata is modified.

When you are ready to upload the diagnostic data to Oracle Support, you first create a zip file that contains all the files referenced by the package metadata. You then upload the zip file through Oracle Configuration Manager.

Note: If you do not have Oracle Configuration Manager installed and properly configured, you must upload the zip file manually through Oracle*MetaLink*.

For more information about Oracle Configuration Manager, see *Oracle Configuration Manager Installation and Administration Guide*.

More information about packages is presented in the following sections:

- About Correlated Diagnostic Data in Incident Packages
- About Quick Packaging and Custom Packaging

See Also:

- "Packaging and Uploading Problems with Custom Packaging" on page 8-32
- "Viewing and Modifying Incident Packages" on page 8-35

About Correlated Diagnostic Data in Incident Packages

To improve the diagnosability of a problem, it is sometimes necessary to examine not only diagnostic data that is directly related to the problem, but also diagnostic data that is *correlated* with the directly related data. Diagnostic data can be correlated by time, by process ID, or by other criteria. For example, when examining an incident, it may be helpful to also examine an incident that occurred five minutes after the original incident. Similarly, while it is clear that the diagnostic data for an incident should include the trace file for the Oracle Database process that was running when the incident occurred, it might be helpful to also include trace files for other processes that are related to the original process.

Thus, when problems and their associated incidents are added to a package, any correlated incidents are added at the same time, with their associated trace files.

During the process of creating the physical file for a package, the Support Workbench calls upon the Incident Packaging Service to finalize the package. **Finalizing** means adding to the package any additional trace files that are correlated by time to incidents in the package, and adding other diagnostic information such as the alert log, health checker reports, SQL test cases, configuration information, and so on. This means that the number of files in the zip file may be greater than the number of files that the Support Workbench had previously displayed as the package contents.

The Incident Packaging Service follows a set of rules to determine the trace files in the ADR that are correlated to existing package data. You can modify some of those rules in the Incident Packaging Configuration page in Enterprise Manager.

Because both initial package data and added correlated data may contain sensitive information, it is important to have an opportunity to remove or edit files that contain this information before uploading to Oracle Support. For this reason, the Support Workbench enables you to run a command that finalizes the package as a separate operation. After manually finalizing a package, you can examine the package contents, remove or edit files, and then generate and upload a zip file.

Note: Finalizing a package does not mean closing it to further modifications. You can continue to add diagnostic data to a finalized package. You can also finalize the same package multiple times. Each time that you finalize, any new correlated data is added.

See Also: "Setting Incident Packaging Preferences" on page 8-41

About Quick Packaging and Custom Packaging

The Enterprise Manager Support Workbench provides two methods for creating and uploading an incident package: the quick packaging method and the custom packaging method.

Quick Packaging—This is the more automated method with a minimum of steps, organized in a guided workflow (a wizard). You select a single problem, provide a package name and description, and then schedule upload of the package contents, either immediately or at a specified date and time. The Support Workbench automatically places diagnostic data related to the problem into the package, finalizes the package, creates the zip file, and then uploads the file. With this method, you do not have the opportunity to add, edit, or remove package files or add other diagnostic data such as SQL test cases. However, it is the simplest and quickest way to get first-failure diagnostic data to Oracle Support.

Note that when quick packaging is complete, the package that was created by the wizard remains. You can then modify the package with custom packaging operations at a later time and manually reupload.

Custom Packaging—This is the more manual method, with more steps. It is intended for expert Support Workbench users who want more control over the packaging process. With custom packaging, you can create a new package with one or more problems, or you can add one or more problems to an existing package. You can then perform a variety of operations on the new or updated package, including:

- Adding or removing problems or incidents
- Adding, editing, or removing trace files in the package
- Adding or removing external files of any type
- Adding other diagnostic data such as SQL test cases
- Manually finalizing the package and then viewing package contents to determine if you must edit or remove sensitive data or remove files to reduce package size.

You might conduct these operations over a number of days, before deciding that you have enough diagnostic information to send to Oracle Support.

With custom packaging, you create the zip file and request upload to Oracle Support as two separate steps. Each of these steps can be performed immediately or scheduled for a future date and time.

See Also: "Task 5 – Package and Upload Diagnostic Data to Oracle Support" on page 8-13 for instructions for the Quick Packaging method

Packaging and Uploading Problems with Custom Packaging

This section walks you through an advanced workflow to view and package one or more problems for upload to Oracle Support. This workflow uses the custom packaging facility of the Support Workbench, which enables you to add, edit, and remove files from the incident package (package) before uploading.

To package and upload problems with custom packaging:

1. Access the Support Workbench home page.

   See "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16 for instructions.

2. (Optional) For each problem that you want to include in the package, indicate the service request number (SR#) associated with the problem, if any. To do so, complete the following steps for each problem:

   a. In the Problems subpage at the bottom of the Support Workbench home page, select the problem, and then click **View**.

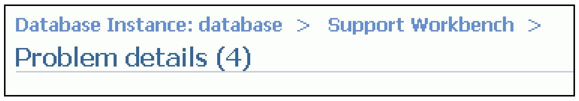
      Note: If you do not see the desired problem in the list of problems, or if there are too many problems to scroll through, select a time period from the View list and click **Go**. You can then select the desired problem and click **View**.

      The Problem Details page appears.

   b. Next to the SR# label, click **Edit**, enter a service request number, and then click **OK**.

      The service request number is displayed on the Problem Details page.

   c. Return to the Support Workbench home page by clicking **Support Workbench** in the locator links at the top of the page.



3. On the Support Workbench home page, select the problems that you want to package, and then click **Package**.

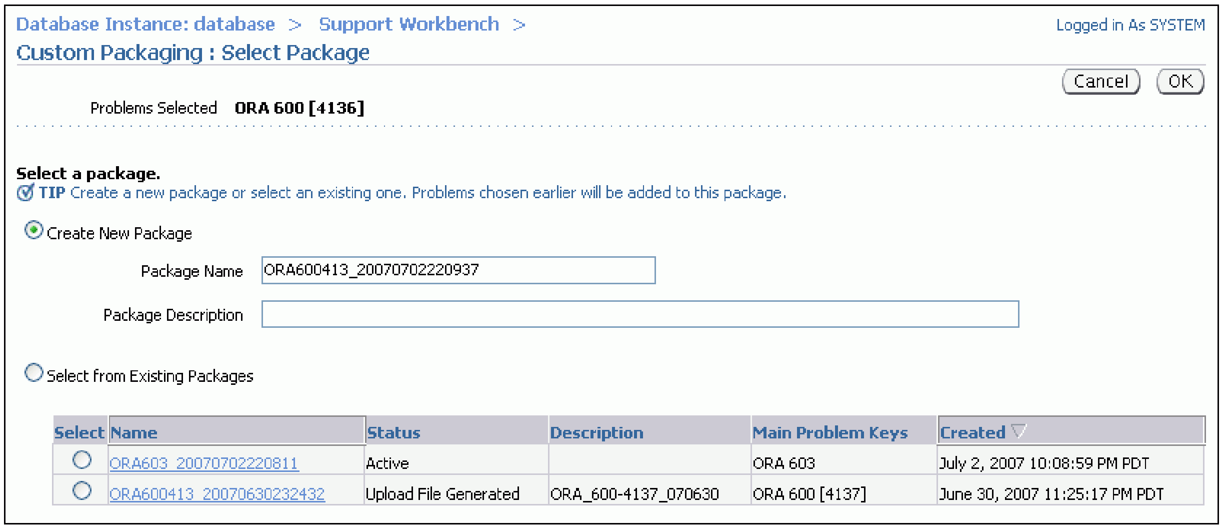
   The Select Packaging Mode page appears.

   Note: The packaging process may automatically select additional correlated problems to add to the package. An example of a correlated problem is one that occurs within a few minutes of the selected problem. See "About Correlated Diagnostic Data in Incident Packages" on page 8-30 for more information.

4. Select the **Custom packaging** option, and then click **Continue**.

   The Select Package page appears.

Figure 8–5 Select Package Page



Database Instance: database > Support Workbench > Logged in As SYSTEM

Custom Packaging : Select Package

Cancel OK

Problems Selected **ORA 600 [4136]**

Select a package.

TIP Create a new package or select an existing one. Problems chosen earlier will be added to this package.

(●) Create New Package

Package Name ORA600413_20070702220937

Package Description

( ) Select from Existing Packages

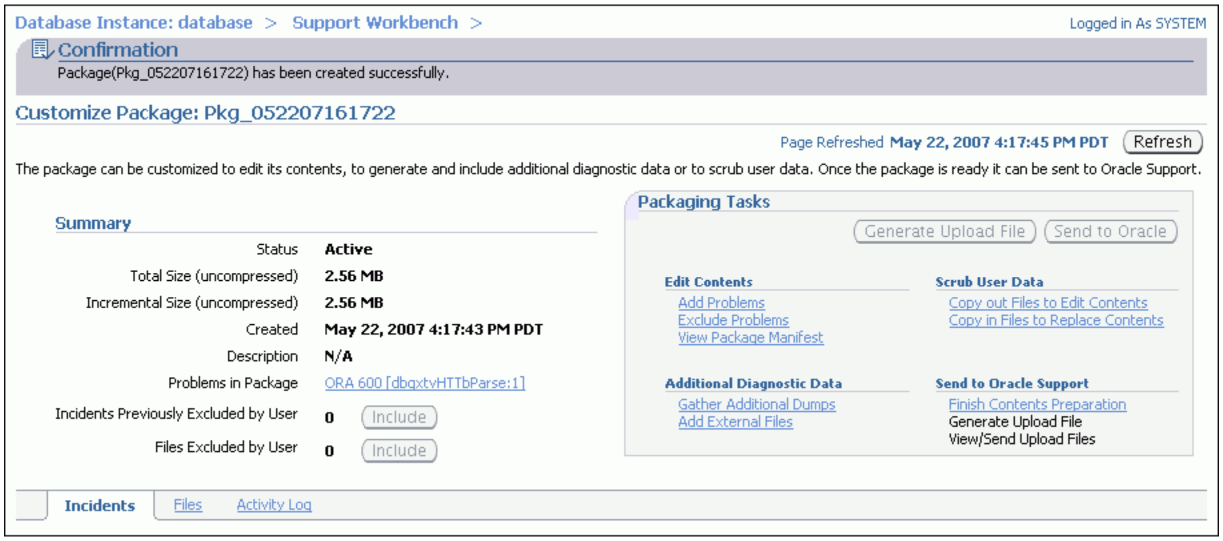
Select	Name	Status	Description	Main Problem Keys	Created
○	ORA603_20070702220811	Active		ORA 603	July 2, 2007 10:08:59 PM PDT
○	ORA600413_20070630232432	Upload File Generated	ORA_600-4137_070630	ORA 600 [4137]	June 30, 2007 11:25:17 PM PDT

5. Do one of the following:

   - To create a new package, select the **Create new package** option, enter a package name and description, and then click **OK**.
   - To add the selected problems to an existing package, select the **Select from existing packages** option, select the package to update, and then click **OK**.

   The Customize Package page appears. It displays the problems and incidents that are contained in the package, plus a selection of packaging tasks to choose from. You run these tasks against the new package or the updated existing package.

Figure 8–6 Customize Package Page



Database Instance: database > Support Workbench > Logged in As SYSTEM

Confirmation

Package(Pkg_052207161722) has been created successfully.

Customize Package: Pkg_052207161722

Page Refreshed **May 22, 2007 4:17:45 PM PDT** Refresh

The package can be customized to edit its contents, to generate and include additional diagnostic data or to scrub user data. Once the package is ready it can be sent to Oracle Support.

Summary

Status	**Active**
Total Size (uncompressed)	**2.56 MB**
Incremental Size (uncompressed)	**2.56 MB**
Created	**May 22, 2007 4:17:43 PM PDT**
Description	**N/A**
Problems in Package	ORA 600 [dbgxtvHTTbParse:1]
Incidents Previously Excluded by User	0 Include
Files Excluded by User	0 Include

Packaging Tasks

Generate Upload File Send to Oracle

Edit Contents: Add Problems, Exclude Problems, View Package Manifest

Scrub User Data: Copy out Files to Edit Contents, Copy in Files to Replace Contents

Additional Diagnostic Data: Gather Additional Dumps, Add External Files

Send to Oracle Support: Finish Contents Preparation, Generate Upload File, View/Send Upload Files

Incidents | Files | Activity Log

6. (Optional) In the Packaging Tasks section, click links to perform one or more packaging tasks. Or, use other controls on the Customize Package page and its

subpages to manipulate the package. Return to the Customize Package page when you are finished.

See "Viewing and Modifying Incident Packages" on page 8-35 for instructions for some of the most common packaging tasks.

7. In the Packaging Tasks section of the Customize Package page, under the heading Send to Oracle Support, click **Finish Contents Preparation** to finalize the package.

   A list (or partial list) of files included in the package is displayed. (This may take a while.) The list includes files that were determined to contain correlated diagnostic information and added by the finalization process.

   See "About Correlated Diagnostic Data in Incident Packages" on page 8-30 for a definition of package finalization.

8. Click the **Files** link to view all the files in the package. Examine the list to see if there are any files that might contain sensitive data that you do not want to expose. If you find such files, exclude (remove) or edit them.

   See "Editing Incident Package Files (Copying Out and In)" on page 8-37 and "Removing Incident Package Files" on page 8-40 for instructions for editing and removing files.

   To view the contents of a file, click the eyeglasses icon in the rightmost column in the table of files. Enter host credentials, if prompted.

   Note: Trace files are generally for Oracle internal use only.

9. Click **Generate Upload File**.

   The Generate Upload File page appears.

10. Select the **Full** or **Incremental** option to generate a full package zip file or an incremental package zip file.

    For a full package zip file, all the contents of the package (original contents and all correlated data) are always added to the zip file.

    For an incremental package zip file, only the diagnostic information that is new or modified since the last time that you created a zip file for the same package is added to the zip file. For example, if trace information was appended to a trace file since that file was last included in the generated physical file for a package, the trace file is added to the incremental package zip file. Conversely, if no changes were made to a trace file since it was last uploaded for a package, that trace file is not included in the incremental package zip file.

    Note: The Incremental option is dimmed (unavailable) if an upload file was never created for the package.

11. Schedule file creation either immediately or at a future date and time (select **Immediately** or **Later**), and then click **Submit**.

    File creation can use significant system resources, so it may be advisable to schedule it for a period of low system usage.

    A Processing page appears, and creation of the zip file proceeds. A confirmation page appears when processing is complete.

Note: The package is automatically finalized when the zip file is created.

12. Click **OK**.

    The Customize Package page returns.

13. Click **Send to Oracle**.

    The View/Send Upload Files page appears.

14. Select the zip files to upload, and then click **Send to Oracle**.

    The Send to Oracle page appears. The selected zip files are listed in a table.

15. Fill in the requested Oracle*MetaLink* information. Next to Create new Service Request (SR), select **Yes** or **No**. If you select Yes, a draft service request will be created for you. You must later log in to Oracle*MetaLink* and fill in the service request details. If you select No, enter an existing service request number.

16. Schedule the upload to take place immediately or at a future date and time, and then click **Submit**.

    A Processing page appears. If the upload is completed successfully, a confirmation page appears. If the upload could not complete, an error page appears. The error page may include a message that requests that you upload the zip file to Oracle manually. If so, contact your Oracle Support representative for instructions.

17. Click **OK**.

    The View/Send Upload Files page returns. Under the Time Sent column, check the status of the files that you attempted to upload.

Note: The Support Workbench uses Oracle Configuration Manager to upload the physical files. If Oracle Configuration Manager is not installed or properly configured, the upload may fail. In this case, a message is displayed with a path to the package zip file and a request that you upload the file to Oracle Support manually. You can upload manually with Oracle*MetaLink*.

For more information about Oracle Configuration Manager, see *Oracle Configuration Manager Installation and Administration Guide*.

See Also:

- "About Incidents and Problems" on page 8-3
- "About Incident Packages" on page 8-29
- "About Quick Packaging and Custom Packaging" on page 8-31

Viewing and Modifying Incident Packages

After creating an incident package with the custom packaging method, you can view or modify the contents of the package before uploading the package to Oracle Support. In addition, after using the quick packaging method to package and upload diagnostic data, you can view or modify the contents of the package that the Support Workbench created, and then reupload the package. To modify a package, you choose from among a selection of *packaging tasks*, most of which are available from the Customize Package page.

This section provides instructions for some of the most common packaging tasks. It includes the following topics:

- Editing Incident Package Files (Copying Out and In)
- Adding an External File to an Incident Package
- Removing Incident Package Files
- Viewing and Updating the Incident Package Activity Log

Also included are the following topics, which explains how to view package details and how to access the Customize Package page for a particular package:

- Viewing Package Details
- Accessing the Customize Package Page

See Also:

- "About Incident Packages" on page 8-29
- "Packaging and Uploading Problems with Custom Packaging" on page 8-32

Viewing Package Details

The Package Details page contains information about the incidents, trace files, and other files in a package, and enables you to view and add to the package activity log.

To view package details:

1. Access the Support Workbench home page.

   See "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16 for instructions.

2. Click the **Packages** link to view the Packages subpage.

   A list of packages that are currently in the Automatic Diagnostic Repository (ADR) is displayed.

3. (Optional) To reduce the number of packages displayed, enter text into the **Search** field above the list, and then click **Go**.

   All packages that contain the search text anywhere in the package name are displayed. To view the full list of packages, click the **Packages** link again.

4. Under the Package Name column, click the link for the desired package.

   The Package Details page appears.

Accessing the Customize Package Page

The Customize Package page is used to perform various packaging tasks, such as adding and removing problems; adding, removing, and scrubbing (editing) package files; and generating and uploading the package zip file.

To access the Customize Package page:

1. Access the Package Details page for the desired package, as described in "Viewing Package Details" on page 8-36.
2. Click **Customize Package**.

The Customize Package page appears.

Editing Incident Package Files (Copying Out and In)

The Support Workbench enables you to edit one or more files in an incident package. You may want to do this to delete or overwrite sensitive data in the files. To edit package files, you must first copy the files out of the package into a designated directory, edit the files with a text editor or other utility, and then copy the files back into the package, overwriting the original package files.

The following procedure assumes that the package is already created and contains diagnostic data.

To edit incident package files:

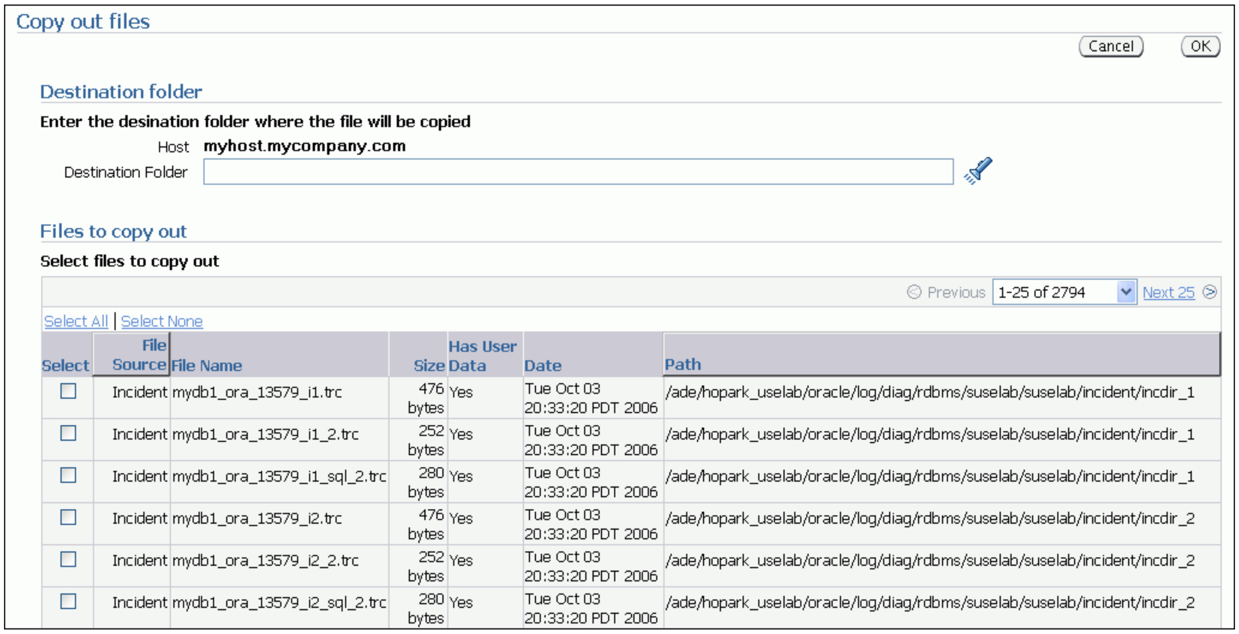
1. Access the Customize Package page for the desired incident package.

   See "Accessing the Customize Package Page" on page 8-36 for instructions.

2. In the Packaging Tasks section, under the Scrub User Data heading, click **Copy out Files to Edit contents**.

   The Copy Out Files page appears. It displays the name of the host to which you can copy files.

Figure 8–7 Copy Out Files Page



Copy out files

Destination folder

Enter the desination folder where the file will be copied

Host myhost.mycompany.com

Destination Folder

Files to copy out

Select files to copy out

Previous 1-25 of 2794 Next 25

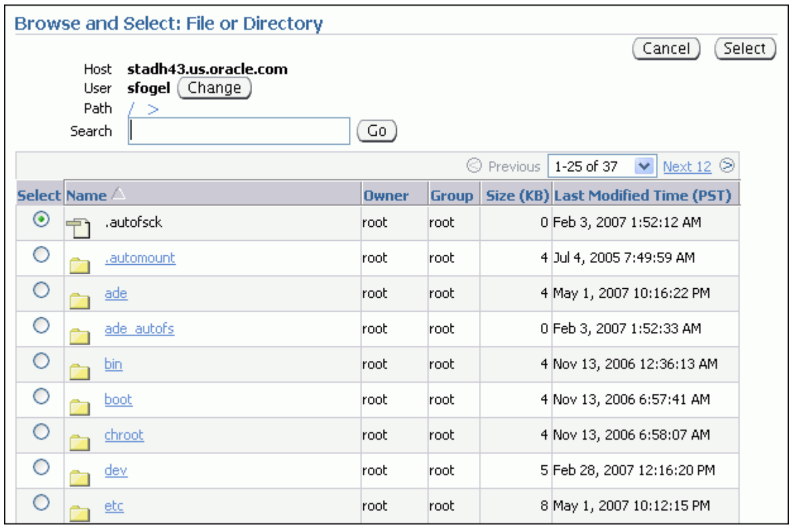
Select All | Select None

Select	File Source	File Name	Size	Has User Data	Date	Path
☐	Incident	mydb1_ora_13579_i1.trc	476 bytes	Yes	Tue Oct 03 20:33:20 PDT 2006	/ade/hopark_uselab/oracle/log/diag/rdbms/suselab/suselab/incident/incdir_1
☐	Incident	mydb1_ora_13579_i1_2.trc	252 bytes	Yes	Tue Oct 03 20:33:20 PDT 2006	/ade/hopark_uselab/oracle/log/diag/rdbms/suselab/suselab/incident/incdir_1
☐	Incident	mydb1_ora_13579_i1_sql_2.trc	280 bytes	Yes	Tue Oct 03 20:33:20 PDT 2006	/ade/hopark_uselab/oracle/log/diag/rdbms/suselab/suselab/incident/incdir_1
☐	Incident	mydb1_ora_13579_i2.trc	476 bytes	Yes	Tue Oct 03 20:33:20 PDT 2006	/ade/hopark_uselab/oracle/log/diag/rdbms/suselab/suselab/incident/incdir_2
☐	Incident	mydb1_ora_13579_i2_2.trc	252 bytes	Yes	Tue Oct 03 20:33:20 PDT 2006	/ade/hopark_uselab/oracle/log/diag/rdbms/suselab/suselab/incident/incdir_2
☐	Incident	mydb1_ora_13579_i2_sql_2.trc	280 bytes	Yes	Tue Oct 03 20:33:20 PDT 2006	/ade/hopark_uselab/oracle/log/diag/rdbms/suselab/suselab/incident/incdir_2

3. Do one of the following to specify a destination directory for the files:

   - Enter a directory path in the **Destination Folder** field.
   - Click the flashlight icon next to the **Destination Folder** field, and then complete the following steps:
     - If prompted for host credentials, enter credentials for the host to which you want to copy out the files, and then click **OK**. (Select **Save as Preferred Credential** to avoid the prompt for credentials next time.)
     - In the Browse and Select File or Directory window, click directory links to move down the directory hierarchy, and click directory names next to the

Path label to move up the directory hierarchy, until you see the desired destination directory.



Browse and Select: File or Directory

Host **stadh43.us.oracle.com**
User **sfogel** Change
Path / >
Search

Select	Name	Owner	Group	Size (KB)	Last Modified Time (PST)
●	.autofsck	root	root	0	Feb 3, 2007 1:52:12 AM
○	.automount	root	root	4	Jul 4, 2005 7:49:59 AM
○	ade	root	root	4	May 1, 2007 10:16:22 PM
○	ade_autofs	root	root	0	Feb 3, 2007 1:52:33 AM
○	bin	root	root	4	Nov 13, 2006 12:36:13 AM
○	boot	root	root	4	Nov 13, 2006 6:57:41 AM
○	chroot	root	root	4	Nov 13, 2006 6:58:07 AM
○	dev	root	root	5	Feb 28, 2007 12:16:20 PM
○	etc	root	root	8	May 1, 2007 10:12:15 PM

To reduce the number of directories displayed in the list, enter search text in the **Search** field and click **Go**. All directories that have the search text anywhere in the directory name are displayed.

– Select the desired destination directory, and then click **Select**.

  The Browse and Select File or Directory window closes, and the path to the selected directory appears in the Destination Folder field of the Copy Out Files page.

4. Under Files to Copy Out, select the desired files, and then click **OK**.

   Note: If you do not see the desired files, they may be on another page. Click the **Next** link to view the next page. Continue clicking **Next**, or select from the list of file numbers (to the left of the Next link) until you see the desired files. You can then select the files and click **OK**.

   The Customize Package page returns, displaying a confirmation message that lists the files that were copied out.

5. Using a text editor or other utility, edit the files.

6. On the Customize Package page, in the Packaging Tasks section, under the Scrub User Data heading, click **Copy in Files to Replace Contents**.

   The Copy In Files page appears. It displays the files that you copied out.

7. Select the files to copy in, and then click **OK**.

   The files are copied into the package, overwriting the existing files. The Customize Package page returns, displaying a confirmation message that lists the files that were copied in.

Adding an External File to an Incident Package

You can add any type of external file to an incident package.

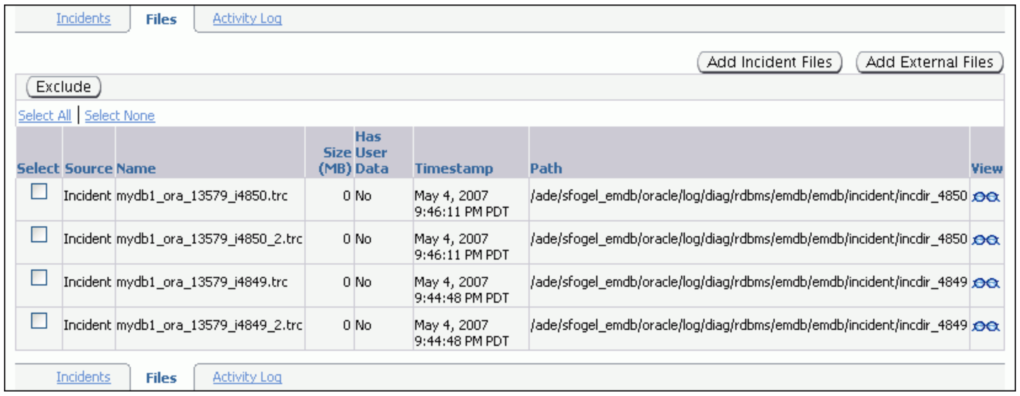
To add an external file to an incident package:

1. Access the Customize Package page for the desired incident package.

   See "Accessing the Customize Package Page" on page 8-36 for instructions.

2. Click the **Files** link to view the Files subpage.

Figure 8–8 Files Subpage of Customize Package Page



Select	Source	Name	Size (MB)	Has User Data	Timestamp	Path	View
☐	Incident	mydb1_ora_13579_i4850.trc	0	No	May 4, 2007 9:46:11 PM PDT	/ade/sfogel_emdb/oracle/log/diag/rdbms/emdb/emdb/incident/incdir_4850	
☐	Incident	mydb1_ora_13579_i4850_2.trc	0	No	May 4, 2007 9:46:11 PM PDT	/ade/sfogel_emdb/oracle/log/diag/rdbms/emdb/emdb/incident/incdir_4850	
☐	Incident	mydb1_ora_13579_i4849.trc	0	No	May 4, 2007 9:44:48 PM PDT	/ade/sfogel_emdb/oracle/log/diag/rdbms/emdb/emdb/incident/incdir_4849	
☐	Incident	mydb1_ora_13579_i4849_2.trc	0	No	May 4, 2007 9:44:48 PM PDT	/ade/sfogel_emdb/oracle/log/diag/rdbms/emdb/emdb/incident/incdir_4849	

From this page, you can add and remove files to and from the package.

Note: The View list appears only for packages for which you already created a physical file. It enables you to view either incremental package contents or the full package contents. The default selection is incremental package contents. This default selection displays only those package files that were created or modified since the last time that a physical file was generated for the package.

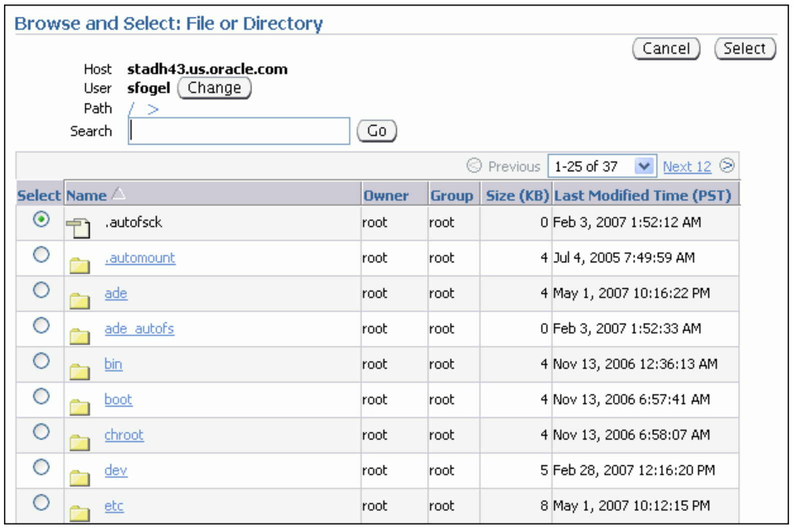
---

3. Click **Add external files**.

   The Add External File page appears. It displays the host name from which you may select a file.

4. Do one of the following to specify a file to add:

   - Enter the full path to the file in the **File Name** field.
   - Click the flashlight icon next to the **File Name** field, and then complete the following steps:
     – If prompted for host credentials, enter credentials for the host on which the external file resides, and then click **OK**. (Select **Save as Preferred Credential** to avoid the prompt for credentials next time.)
     – In the Browse and Select File or Directory window, click directory links to move down the directory hierarchy, and click directory names next to the **Path** label to move up the directory hierarchy, until you see the desired file.



Host stadh43.us.oracle.com
User sfogel
Path / >
Search

1-25 of 37

Select	Name	Owner	Group	Size (KB)	Last Modified Time (PST)
●	.autofsck	root	root	0	Feb 3, 2007 1:52:12 AM
○	.automount	root	root	4	Jul 4, 2005 7:49:59 AM
○	ade	root	root	4	May 1, 2007 10:16:22 PM
○	ade_autofs	root	root	0	Feb 3, 2007 1:52:33 AM
○	bin	root	root	4	Nov 13, 2006 12:36:13 AM
○	boot	root	root	4	Nov 13, 2006 6:57:41 AM
○	chroot	root	root	4	Nov 13, 2006 6:58:07 AM
○	dev	root	root	5	Feb 28, 2007 12:16:20 PM
○	etc	root	root	8	May 1, 2007 10:12:15 PM

To reduce the number of files or directories displayed in the list, enter search text in the **Search** field and click **Go**. All files or directories that have the search text anywhere in the file name or directory name are displayed.

– In the Select column, click to select the desired file, and then click **Select**.

  The Browse and Select window closes, and the path to the selected file appears in the File Name field of the Add External File page.

5. Click **OK**.

   The Customize Package page returns, displaying the Files subpage. The selected file is now shown in the list of files.

Removing Incident Package Files

You can remove one or more files of any type from the incident package.

To remove incident package files:

1. Access the Customize Package page for the desired incident package.

   See "Accessing the Customize Package Page" on page 8-36 for instructions.

2. Click the **Files** link to view the Files subpage.

   A list of files in the package is displayed.

   If you have not yet generated a physical file for this package, all package files are displayed in the list. If you have already generated a physical file, a View list appears above the files list. It enables you to choose between viewing only incremental package contents or the full package contents. The default selection is incremental package contents. This default selection displays only those package files that were created or modified since the last time that a physical file was generated for the package. Select **Full package contents** from the View list to view all package files.

3. Select the files to remove, and then click **Exclude**.

Note: If you do not see the desired files, they may be on another page. Click the **Next** link to view the next page. Continue clicking **Next**, or select from the list of file numbers (to the left of the Next link) until you see the desired files. You can then select the files and click **Remove**.

Viewing and Updating the Incident Package Activity Log

The Support Workbench maintains an activity log for each incident package. Most activities that you perform on a package, such as adding or removing files or creating a package zip file, are recorded in the log. You can also add your own notes to the log. This is especially useful if more than one database administrator is working with packages.

To view and update the incident package activity log:

1. Access the Package Details page for the desired incident package.

   See "Accessing the Customize Package Page" on page 8-36 for instructions.

2. Click the **Activity Log** link to view the Activity Log subpage.

   The activity log is displayed.

3. To add your own note to the activity log, enter text into the **Note** field, and then click **Add Note**.

   Your note is timestamped and appended to the list.

Setting Incident Packaging Preferences

This section provides instructions for setting incident packaging preferences. Examples of incident packaging preferences include the number of days to retain incident information, and the number of leading and trailing incidents to include in a package for each problem. (By default, if a problem has many incidents, only the first three and last three incidents are packaged.) You can change these and other incident packaging preferences with Enterprise Manager or with the ADRCI utility.

To set incident packaging preferences with Enterprise Manager:

1. Access the Support Workbench home page.

   See "Viewing Problems with the Enterprise Manager Support Workbench" on page 8-16 for instructions.

2. In the Related Links section at the bottom of the page, click **Incident Packaging Configuration**.

   The View Incident Packaging Configuration page appears. Click **Help** to view descriptions of the settings on this page.

3. Click **Edit**.

   The Edit Incident Packaging Configuration page appears.

4. Edit settings, and then click **OK** to apply changes.

See Also:

- "About Incident Packages" on page 8-29
- "About Incidents and Problems" on page 8-3
- "Task 5 – Package and Upload Diagnostic Data to Oracle Support" on page 8-13
- *Oracle Database Utilities* for information on ADRCI

Part II

Oracle Database Structure and Storage

This part describes database structure in terms of its storage components and how to create and manage those components. It contains the following chapters:

9 Managing Control Files

This chapter explains how to create and maintain the control files for your database and contains the following topics:

See Also: Chapter 15, "Using Oracle-Managed Files" for information about creating control files that are both created and managed by the Oracle Database server

What Is a Control File?

Every Oracle Database has a **control file**, which is a small binary file that records the physical structure of the database. The control file includes:

- The database name
- Names and locations of associated datafiles and redo log files
- The timestamp of the database creation
- The current log sequence number
- Checkpoint information

The control file must be available for writing by the Oracle Database server whenever the database is open. Without the control file, the database cannot be mounted and recovery is difficult.

The control file of an Oracle Database is created at the same time as the database. By default, at least one copy of the control file is created during database creation. On some operating systems the default is to create multiple copies. You should create two or more copies of the control file during database creation. You can also create control files later, if you lose control files or want to change particular settings in the control files.

Guidelines for Control Files

This section describes guidelines you can use to manage the control files for a database, and contains the following topics:

- Provide Filenames for the Control Files
- Multiplex Control Files on Different Disks
- Back Up Control Files
- Manage the Size of Control Files

Provide Filenames for the Control Files

You specify control file names using the `CONTROL_FILES` initialization parameter in the database initialization parameter file (see "Creating Initial Control Files" on page 9-3). The instance recognizes and opens all the listed file during startup, and the instance writes to and maintains all listed control files during database operation.

If you do not specify files for `CONTROL_FILES` before database creation:

- If you are not using Oracle-managed files, then the database creates a control file and uses a default filename. The default name is operating system specific.
- If you are using Oracle-managed files, then the initialization parameters you set to enable that feature determine the name and location of the control files, as described in Chapter 15, "Using Oracle-Managed Files".
- If you are using Automatic Storage Management, you can place incomplete ASM filenames in the `DB_CREATE_FILE_DEST` and `DB_RECOVERY_FILE_DEST` initialization parameters. ASM then automatically creates control files in the appropriate places. See the sections "About ASM Filenames" and "Creating a Database That Uses ASM" in *Oracle Database Storage Administrator's Guide* for more information.

Multiplex Control Files on Different Disks

Every Oracle Database should have at least two control files, each stored on a different physical disk. If a control file is damaged due to a disk failure, the associated instance must be shut down. Once the disk drive is repaired, the damaged control file can be restored using the intact copy of the control file from the other disk and the instance can be restarted. In this case, no media recovery is required.

The behavior of multiplexed control files is this:

- The database writes to all filenames listed for the initialization parameter `CONTROL_FILES` in the database initialization parameter file.
- The database reads only the first file listed in the `CONTROL_FILES` parameter during database operation.
- If any of the control files become unavailable during database operation, the instance becomes inoperable and should be aborted.

Note: Oracle strongly recommends that your database has a minimum of two control files and that they are located on separate physical disks.

One way to multiplex control files is to store a control file copy on every disk drive that stores members of redo log groups, if the redo log is multiplexed. By storing control files in these locations, you minimize the risk that all control files and all groups of the redo log will be lost in a single disk failure.

Back Up Control Files

It is very important that you back up your control files. This is true initially, and every time you change the physical structure of your database. Such structural changes include:

- Adding, dropping, or renaming datafiles
- Adding or dropping a tablespace, or altering the read/write state of the tablespace
- Adding or dropping redo log files or groups

The methods for backing up control files are discussed in "Backing Up Control Files" on page 9-8.

Manage the Size of Control Files

The main determinants of the size of a control file are the values set for the `MAXDATAFILES`, `MAXLOGFILES`, `MAXLOGMEMBERS`, `MAXLOGHISTORY`, and `MAXINSTANCES` parameters in the `CREATE DATABASE` statement that created the associated database. Increasing the values of these parameters increases the size of a control file of the associated database.

See Also:

- Your operating system specific Oracle documentation contains more information about the maximum control file size.
- *Oracle Database SQL Language Reference* for a description of the `CREATE DATABASE` statement

Creating Control Files

This section describes ways to create control files, and contains the following topics:

- Creating Initial Control Files
- Creating Additional Copies, Renaming, and Relocating Control Files
- Creating New Control Files

Creating Initial Control Files

The initial control files of an Oracle Database are created when you issue the `CREATE DATABASE` statement. The names of the control files are specified by the `CONTROL_FILES` parameter in the initialization parameter file used during database creation. The filenames specified in `CONTROL_FILES` should be fully specified and are operating system specific. The following is an example of a `CONTROL_FILES` initialization parameter:

```
CONTROL_FILES = (/u01/oracle/prod/control01.ctl,
                 /u02/oracle/prod/control02.ctl,
                 /u03/oracle/prod/control03.ctl)
```

If files with the specified names currently exist at the time of database creation, you must specify the `CONTROLFILE REUSE` clause in the `CREATE DATABASE` statement, or else an error occurs. Also, if the size of the old control file differs from the `SIZE` parameter of the new one, you cannot use the `REUSE` clause.

The size of the control file changes between some releases of Oracle Database, as well as when the number of files specified in the control file changes. Configuration parameters such as `MAXLOGFILES`, `MAXLOGMEMBERS`, `MAXLOGHISTORY`, `MAXDATAFILES`, and `MAXINSTANCES` affect control file size.

You can subsequently change the value of the `CONTROL_FILES` initialization parameter to add more control files or to change the names or locations of existing control files.

See Also: Your operating system specific Oracle documentation contains more information about specifying control files.

Creating Additional Copies, Renaming, and Relocating Control Files

You can create an additional control file copy for multiplexing by copying an existing control file to a new location and adding the file name to the list of control files. Similarly, you rename an existing control file by copying the file to its new name or location, and changing the file name in the control file list. In both cases, to guarantee that control files do not change during the procedure, shut down the database before copying the control file.

To add a multiplexed copy of the current control file or to rename a control file:

1. Shut down the database.
2. Copy an existing control file to a new location, using operating system commands.
3. Edit the `CONTROL_FILES` parameter in the database initialization parameter file to add the new control file name, or to change the existing control filename.
4. Restart the database.

Creating New Control Files

This section discusses when and how to create new control files.

When to Create New Control Files

It is necessary for you to create new control files in the following situations:

- All control files for the database have been permanently damaged and you do not have a control file backup.
- You want to change the database name.

  For example, you would change a database name if it conflicted with another database name in a distributed environment.

Note: You can change the database name and DBID (internal database identifier) using the DBNEWID utility. See *Oracle Database Utilities* for information about using this utility.

- The compatibility level is set to a value that is earlier than 10.2.0, and you must make a change to an area of database configuration that relates to any of the following parameters from the `CREATE DATABASE` or `CREATE CONTROLFILE` commands: `MAXLOGFILES`, `MAXLOGMEMBERS`, `MAXLOGHISTORY`, and `MAXINSTANCES`. If compatibility is 10.2.0 or later, you do not have to create new control files when you make such a change; the control files automatically expand, if necessary, to accommodate the new configuration information.

For example, assume that when you created the database or recreated the control files, you set `MAXLOGFILES` to 3. Suppose that now you want to add a fourth redo log file group to the database with the `ALTER DATABASE` command. If compatibility is set to 10.2.0 or later, you can do so and the controlfiles automatically expand to accommodate the new logfile information. However, with compatibility set earlier than 10.2.0, your `ALTER DATABASE` command would generate an error, and you would have to first create new control files.

For information on compatibility level, see "The COMPATIBLE Initialization Parameter and Irreversible Compatibility" on page 2-25.

The CREATE CONTROLFILE Statement

You can create a new control file for a database using the `CREATE CONTROLFILE` statement. The following statement creates a new control file for the `prod` database (a database that formerly used a different database name):

```
CREATE CONTROLFILE
   SET DATABASE prod
   LOGFILE GROUP 1 ('/u01/oracle/prod/redo01_01.log',
                    '/u01/oracle/prod/redo01_02.log'),
           GROUP 2 ('/u01/oracle/prod/redo02_01.log',
                    '/u01/oracle/prod/redo02_02.log'),
           GROUP 3 ('/u01/oracle/prod/redo03_01.log',
                    '/u01/oracle/prod/redo03_02.log')
   RESETLOGS
   DATAFILE '/u01/oracle/prod/system01.dbf' SIZE 3M,
            '/u01/oracle/prod/rbs01.dbs' SIZE 5M,
            '/u01/oracle/prod/users01.dbs' SIZE 5M,
            '/u01/oracle/prod/temp01.dbs' SIZE 5M
   MAXLOGFILES 50
   MAXLOGMEMBERS 3
   MAXLOGHISTORY 400
   MAXDATAFILES 200
   MAXINSTANCES 6
   ARCHIVELOG;
```

Cautions:

- The `CREATE CONTROLFILE` statement can potentially damage specified datafiles and redo log files. Omitting a filename can cause loss of the data in that file, or loss of access to the entire database. Use caution when issuing this statement and be sure to follow the instructions in "Steps for Creating New Control Files".
- If the database had forced logging enabled before creating the new control file, and you want it to continue to be enabled, then you must specify the `FORCE LOGGING` clause in the `CREATE CONTROLFILE` statement. See "Specifying FORCE LOGGING Mode" on page 2-18.

See Also: *Oracle Database SQL Language Reference* describes the complete syntax of the `CREATE CONTROLFILE` statement

Steps for Creating New Control Files

Complete the following steps to create a new control file.

1. Make a list of all datafiles and redo log files of the database.

   If you follow recommendations for control file backups as discussed in "Backing Up Control Files" on page 9-8, you will already have a list of datafiles and redo log files that reflect the current structure of the database. However, if you have no such list, executing the following statements will produce one.

   ```
   SELECT MEMBER FROM V$LOGFILE;
   SELECT NAME FROM V$DATAFILE;
   SELECT VALUE FROM V$PARAMETER WHERE NAME = 'control_files';
   ```

   If you have no such lists and your control file has been damaged so that the database cannot be opened, try to locate all of the datafiles and redo log files that constitute the database. Any files not specified in step 5 are not recoverable once a new control file has been created. Moreover, if you omit any of the files that make up the `SYSTEM` tablespace, you might not be able to recover the database.

2. Shut down the database.

   If the database is open, shut down the database normally if possible. Use the `IMMEDIATE` or `ABORT` clauses only as a last resort.

3. Back up all datafiles and redo log files of the database.

4. Start up a new instance, but do not mount or open the database:

   ```
   STARTUP NOMOUNT
   ```

5. Create a new control file for the database using the `CREATE CONTROLFILE` statement.

   When creating a new control file, specify the `RESETLOGS` clause if you have lost any redo log groups in addition to control files. In this case, you will need to recover from the loss of the redo logs (step 8). You must specify the `RESETLOGS` clause if you have renamed the database. Otherwise, select the `NORESETLOGS` clause.

6. Store a backup of the new control file on an offline storage device. See "Backing Up Control Files" on page 9-8 for instructions for creating a backup.

7. Edit the `CONTROL_FILES` initialization parameter for the database to indicate all of the control files now part of your database as created in step 5 (not including the backup control file). If you are renaming the database, edit the `DB_NAME` parameter in your instance parameter file to specify the new name.

8. Recover the database if necessary. If you are not recovering the database, skip to step 9.

   If you are creating the control file as part of recovery, recover the database. If the new control file was created using the `NORESETLOGS` clause (step 5), you can recover the database with complete, closed database recovery.

   If the new control file was created using the `RESETLOGS` clause, you must specify `USING BACKUP CONTROL FILE`. If you have lost online or archived redo logs or datafiles, use the procedures for recovering those files.

   > **See Also:** *Oracle Database Backup and Recovery User's Guide* for information about recovering your database and methods of recovering a lost control file

9. Open the database using one of the following methods:

   - If you did not perform recovery, or you performed complete, closed database recovery in step 8, open the database normally.

     ```
     ALTER DATABASE OPEN;
     ```

   - If you specified `RESETLOGS` when creating the control file, use the `ALTER DATABASE` statement, indicating `RESETLOGS`.

     ```
     ALTER DATABASE OPEN RESETLOGS;
     ```

   The database is now open and available for use.

Troubleshooting After Creating Control Files

After issuing the `CREATE CONTROLFILE` statement, you may encounter some errors. This section describes the most common control file errors:

- Checking for Missing or Extra Files
- Handling Errors During CREATE CONTROLFILE

Checking for Missing or Extra Files

After creating a new control file and using it to open the database, check the alert log to see if the database has detected inconsistencies between the data dictionary and the control file, such as a datafile in the data dictionary includes that the control file does not list.

If a datafile exists in the data dictionary but not in the new control file, the database creates a placeholder entry in the control file under the name `MISSING`*nnnn*, where *nnnn* is the file number in decimal. `MISSING`*nnnn* is flagged in the control file as being offline and requiring media recovery.

If the actual datafile corresponding to `MISSING`*nnnn* is read-only or offline normal, then you can make the datafile accessible by renaming `MISSING`*nnnn* to the name of the actual datafile. If `MISSING`*nnnn* corresponds to a datafile that was not read-only or offline normal, then you cannot use the rename operation to make the datafile accessible, because the datafile requires media recovery that is precluded by the results of `RESETLOGS`. In this case, you must drop the tablespace containing the datafile.

Conversely, if a datafile listed in the control file is not present in the data dictionary, then the database removes references to it from the new control file. In both cases, the database includes an explanatory message in the alert log to let you know what was found.

Handling Errors During CREATE CONTROLFILE

If Oracle Database sends you an error (usually error `ORA-01173`, `ORA-01176`, `ORA-01177`, `ORA-01215`, or `ORA-01216`) when you attempt to mount and open the database after creating a new control file, the most likely cause is that you omitted a file from the `CREATE CONTROLFILE` statement or included one that should not have been listed. In this case, you should restore the files you backed up in step 3 on page 9-6 and repeat the procedure from step 4, using the correct filenames.

Backing Up Control Files

Use the `ALTER DATABASE BACKUP CONTROLFILE` statement to back up your control files. You have two options:

1. Back up the control file to a binary file (duplicate of existing control file) using the following statement:

   ```
   ALTER DATABASE BACKUP CONTROLFILE TO '/oracle/backup/control.bkp';
   ```

2. Produce SQL statements that can later be used to re-create your control file:

   ```
   ALTER DATABASE BACKUP CONTROLFILE TO TRACE;
   ```

   This command writes a SQL script to the database trace file where it can be captured and edited to reproduce the control file.

See Also: *Oracle Database Backup and Recovery User's Guide* for more information on backing up your control files

Recovering a Control File Using a Current Copy

This section presents ways that you can recover your control file from a current backup or from a multiplexed copy.

Recovering from Control File Corruption Using a Control File Copy

This procedure assumes that one of the control files specified in the `CONTROL_FILES` parameter is corrupted, that the control file directory is still accessible, and that you have a multiplexed copy of the control file.

1. With the instance shut down, use an operating system command to overwrite the bad control file with a good copy:

   ```
   % cp /u03/oracle/prod/control03.ctl  /u02/oracle/prod/control02.ctl
   ```

2. Start SQL*Plus and open the database:

   ```
   SQL> STARTUP
   ```

Recovering from Permanent Media Failure Using a Control File Copy

This procedure assumes that one of the control files specified in the `CONTROL_FILES` parameter is inaccessible due to a permanent media failure and that you have a multiplexed copy of the control file.

1. With the instance shut down, use an operating system command to copy the current copy of the control file to a new, accessible location:

   ```
   % cp /u01/oracle/prod/control01.ctl  /u04/oracle/prod/control03.ctl
   ```

2. Edit the `CONTROL_FILES` parameter in the initialization parameter file to replace the bad location with the new location:

   ```
   CONTROL_FILES = (/u01/oracle/prod/control01.ctl,
                    /u02/oracle/prod/control02.ctl,
                    /u04/oracle/prod/control03.ctl)
   ```

3. Start SQL*Plus and open the database:

   ```
   SQL> STARTUP
   ```

If you have multiplexed control files, you can get the database started up quickly by editing the CONTROL_FILES initialization parameter. Remove the bad control file from CONTROL_FILES setting and you can restart the database immediately. Then you can perform the reconstruction of the bad control file and at some later time shut down and restart the database after editing the CONTROL_FILES initialization parameter to include the recovered control file.

Dropping Control Files

You want to drop control files from the database, for example, if the location of a control file is no longer appropriate. Remember that the database should have at least two control files at all times.

1. Shut down the database.
2. Edit the CONTROL_FILES parameter in the database initialization parameter file to delete the old control file name.
3. Restart the database.

Note: This operation does not physically delete the unwanted control file from the disk. Use operating system commands to delete the unnecessary file after you have dropped the control file from the database.

Control Files Data Dictionary Views

The following views display information about control files:

View	Description
V$DATABASE	Displays database information from the control file
V$CONTROLFILE	Lists the names of control files
V$CONTROLFILE_RECORD_SECTION	Displays information about control file record sections
V$PARAMETER	Displays the names of control files as specified in the CONTROL_FILES initialization parameter

This example lists the names of the control files.

```
SQL> SELECT NAME FROM V$CONTROLFILE;

NAME
-------------------------------------
/u01/oracle/prod/control01.ctl
/u02/oracle/prod/control02.ctl
/u03/oracle/prod/control03.ctl
```

10 Managing the Redo Log

This chapter explains how to manage the online redo log. The current redo log is always online, unlike archived copies of a redo log. Therefore, the online redo log is usually referred to as simply the **redo log**.

This chapter contains the following topics:

See Also: Chapter 15, "Using Oracle-Managed Files" for information about redo log files that are both created and managed by the Oracle Database server

What Is the Redo Log?

The most crucial structure for recovery operations is the **redo log**, which consists of two or more preallocated files that store all changes made to the database as they occur. Every instance of an Oracle Database has an associated redo log to protect the database in case of an instance failure.

Redo Threads

When speaking in the context of multiple database instances, the redo log for each database instance is also referred to as a *redo thread*. In typical configurations, only one database instance accesses an Oracle Database, so only one thread is present. In an Oracle Real Application Clusters environment, however, two or more instances concurrently access a single database and each instance has its own thread of redo. A separate redo thread for each instance avoids contention for a single set of redo log files, thereby eliminating a potential performance bottleneck.

This chapter describes how to configure and manage the redo log on a standard single-instance Oracle Database. The thread number can be assumed to be 1 in all discussions and examples of statements. For information about redo log groups in an Oracle Real Application Clusters environment, please refer to *Oracle Real Application Clusters Administration and Deployment Guide*.

Redo Log Contents

Redo log files are filled with **redo records**. A redo record, also called a **redo entry**, is made up of a group of **change vectors**, each of which is a description of a change made to a single block in the database. For example, if you change a salary value in an employee table, you generate a redo record containing change vectors that describe changes to the data segment block for the table, the undo segment data block, and the transaction table of the undo segments.

Redo entries record data that you can use to reconstruct all changes made to the database, including the undo segments. Therefore, the redo log also protects rollback data. When you recover the database using redo data, the database reads the change vectors in the redo records and applies the changes to the relevant blocks.

Redo records are buffered in a circular fashion in the redo log buffer of the SGA (see "How Oracle Database Writes to the Redo Log" on page 10-2) and are written to one of the redo log files by the Log Writer (LGWR) database background process. Whenever a transaction is committed, LGWR writes the transaction redo records from the redo log buffer of the SGA to a redo log file, and assigns a **system change number** (SCN) to identify the redo records for each committed transaction. Only when all redo records associated with a given transaction are safely on disk in the online logs is the user process notified that the transaction has been committed.

Redo records can also be written to a redo log file before the corresponding transaction is committed. If the redo log buffer fills, or another transaction commits, LGWR flushes all of the redo log entries in the redo log buffer to a redo log file, even though some redo records may not be committed. If necessary, the database can roll back these changes.

How Oracle Database Writes to the Redo Log

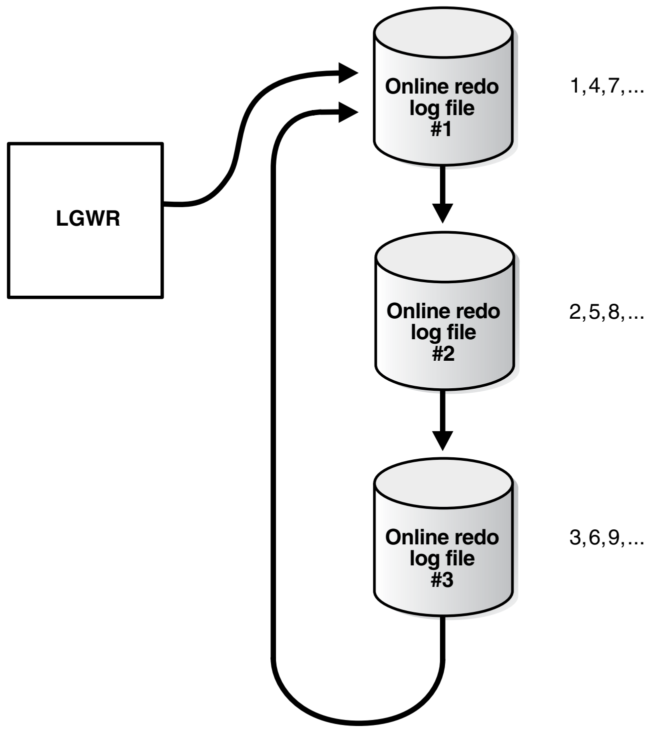
The redo log of a database consists of two or more redo log files. The database requires a minimum of two files to guarantee that one is always available for writing while the other is being archived (if the database is in `ARCHIVELOG` mode). See "Managing Archived Redo Logs" on page 11-1 for more information.

LGWR writes to redo log files in a circular fashion. When the current redo log file fills, LGWR begins writing to the next available redo log file. When the last available redo log file is filled, LGWR returns to the first redo log file and writes to it, starting the cycle again. Figure 10–1 illustrates the circular writing of the redo log file. The numbers next to each line indicate the sequence in which LGWR writes to each redo log file.

Filled redo log files are available to LGWR for reuse depending on whether archiving is enabled.

- If archiving is disabled (the database is in `NOARCHIVELOG` mode), a filled redo log file is available after the changes recorded in it have been written to the datafiles.
- If archiving is enabled (the database is in `ARCHIVELOG` mode), a filled redo log file is available to LGWR after the changes recorded in it have been written to the datafiles *and* the file has been archived.

Figure 10–1 Reuse of Redo Log Files by LGWR



Active (Current) and Inactive Redo Log Files

Oracle Database uses only one redo log files at a time to store redo records written from the redo log buffer. The redo log file that LGWR is actively writing to is called the **current** redo log file.

Redo log files that are required for instance recovery are called **active** redo log files. Redo log files that are no longer required for instance recovery are called **inactive** redo log files.

If you have enabled archiving (the database is in `ARCHIVELOG` mode), then the database cannot reuse or overwrite an active online log file until one of the archiver background processes (ARC*n*) has archived its contents. If archiving is disabled (the database is in `NOARCHIVELOG` mode), then when the last redo log file is full, LGWR continues by overwriting the first available active file.

Log Switches and Log Sequence Numbers

A **log switch** is the point at which the database stops writing to one redo log file and begins writing to another. Normally, a log switch occurs when the current redo log file is completely filled and writing must continue to the next redo log file. However, you can configure log switches to occur at regular intervals, regardless of whether the current redo log file is completely filled. You can also force log switches manually.

Oracle Database assigns each redo log file a new **log sequence number** every time a log switch occurs and LGWR begins writing to it. When the database archives redo log files, the archived log retains its log sequence number. A redo log file that is cycled back for use is given the next available log sequence number.

Each online or archived redo log file is uniquely identified by its log sequence number. During crash, instance, or media recovery, the database properly applies redo log files in ascending order by using the log sequence number of the necessary archived and redo log files.

Planning the Redo Log

This section provides guidelines you should consider when configuring a database instance redo log and contains the following topics:

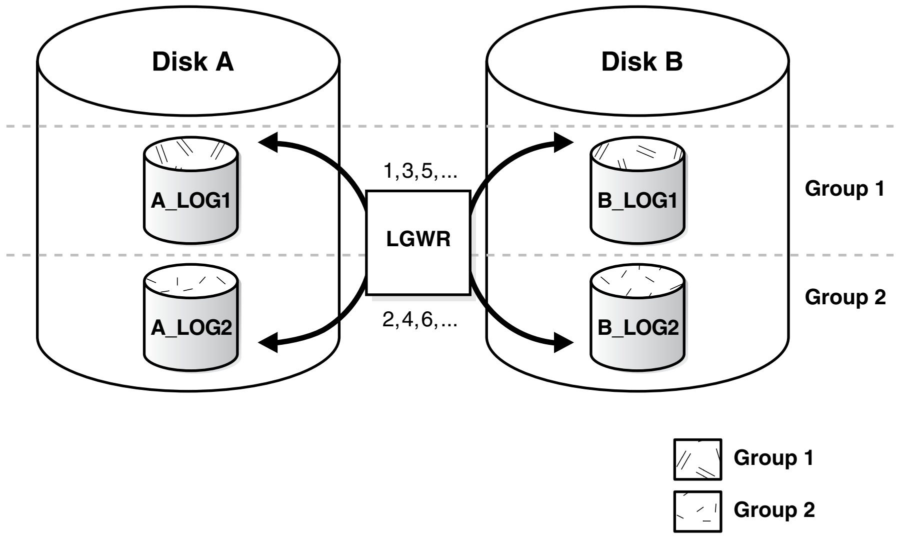
- Multiplexing Redo Log Files
- Placing Redo Log Members on Different Disks
- Setting the Size of Redo Log Members
- Choosing the Number of Redo Log Files
- Controlling Archive Lag

Multiplexing Redo Log Files

To protect against a failure involving the redo log itself, Oracle Database allows a **multiplexed** redo log, meaning that two or more identical copies of the redo log can be automatically maintained in separate locations. For the most benefit, these locations should be on separate disks. Even if all copies of the redo log are on the same disk, however, the redundancy can help protect against I/O errors, file corruption, and so on. When redo log files are multiplexed, LGWR concurrently writes the same redo log information to multiple identical redo log files, thereby eliminating a single point of redo log failure.

Multiplexing is implemented by creating *groups* of redo log files. A **group** consists of a redo log file and its multiplexed copies. Each identical copy is said to be a **member** of the group. Each redo log group is defined by a number, such as group 1, group 2, and so on.

Figure 10–2 Multiplexed Redo Log Files



In Figure 10–2, `A_LOG1` and `B_LOG1` are both members of Group 1, `A_LOG2` and `B_LOG2` are both members of Group 2, and so forth. Each member in a group must be exactly the same size.

Each member of a log file group is concurrently active—that is, concurrently written to by LGWR—as indicated by the identical log sequence numbers assigned by LGWR. In Figure 10–2, first LGWR writes concurrently to both `A_LOG1` and `B_LOG1`. Then it writes concurrently to both `A_LOG2` and `B_LOG2`, and so on. LGWR never writes concurrently to members of different groups (for example, to `A_LOG1` and `B_LOG2`).

Note: Oracle recommends that you multiplex your redo log files. The loss of the log file data can be catastrophic if recovery is required. Note that when you multiplex the redo log, the database must increase the amount of I/O that it performs. Depending on your configuration, this may impact overall database performance.

Responding to Redo Log Failure

Whenever LGWR cannot write to a member of a group, the database marks that member as `INVALID` and writes an error message to the LGWR trace file and to the database alert log to indicate the problem with the inaccessible files. The specific reaction of LGWR when a redo log member is unavailable depends on the reason for the lack of availability, as summarized in the table that follows.

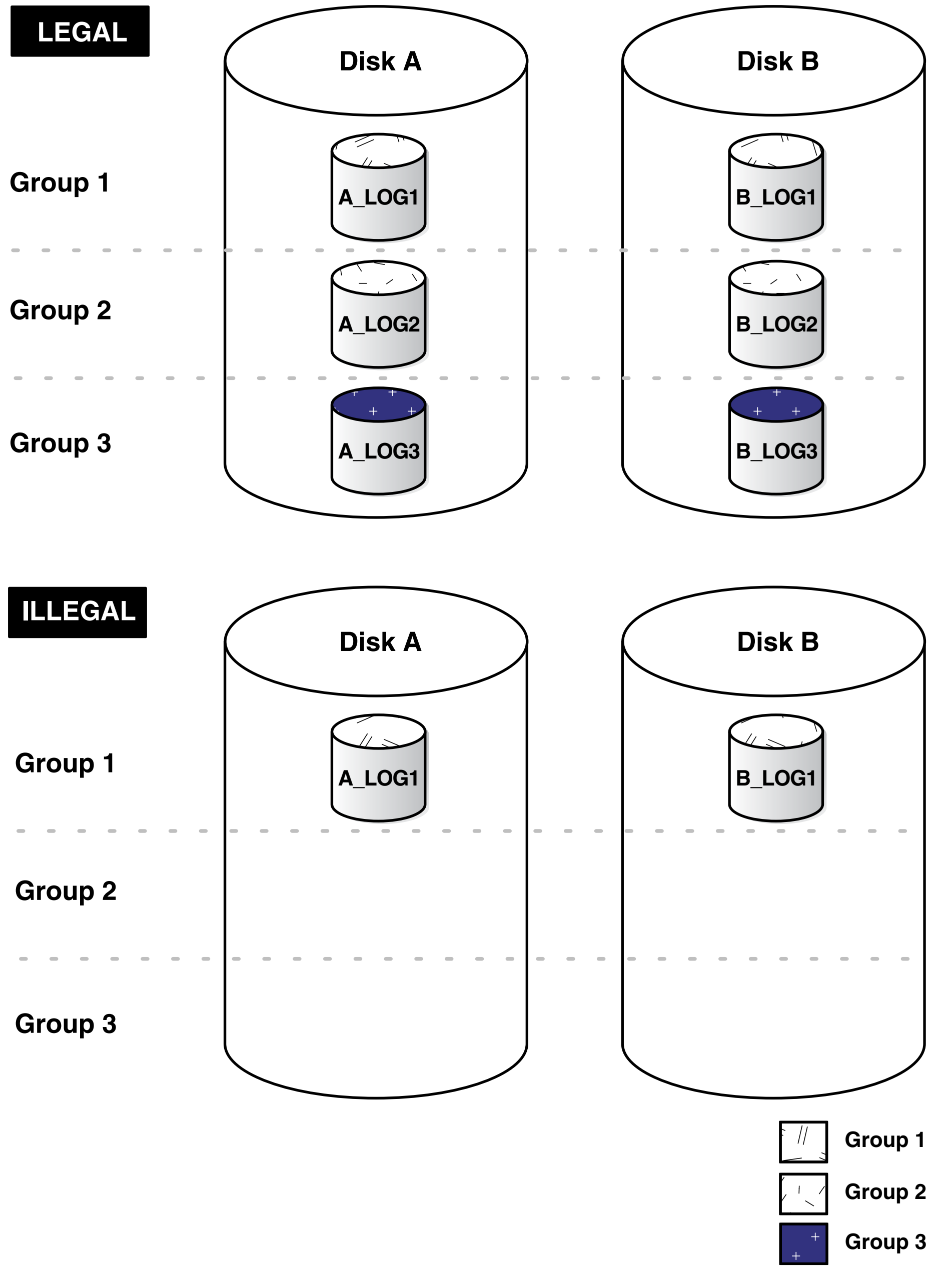
Condition	LGWR Action
LGWR can successfully write to at least one member in a group	Writing proceeds as normal. LGWR writes to the available members of a group and ignores the unavailable members.
LGWR cannot access the next group at a log switch because the group needs to be archived	Database operation temporarily halts until the group becomes available or until the group is archived.
All members of the next group are inaccessible to LGWR at a log switch because of media failure	Oracle Database returns an error, and the database instance shuts down. In this case, you may need to perform media recovery on the database from the loss of a redo log file. If the database checkpoint has moved beyond the lost redo log, media recovery is not necessary, because the database has saved the data recorded in the redo log to the datafiles. You need only drop the inaccessible redo log group. If the database did not archive the bad log, use `ALTER DATABASE CLEAR UNARCHIVED LOG` to disable archiving before the log can be dropped.
All members of a group suddenly become inaccessible to LGWR while it is writing to them	Oracle Database returns an error and the database instance immediately shuts down. In this case, you may need to perform media recovery. If the media containing the log is not actually lost--for example, if the drive for the log was inadvertently turned off--media recovery may not be needed. In this case, you need only turn the drive back on and let the database perform automatic instance recovery.

Legal and Illegal Configurations

In most cases, a multiplexed redo log should be symmetrical: all groups of the redo log should have the same number of members. However, the database does not require that a multiplexed redo log be symmetrical. For example, one group can have only one member, and other groups can have two members. This configuration protects against disk failures that temporarily affect some redo log members but leave others intact.

The only requirement for an instance redo log is that it have at least two groups. Figure 10–3 shows legal and illegal multiplexed redo log configurations. The second configuration is illegal because it has only one group.

Figure 10–3 Legal and Illegal Multiplexed Redo Log Configuration



Placing Redo Log Members on Different Disks

When setting up a multiplexed redo log, place members of a group on different physical disks. If a single disk fails, then only one member of a group becomes unavailable to LGWR and other members remain accessible to LGWR, so the instance can continue to function.

If you archive the redo log, spread redo log members across disks to eliminate contention between the LGWR and ARC*n* background processes. For example, if you have two groups of multiplexed redo log members (a *duplexed* redo log), place each member on a different disk and set your archiving destination to a fifth disk. Doing so will avoid contention between LGWR (writing to the members) and ARC*n* (reading the members).

Datafiles should also be placed on different disks from redo log files to reduce contention in writing data blocks and redo records.

Setting the Size of Redo Log Members

When setting the size of redo log files, consider whether you will be archiving the redo log. Redo log files should be sized so that a filled group can be archived to a single unit of offline storage media (such as a tape or disk), with the least amount of space on the medium left unused. For example, suppose only one filled redo log group can fit on a tape and 49% of the tape storage capacity remains unused. In this case, it is better to decrease the size of the redo log files slightly, so that two log groups could be archived on each tape.

All members of the same multiplexed redo log group must be the same size. Members of different groups can have different sizes. However, there is no advantage in varying file size between groups. If checkpoints are not set to occur between log switches, make all groups the same size to guarantee that checkpoints occur at regular intervals.

The minimum size permitted for a redo log file is 4 MB.

See Also: Your operating system–specific Oracle documentation. The default size of redo log files is operating system dependent.

Choosing the Number of Redo Log Files

The best way to determine the appropriate number of redo log files for a database instance is to test different configurations. The optimum configuration has the fewest groups possible without hampering LGWR from writing redo log information.

In some cases, a database instance may require only two groups. In other situations, a database instance may require additional groups to guarantee that a recycled group is always available to LGWR. During testing, the easiest way to determine whether the current redo log configuration is satisfactory is to examine the contents of the LGWR trace file and the database alert log. If messages indicate that LGWR frequently has to wait for a group because a checkpoint has not completed or a group has not been archived, add groups.

Consider the parameters that can limit the number of redo log files before setting up or altering the configuration of an instance redo log. The following parameters limit the number of redo log files that you can add to a database:

- The `MAXLOGFILES` parameter used in the `CREATE DATABASE` statement determines the maximum number of groups of redo log files for each database. Group values can range from 1 to `MAXLOGFILES`. When the compatibility level is set earlier than 10.2.0, the only way to override this upper limit is to re-create the database or its control file. Therefore, it is important to consider this limit before creating a database. When compatibility is set to 10.2.0 or later, you can exceed the `MAXLOGFILES` limit, and the control files expand as needed. If `MAXLOGFILES` is not specified for the `CREATE DATABASE` statement, then the database uses an operating system specific default value.
- The `MAXLOGMEMBERS` parameter used in the `CREATE DATABASE` statement determines the maximum number of members for each group. As with `MAXLOGFILES`, the only way to override this upper limit is to re-create the database or control file. Therefore, it is important to consider this limit before creating a database. If no `MAXLOGMEMBERS` parameter is specified for the `CREATE DATABASE` statement, then the database uses an operating system default value.

See Also:

- Your operating system specific Oracle documentation for the default and legal values of the `MAXLOGFILES` and `MAXLOGMEMBERS` parameters

Controlling Archive Lag

You can force all enabled redo log threads to switch their current logs at regular time intervals. In a primary/standby database configuration, changes are made available to the standby database by archiving redo logs at the primary site and then shipping them to the standby database. The changes that are being applied by the standby database can lag behind the changes that are occurring on the primary database, because the standby database must wait for the changes in the primary database redo log to be archived (into the archived redo log) and then shipped to it. To limit this lag, you can set the `ARCHIVE_LAG_TARGET` initialization parameter. Setting this parameter lets you specify in seconds how long that lag can be.

Setting the ARCHIVE_LAG_TARGET Initialization Parameter

When you set the `ARCHIVE_LAG_TARGET` initialization parameter, you cause the database to examine the current redo log of the instance periodically. If the following conditions are met, then the instance will switch the log:

- The current log was created prior to *n* seconds ago, and the estimated archival time for the current log is *m* seconds (proportional to the number of redo blocks used in the current log), where *n* + *m* exceeds the value of the `ARCHIVE_LAG_TARGET` initialization parameter.
- The current log contains redo records.

In an Oracle Real Application Clusters environment, the instance also causes other threads to switch and archive their logs if they are falling behind. This can be particularly useful when one instance in the cluster is more idle than the other instances (as when you are running a 2-node primary/secondary configuration of Oracle Real Application Clusters).

The `ARCHIVE_LAG_TARGET` initialization parameter specifies the target of how many seconds of redo the standby could lose in the event of a primary shutdown or failure if the Oracle Data Guard environment is not configured in a no-data-loss mode. It also provides an upper limit of how long (in seconds) the current log of the primary database can span. Because the estimated archival time is also considered, this is not the exact log switch time.

The following initialization parameter setting sets the log switch interval to 30 minutes (a typical value).

```
ARCHIVE_LAG_TARGET = 1800
```

A value of 0 disables this time-based log switching functionality. This is the default setting.

You can set the `ARCHIVE_LAG_TARGET` initialization parameter even if there is no standby database. For example, the `ARCHIVE_LAG_TARGET` parameter can be set specifically to force logs to be switched and archived.

`ARCHIVE_LAG_TARGET` is a dynamic parameter and can be set with the `ALTER SYSTEM SET` statement.

Caution: The `ARCHIVE_LAG_TARGET` parameter must be set to the same value in all instances of an Oracle Real Application Clusters environment. Failing to do so results in unpredictable behavior.

Factors Affecting the Setting of ARCHIVE_LAG_TARGET

Consider the following factors when determining if you want to set the `ARCHIVE_LAG_TARGET` parameter and in determining the value for this parameter.

- Overhead of switching (as well as archiving) logs
- How frequently normal log switches occur as a result of log full conditions
- How much redo loss is tolerated in the standby database

Setting `ARCHIVE_LAG_TARGET` may not be very useful if natural log switches already occur more frequently than the interval specified. However, in the case of irregularities of redo generation speed, the interval does provide an upper limit for the time range each current log covers.

If the `ARCHIVE_LAG_TARGET` initialization parameter is set to a very low value, there can be a negative impact on performance. This can force frequent log switches. Set the parameter to a reasonable value so as not to degrade the performance of the primary database.

Creating Redo Log Groups and Members

Plan the redo log of a database and create all required groups and members of redo log files during database creation. However, there are situations where you might want to create additional groups or members. For example, adding groups to a redo log can correct redo log group availability problems.

To create new redo log groups and members, you must have the `ALTER DATABASE` system privilege. A database can have up to `MAXLOGFILES` groups.

See Also: *Oracle Database SQL Language Reference* for a complete description of the `ALTER DATABASE` statement

Creating Redo Log Groups

To create a new group of redo log files, use the SQL statement `ALTER DATABASE` with the `ADD LOGFILE` clause.

The following statement adds a new group of redo logs to the database:

```
ALTER DATABASE
  ADD LOGFILE ('/oracle/dbs/log1c.rdo', '/oracle/dbs/log2c.rdo') SIZE 500K;
```

Note: Use fully specify filenames of new log members to indicate where the operating system file should be created. Otherwise, the files will be created in either the default or current directory of the database server, depending upon your operating system.

You can also specify the number that identifies the group using the `GROUP` clause:

```
ALTER DATABASE
  ADD LOGFILE GROUP 10 ('/oracle/dbs/log1c.rdo', '/oracle/dbs/log2c.rdo')
```

```
      SIZE 500K;
```

Using group numbers can make administering redo log groups easier. However, the group number must be between 1 and MAXLOGFILES. Do not skip redo log file group numbers (that is, do not number your groups 10, 20, 30, and so on), or you will consume unnecessary space in the control files of the database.

Creating Redo Log Members

In some cases, it might not be necessary to create a complete group of redo log files. A group could already exist, but not be complete because one or more members of the group were dropped (for example, because of a disk failure). In this case, you can add new members to an existing group.

To create new redo log members for an existing group, use the SQL statement ALTER DATABASE with the ADD LOGFILE MEMBER clause. The following statement adds a new redo log member to redo log group number 2:

```
ALTER DATABASE ADD LOGFILE MEMBER '/oracle/dbs/log2b.rdo' TO GROUP 2;
```

Notice that filenames must be specified, but sizes need not be. The size of the new members is determined from the size of the existing members of the group.

When using the ALTER DATABASE statement, you can alternatively identify the target group by specifying all of the other members of the group in the TO clause, as shown in the following example:

```
ALTER DATABASE ADD LOGFILE MEMBER '/oracle/dbs/log2c.rdo'
    TO ('/oracle/dbs/log2a.rdo', '/oracle/dbs/log2b.rdo');
```

Note: Fully specify the filenames of new log members to indicate where the operating system files should be created. Otherwise, the files will be created in either the default or current directory of the database server, depending upon your operating system. You may also note that the status of the new log member is shown as INVALID. This is normal and it will change to active (blank) when it is first used.

Relocating and Renaming Redo Log Members

You can use operating system commands to relocate redo logs, then use the ALTER DATABASE statement to make their new names (locations) known to the database. This procedure is necessary, for example, if the disk currently used for some redo log files is going to be removed, or if datafiles and a number of redo log files are stored on the same disk and should be separated to reduce contention.

To rename redo log members, you must have the ALTER DATABASE system privilege. Additionally, you might also need operating system privileges to copy files to the desired location and privileges to open and back up the database.

Before relocating your redo logs, or making any other structural changes to the database, completely back up the database in case you experience problems while performing the operation. As a precaution, after renaming or relocating a set of redo log files, immediately back up the database control file.

Use the following steps for relocating redo logs. The example used to illustrate these steps assumes:

- The log files are located on two disks: diska and diskb.

- The redo log is duplexed: one group consists of the members `/diska/logs/log1a.rdo` and `/diskb/logs/log1b.rdo`, and the second group consists of the members `/diska/logs/log2a.rdo` and `/diskb/logs/log2b.rdo`.
- The redo log files located on `diska` must be relocated to `diskc`. The new filenames will reflect the new location: `/diskc/logs/log1c.rdo` and `/diskc/logs/log2c.rdo`.

Steps for Renaming Redo Log Members

1. Shut down the database.

   ```
   SHUTDOWN
   ```

2. Copy the redo log files to the new location.

   Operating system files, such as redo log members, must be copied using the appropriate operating system commands. See your operating system specific documentation for more information about copying files.

   > **Note:** You can execute an operating system command to copy a file (or perform other operating system commands) without exiting SQL*Plus by using the `HOST` command. Some operating systems allow you to use a character in place of the word `HOST`. For example, you can use an exclamation point (!) in UNIX.

   The following example uses operating system commands (UNIX) to move the redo log members to a new location:

   ```
   mv /diska/logs/log1a.rdo /diskc/logs/log1c.rdo
   mv /diska/logs/log2a.rdo /diskc/logs/log2c.rdo
   ```

3. Startup the database, mount, but do not open it.

   ```
   CONNECT / as SYSDBA
   STARTUP MOUNT
   ```

4. Rename the redo log members.

   Use the `ALTER DATABASE` statement with the `RENAME FILE` clause to rename the database redo log files.

   ```
   ALTER DATABASE
     RENAME FILE '/diska/logs/log1a.rdo', '/diska/logs/log2a.rdo'
              TO '/diskc/logs/log1c.rdo', '/diskc/logs/log2c.rdo';
   ```

5. Open the database for normal operation.

   The redo log alterations take effect when the database is opened.

   ```
   ALTER DATABASE OPEN;
   ```

Dropping Redo Log Groups and Members

In some cases, you may want to drop an entire group of redo log members. For example, you want to reduce the number of groups in an instance redo log. In a different case, you may want to drop one or more specific redo log members. For example, if a disk failure occurs, you may need to drop all the redo log files on the failed disk so that the database does not try to write to the inaccessible files. In other situations, particular redo log files become unnecessary. For example, a file might be stored in an inappropriate location.

Dropping Log Groups

To drop a redo log group, you must have the `ALTER DATABASE` system privilege. Before dropping a redo log group, consider the following restrictions and precautions:

- An instance requires at least two groups of redo log files, regardless of the number of members in the groups. (A group comprises one or more members.)
- You can drop a redo log group only if it is inactive. If you need to drop the current group, first force a log switch to occur.
- Make sure a redo log group is archived (if archiving is enabled) before dropping it. To see whether this has happened, use the `V$LOG` view.

```
SELECT GROUP#, ARCHIVED, STATUS FROM V$LOG;

   GROUP# ARC STATUS
--------- --- ----------------
        1 YES ACTIVE
        2 NO  CURRENT
        3 YES INACTIVE
        4 YES INACTIVE
```

Drop a redo log group with the SQL statement `ALTER DATABASE` with the `DROP LOGFILE` clause.

The following statement drops redo log group number 3:

```
ALTER DATABASE DROP LOGFILE GROUP 3;
```

When a redo log group is dropped from the database, and you are not using the Oracle-managed files feature, the operating system files are not deleted from disk. Rather, the control files of the associated database are updated to drop the members of the group from the database structure. After dropping a redo log group, make sure that the drop completed successfully, and then use the appropriate operating system command to delete the dropped redo log files.

When using Oracle-managed files, the cleanup of operating systems files is done automatically for you.

Dropping Redo Log Members

To drop a redo log member, you must have the `ALTER DATABASE` system privilege. Consider the following restrictions and precautions before dropping individual redo log members:

- It is permissible to drop redo log files so that a multiplexed redo log becomes temporarily asymmetric. For example, if you use duplexed groups of redo log files, you can drop one member of one group, even though all other groups have two members each. However, you should rectify this situation immediately so that all groups have at least two members, and thereby eliminate the single point of failure possible for the redo log.
- An instance always requires at least two valid groups of redo log files, regardless of the number of members in the groups. (A group comprises one or more members.) If the member you want to drop is the last valid member of the group, you cannot drop the member until the other members become valid. To see a redo log file status, use the `V$LOGFILE` view. A redo log file becomes `INVALID` if the

database cannot access it. It becomes STALE if the database suspects that it is not complete or correct. A stale log file becomes valid again the next time its group is made the active group.

- You can drop a redo log member only if it is *not* part of an active or current group. If you want to drop a member of an active group, first force a log switch to occur.
- Make sure the group to which a redo log member belongs is archived (if archiving is enabled) before dropping the member. To see whether this has happened, use the V$LOG view.

To drop specific inactive redo log members, use the ALTER DATABASE statement with the DROP LOGFILE MEMBER clause.

The following statement drops the redo log /oracle/dbs/log3c.rdo:

```
ALTER DATABASE DROP LOGFILE MEMBER '/oracle/dbs/log3c.rdo';
```

When a redo log member is dropped from the database, the operating system file is not deleted from disk. Rather, the control files of the associated database are updated to drop the member from the database structure. After dropping a redo log file, make sure that the drop completed successfully, and then use the appropriate operating system command to delete the dropped redo log file.

To drop a member of an active group, you must first force a log switch.

Forcing Log Switches

A log switch occurs when LGWR stops writing to one redo log group and starts writing to another. By default, a log switch occurs automatically when the current redo log file group fills.

You can force a log switch to make the currently active group inactive and available for redo log maintenance operations. For example, you want to drop the currently active group, but are not able to do so until the group is inactive. You may also wish to force a log switch if the currently active group needs to be archived at a specific time before the members of the group are completely filled. This option is useful in configurations with large redo log files that take a long time to fill.

To force a log switch, you must have the ALTER SYSTEM privilege. Use the ALTER SYSTEM statement with the SWITCH LOGFILE clause.

The following statement forces a log switch:

```
ALTER SYSTEM SWITCH LOGFILE;
```

Verifying Blocks in Redo Log Files

You can configure the database to use checksums to verify blocks in the redo log files. If you set the initialization parameter DB_BLOCK_CHECKSUM to TYPICAL (the default), the database computes a checksum for each database block when it is written to disk, including each redo log block as it is being written to the current log. The checksum is stored the header of the block.

Oracle Database uses the checksum to detect corruption in a redo log block. The database verifies the redo log block when the block is read from an archived log during recovery and when it writes the block to an archive log file. An error is raised and written to the alert log if corruption is detected.

If corruption is detected in a redo log block while trying to archive it, the system attempts to read the block from another member in the group. If the block is corrupted in all members of the redo log group, then archiving cannot proceed.

The value of the `DB_BLOCK_CHECKSUM` parameter can be changed dynamically using the `ALTER SYSTEM` statement.

Note: There is a slight overhead and decrease in database performance with `DB_BLOCK_CHECKSUM` enabled. Monitor your database performance to decide if the benefit of using data block checksums to detect corruption outweighs the performance impact.

See Also: *Oracle Database Reference* for a description of the `DB_BLOCK_CHECKSUM` initialization parameter

Clearing a Redo Log File

A redo log file might become corrupted while the database is open, and ultimately stop database activity because archiving cannot continue. In this situation the `ALTER DATABASE CLEAR LOGFILE` statement can be used to reinitialize the file without shutting down the database.

The following statement clears the log files in redo log group number 3:

```
ALTER DATABASE CLEAR LOGFILE GROUP 3;
```

This statement overcomes two situations where dropping redo logs is not possible:

- If there are only two log groups
- The corrupt redo log file belongs to the current group

If the corrupt redo log file has not been archived, use the `UNARCHIVED` keyword in the statement.

```
ALTER DATABASE CLEAR UNARCHIVED LOGFILE GROUP 3;
```

This statement clears the corrupted redo logs and avoids archiving them. The cleared redo logs are available for use even though they were not archived.

If you clear a log file that is needed for recovery of a backup, then you can no longer recover from that backup. The database writes a message in the alert log describing the backups from which you cannot recover.

Note: If you clear an unarchived redo log file, you should make another backup of the database.

If you want to clear an unarchived redo log that is needed to bring an offline tablespace online, use the `UNRECOVERABLE DATAFILE` clause in the `ALTER DATABASE CLEAR LOGFILE` statement.

If you clear a redo log needed to bring an offline tablespace online, you will not be able to bring the tablespace online again. You will have to drop the tablespace or perform an incomplete recovery. Note that tablespaces taken offline normal do not require recovery.

Redo Log Data Dictionary Views

The following views provide information on redo logs.

View	Description
`V$LOG`	Displays the redo log file information from the control file
`V$LOGFILE`	Identifies redo log groups and members and member status
`V$LOG_HISTORY`	Contains log history information

The following query returns the control file information about the redo log for a database.

```
SELECT * FROM V$LOG;

GROUP# THREAD#   SEQ   BYTES  MEMBERS  ARC STATUS     FIRST_CHANGE# FIRST_TIM
------ ------- ----- -------  -------  --- ---------  ------------- ---------
     1       1 10605 1048576        1  YES ACTIVE          11515628 16-APR-00
     2       1 10606 1048576        1  NO  CURRENT         11517595 16-APR-00
     3       1 10603 1048576        1  YES INACTIVE        11511666 16-APR-00
     4       1 10604 1048576        1  YES INACTIVE        11513647 16-APR-00
```

To see the names of all of the member of a group, use a query similar to the following:

```
SELECT * FROM V$LOGFILE;

GROUP#   STATUS  MEMBER
------  -------  ----------------------------------
     1           D:\ORANT\ORADATA\IDDB2\REDO04.LOG
     2           D:\ORANT\ORADATA\IDDB2\REDO03.LOG
     3           D:\ORANT\ORADATA\IDDB2\REDO02.LOG
     4           D:\ORANT\ORADATA\IDDB2\REDO01.LOG
```

If `STATUS` is blank for a member, then the file is in use.

> **See Also:** *Oracle Database Reference* for detailed information about these views

11 Managing Archived Redo Logs

This chapter describes how to archive redo data. It contains the following topics:

See Also:

- Chapter 15, "Using Oracle-Managed Files" for information about creating an archived redo log that is both created and managed by the Oracle Database server
- *Oracle Real Application Clusters Administration and Deployment Guide* for information specific to archiving in the Oracle Real Application Clusters environment

What Is the Archived Redo Log?

Oracle Database lets you save filled groups of redo log files to one or more offline destinations, known collectively as the **archived redo log**. The process of turning redo log files into archived redo log files is called **archiving**. This process is only possible if the database is running in **`ARCHIVELOG` mode**. You can choose automatic or manual archiving.

An archived redo log file is a copy of one of the filled members of a redo log group. It includes the redo entries and the unique log sequence number of the identical member of the redo log group. For example, if you are multiplexing your redo log, and if group 1 contains identical member files `a_log1` and `b_log1`, then the archiver process (ARC*n*) will archive one of these member files. Should `a_log1` become corrupted, then ARC*n* can still archive the identical `b_log1`. The archived redo log contains a copy of every group created since you enabled archiving.

When the database is running in `ARCHIVELOG` mode, the log writer process (LGWR) cannot reuse and hence overwrite a redo log group until it has been archived. The background process ARC*n* automates archiving operations when automatic archiving is enabled. The database starts multiple archiver processes as needed to ensure that the archiving of filled redo logs does not fall behind.

You can use archived redo logs to:

- Recover a database
- Update a standby database
- Get information about the history of a database using the LogMiner utility

> **See Also:** The following sources document the uses for archived redo logs:
>
> - *Oracle Database Backup and Recovery User's Guide*
> - *Oracle Data Guard Concepts and Administration* discusses setting up and maintaining a standby database
> - *Oracle Database Utilities* contains instructions for using the LogMiner PL/SQL package

Choosing Between NOARCHIVELOG and ARCHIVELOG Mode

This section describes the issues you must consider when choosing to run your database in `NOARCHIVELOG` or `ARCHIVELOG` mode, and contains these topics:

- Running a Database in NOARCHIVELOG Mode
- Running a Database in ARCHIVELOG Mode

The choice of whether to enable the archiving of filled groups of redo log files depends on the availability and reliability requirements of the application running on the database. If you cannot afford to lose any data in your database in the event of a disk failure, use `ARCHIVELOG` mode. The archiving of filled redo log files can require you to perform extra administrative operations.

Running a Database in NOARCHIVELOG Mode

When you run your database in `NOARCHIVELOG` mode, you disable the archiving of the redo log. The database control file indicates that filled groups are not required to be archived. Therefore, when a filled group becomes inactive after a log switch, the group is available for reuse by LGWR.

`NOARCHIVELOG` mode protects a database from instance failure but not from media failure. Only the most recent changes made to the database, which are stored in the online redo log groups, are available for instance recovery. If a media failure occurs while the database is in `NOARCHIVELOG` mode, you can only restore the database to the point of the most recent full database backup. You cannot recover transactions subsequent to that backup.

In `NOARCHIVELOG` mode you cannot perform online tablespace backups, nor can you use online tablespace backups taken earlier while the database was in `ARCHIVELOG` mode. To restore a database operating in `NOARCHIVELOG` mode, you can use only whole database backups taken while the database is closed. Therefore, if you decide to operate a database in `NOARCHIVELOG` mode, take whole database backups at regular, frequent intervals.

Running a Database in ARCHIVELOG Mode

When you run a database in `ARCHIVELOG` mode, you enable the archiving of the redo log. The database control file indicates that a group of filled redo log files cannot be reused by LGWR until the group is archived. A filled group becomes available for archiving immediately after a redo log switch occurs.

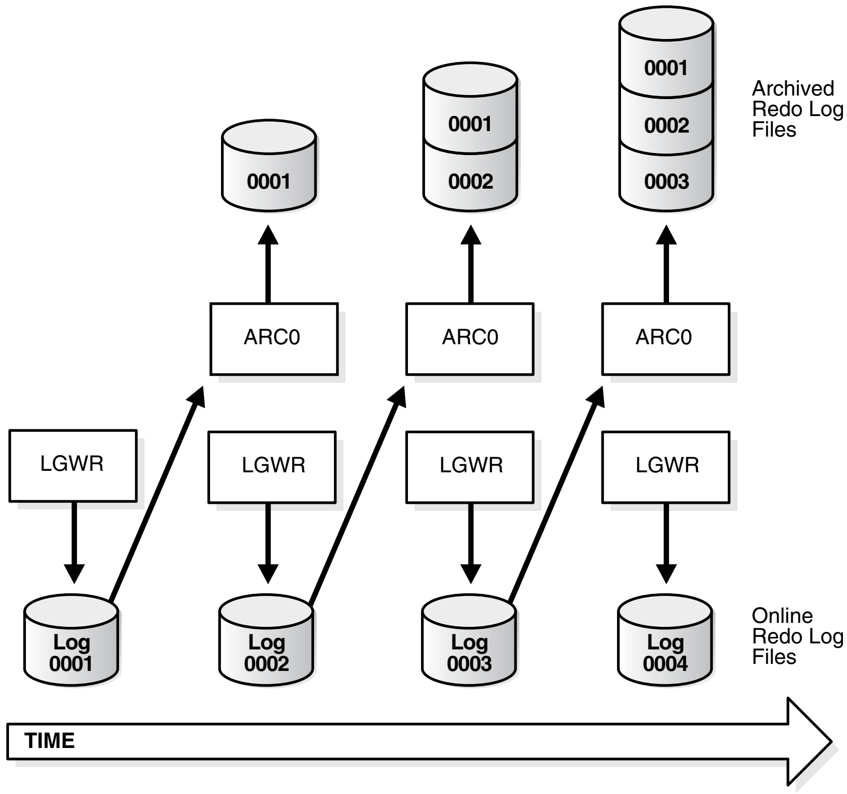
The archiving of filled groups has these advantages:

- A database backup, together with online and archived redo log files, guarantees that you can recover all committed transactions in the event of an operating system or disk failure.
- If you keep an archived log, you can use a backup taken while the database is open and in normal system use.
- You can keep a standby database current with its original database by continuously applying the original archived redo logs to the standby.

You can configure an instance to archive filled redo log files automatically, or you can archive manually. For convenience and efficiency, automatic archiving is usually best. Figure 11–1 illustrates how the archiver process (ARC0 in this illustration) writes filled redo log files to the database archived redo log.

If all databases in a distributed database operate in `ARCHIVELOG` mode, you can perform coordinated distributed database recovery. However, if any database in a distributed database is in `NOARCHIVELOG` mode, recovery of a global distributed database (to make all databases consistent) is limited by the last full backup of any database operating in `NOARCHIVELOG` mode.

Figure 11–1 Redo Log File Use in ARCHIVELOG Mode



Controlling Archiving

This section describes how to set the archiving mode of the database and how to control the archiving process. The following topics are discussed:

- Setting the Initial Database Archiving Mode
- Changing the Database Archiving Mode
- Performing Manual Archiving
- Adjusting the Number of Archiver Processes

See Also: your Oracle operating system specific documentation for additional information on controlling archiving modes

Setting the Initial Database Archiving Mode

You set the initial archiving mode as part of database creation in the `CREATE DATABASE` statement. Usually, you can use the default of `NOARCHIVELOG` mode at database creation because there is no need to archive the redo information generated by that process. After creating the database, decide whether to change the initial archiving mode.

If you specify `ARCHIVELOG` mode, you must have initialization parameters set that specify the destinations for the archived redo log files (see "Specifying Archive Destinations" on page 11-6).

Changing the Database Archiving Mode

To change the archiving mode of the database, use the `ALTER DATABASE` statement with the `ARCHIVELOG` or `NOARCHIVELOG` clause. To change the archiving mode, you must be connected to the database with administrator privileges (`AS SYSDBA`).

The following steps switch the database archiving mode from `NOARCHIVELOG` to `ARCHIVELOG`:

1. Shut down the database instance.

   ```
   SHUTDOWN
   ```

   An open database must first be closed and any associated instances shut down before you can switch the database archiving mode. You cannot change the mode from `ARCHIVELOG` to `NOARCHIVELOG` if any datafiles need media recovery.

2. Back up the database.

   Before making any major change to a database, always back up the database to protect against any problems. This will be your final backup of the database in `NOARCHIVELOG` mode and can be used if something goes wrong during the change to `ARCHIVELOG` mode. See *Oracle Database Backup and Recovery User's Guide* for information about taking database backups.

3. Edit the initialization parameter file to include the initialization parameters that specify the destinations for the archived redo log files (see "Specifying Archive Destinations" on page 11-6).

4. Start a new instance and mount, but do not open, the database.

   ```
   STARTUP MOUNT
   ```

   To enable or disable archiving, the database must be mounted but not open.

5. Change the database archiving mode. Then open the database for normal operations.

   ```
   ALTER DATABASE ARCHIVELOG;
   ALTER DATABASE OPEN;
   ```

6. Shut down the database.

   ```
   SHUTDOWN IMMEDIATE
   ```

7. Back up the database.

   Changing the database archiving mode updates the control file. After changing the database archiving mode, you must back up all of your database files and control file. Any previous backup is no longer usable because it was taken in NOARCHIVELOG mode.

   See Also: *Oracle Real Application Clusters Administration and Deployment Guide* for more information about switching the archiving mode when using Real Application Clusters

Performing Manual Archiving

To operate your database in manual archiving mode, follow the procedure shown in "Changing the Database Archiving Mode" on page 11-4. However, when you specify the new mode in step 5, use the following statement:

```
ALTER DATABASE ARCHIVELOG MANUAL;
```

When you operate your database in manual ARCHIVELOG mode, you must archive inactive groups of filled redo log files or your database operation can be temporarily suspended. To archive a filled redo log group manually, connect with administrator privileges. Ensure that the database is mounted but not open. Use the ALTER SYSTEM statement with the ARCHIVE LOG clause to manually archive filled redo log files. The following statement archives all unarchived log files:

```
ALTER SYSTEM ARCHIVE LOG ALL;
```

When you use manual archiving mode, you cannot specify any standby databases in the archiving destinations.

Even when automatic archiving is enabled, you can use manual archiving for such actions as rearchiving an inactive group of filled redo log members to another location. In this case, it is possible for the instance to reuse the redo log group before you have finished manually archiving, and thereby overwrite the files. If this happens, the database writes an error message to the alert log.

Adjusting the Number of Archiver Processes

The LOG_ARCHIVE_MAX_PROCESSES initialization parameter specifies the number of ARC*n* processes that the database initially invokes. The default is two processes. There is usually no need specify this initialization parameter or to change its default value, because the database starts additional archiver processes (ARC*n*) as needed to ensure that the automatic processing of filled redo log files does not fall behind.

However, to avoid any runtime overhead of invoking additional ARC*n* processes, you can set the LOG_ARCHIVE_MAX_PROCESSES initialization parameter to specify up to ten ARC*n* processes to be started at instance startup. The LOG_ARCHIVE_MAX_PROCESSES parameter is dynamic, and can be changed using the ALTER SYSTEM statement. The database must be mounted but not open. The following statement increases (or decreases) the number of ARC*n* processes currently running:

```
ALTER SYSTEM SET LOG_ARCHIVE_MAX_PROCESSES=3;
```

Specifying the Archive Destination

Before you can archive redo logs, you must determine the destination to which you will archive and familiarize yourself with the various destination states. The dynamic performance (V$) views, listed in "Viewing Information About the Archived Redo Log" on page 11-14, provide all needed archive information.

The following topics are contained in this section:

- Specifying Archive Destinations
- Understanding Archive Destination Status

Specifying Archive Destinations

You can choose whether to archive redo logs to a single destination or **multiplex** them. If you want to archive only to a single destination, you specify that destination in the `LOG_ARCHIVE_DEST` initialization parameter. If you want to multiplex the archived logs, you can choose whether to archive to up to ten locations (using the `LOG_ARCHIVE_DEST_n` parameters) or to archive only to a primary and secondary destination (using `LOG_ARCHIVE_DEST` and `LOG_ARCHIVE_DUPLEX_DEST`). The following table summarizes the multiplexing alternatives, which are further described in the sections that follow.

Method	Initialization Parameter	Host	Example

1	`LOG_ARCHIVE_DEST_`*n*
	where:
	n is an integer from 1 to 10
		Local or remote	`LOG_ARCHIVE_DEST_1 = 'LOCATION=/disk1/arc'`
			`LOG_ARCHIVE_DEST_2 = 'SERVICE=standby1'`

2	`LOG_ARCHIVE_DEST` and
	`LOG_ARCHIVE_DUPLEX_DEST`
		Local only	`LOG_ARCHIVE_DEST = '/disk1/arc'`
			`LOG_ARCHIVE_DUPLEX_DEST = '/disk2/arc'`

See Also:

- *Oracle Database Reference* for additional information about the initialization parameters used to control the archiving of redo logs
- *Oracle Data Guard Concepts and Administration* for information about using the `LOG_ARCHIVE_DEST_`*n* initialization parameter for specifying a standby destination. There are additional keywords that can be specified with this initialization parameter that are not discussed in this book.

Method 1: Using the LOG_ARCHIVE_DEST_*n* Parameter

Use the `LOG_ARCHIVE_DEST_`*n* parameter (where *n* is an integer from 1 to 10) to specify from one to ten different destinations for archival. Each numerically suffixed parameter uniquely identifies an individual destination.

You specify the location for `LOG_ARCHIVE_DEST_`*n* using the keywords explained in the following table:

Keyword	Indicates	Example
LOCATION	A local file system location.	LOG_ARCHIVE_DEST_1 = 'LOCATION=/disk1/arc'
SERVICE	Remote archival through Oracle Net service name.	LOG_ARCHIVE_DEST_2 = 'SERVICE=standby1'

If you use the `LOCATION` keyword, specify a valid path name for your operating system. If you specify `SERVICE`, the database translates the net service name through the `tnsnames.ora` file to a connect descriptor. The descriptor contains the information necessary for connecting to the remote database. The service name must have an associated database SID, so that the database correctly updates the log history of the control file for the standby database.

Perform the following steps to set the destination for archived redo logs using the `LOG_ARCHIVE_DEST_`*n* initialization parameter:

1. Use SQL*Plus to shut down the database.

   ```
   SHUTDOWN
   ```

2. Set the `LOG_ARCHIVE_DEST_`*n* initialization parameter to specify from one to ten archiving locations. The `LOCATION` keyword specifies an operating system specific path name. For example, enter:

   ```
   LOG_ARCHIVE_DEST_1 = 'LOCATION = /disk1/archive'
   LOG_ARCHIVE_DEST_2 = 'LOCATION = /disk2/archive'
   LOG_ARCHIVE_DEST_3 = 'LOCATION = /disk3/archive'
   ```

   If you are archiving to a standby database, use the `SERVICE` keyword to specify a valid net service name from the `tnsnames.ora` file. For example, enter:

   ```
   LOG_ARCHIVE_DEST_4 = 'SERVICE = standby1'
   ```

3. Optionally, set the `LOG_ARCHIVE_FORMAT` initialization parameter, using `%t` to include the thread number as part of the file name, `%s` to include the log sequence number, and `%r` to include the resetlogs ID (a timestamp value represented in ub4). Use capital letters (`%T`, `%S`, and `%R`) to pad the file name to the left with zeroes.

   Note: If the `COMPATIBLE` initialization parameter is set to 10.0.0 or higher, the database requires the specification of resetlogs ID (`%r`) when you include the `LOG_ARCHIVE_FORMAT` parameter. The default for this parameter is operating system dependent. For example, this is the default format for UNIX:

   `LOG_ARCHIVE_FORMAT=%t_%s_%r.dbf`

   The incarnation of a database changes when you open it with the `RESETLOGS` option. Specifying `%r` causes the database to capture the resetlogs ID in the archived redo log file name. See *Oracle Database Backup and Recovery User's Guide* for more information about this method of recovery.

   The following example shows a setting of `LOG_ARCHIVE_FORMAT`:

   ```
   LOG_ARCHIVE_FORMAT = arch_%t_%s_%r.arc
   ```

This setting will generate archived logs as follows for thread 1; log sequence numbers 100, 101, and 102; resetlogs ID 509210197. The identical resetlogs ID indicates that the files are all from the same database incarnation:

```
/disk1/archive/arch_1_100_509210197.arc,
/disk1/archive/arch_1_101_509210197.arc,
/disk1/archive/arch_1_102_509210197.arc

/disk2/archive/arch_1_100_509210197.arc,
/disk2/archive/arch_1_101_509210197.arc,
/disk2/archive/arch_1_102_509210197.arc

/disk3/archive/arch_1_100_509210197.arc,
/disk3/archive/arch_1_101_509210197.arc,
/disk3/archive/arch_1_102_509210197.arc
```

Method 2: Using LOG_ARCHIVE_DEST and LOG_ARCHIVE_DUPLEX_DEST

To specify a maximum of two locations, use the `LOG_ARCHIVE_DEST` parameter to specify a primary archive destination and the `LOG_ARCHIVE_DUPLEX_DEST` to specify an optional secondary archive destination. All locations must be local. Whenever the database archives a redo log, it archives it to every destination specified by either set of parameters.

Perform the following steps the use method 2:

1. Use SQL*Plus to shut down the database.

   ```
   SHUTDOWN
   ```

2. Specify destinations for the `LOG_ARCHIVE_DEST` and `LOG_ARCHIVE_DUPLEX_DEST` parameter (you can also specify `LOG_ARCHIVE_DUPLEX_DEST` dynamically using the `ALTER SYSTEM` statement). For example, enter:

   ```
   LOG_ARCHIVE_DEST = '/disk1/archive'
   LOG_ARCHIVE_DUPLEX_DEST = '/disk2/archive'
   ```

3. Set the `LOG_ARCHIVE_FORMAT` initialization parameter as described in step 3 for method 1.

Understanding Archive Destination Status

Each archive destination has the following variable characteristics that determine its status:

- **Valid/Invalid**: indicates whether the disk location or service name information is specified and valid
- **Enabled/Disabled**: indicates the availability state of the location and whether the database can use the destination
- **Active/Inactive**: indicates whether there was a problem accessing the destination

Several combinations of these characteristics are possible. To obtain the current status and other information about each destination for an instance, query the `V$ARCHIVE_DEST` view.

The characteristics determining a locations status that appear in the view are shown in Table 11–1. Note that for a destination to be used, its characteristics must be valid, enabled, and active.

Table 11–1 Destination Status

STATUS	Characteristics			Meaning
	Valid	Enabled	Active	
VALID	True	True	True	The user has properly initialized the destination, which is available for archiving.
INACTIVE	False	n/a	n/a	The user has not provided or has deleted the destination information.
ERROR	True	True	False	An error occurred creating or writing to the destination file; refer to error data.
FULL	True	True	False	Destination is full (no disk space).
DEFERRED	True	False	True	The user manually and temporarily disabled the destination.
DISABLED	True	False	False	The user manually and temporarily disabled the destination following an error; refer to error data.
BAD PARAM	n/a	n/a	n/a	A parameter error occurred; refer to error data.

The LOG_ARCHIVE_DEST_STATE_*n* (where *n* is an integer from 1 to 10) initialization parameter lets you control the availability state of the specified destination (*n*).

- ENABLE indicates that the database can use the destination.
- DEFER indicates that the location is temporarily disabled.
- ALTERNATE indicates that the destination is an alternate.

The availability state of the destination is DEFER, unless there is a failure of its parent destination, in which case its state becomes ENABLE.

Specifying the Mode of Log Transmission

The two modes of transmitting archived logs to their destination are **normal archiving transmission** and **standby transmission** mode. Normal transmission involves transmitting files to a local disk. Standby transmission involves transmitting files through a network to either a local or remote standby database.

Normal Transmission Mode

In normal transmission mode, the archiving destination is another disk drive of the database server. In this configuration archiving does not contend with other files required by the instance and can complete more quickly. Specify the destination with either the LOG_ARCHIVE_DEST_*n* or LOG_ARCHIVE_DEST parameters.

It is good practice to move archived redo log files and corresponding database backups from the local disk to permanent inexpensive offline storage media such as tape. A primary value of archived logs is database recovery, so you want to ensure that these logs are safe should disaster strike your primary database.

Standby Transmission Mode

In standby transmission mode, the archiving destination is either a local or remote standby database.

Caution: You can maintain a standby database on a local disk, but Oracle strongly encourages you to maximize disaster protection by maintaining your standby database at a remote site.

If you are operating your standby database in **managed recovery mode**, you can keep your standby database synchronized with your source database by automatically applying transmitted archived redo logs.

To transmit files successfully to a standby database, either ARC*n* or a server process must do the following:

- Recognize a remote location
- Transmit the archived logs in conjunction with a **remote file server** (RFS) process that resides on the remote server

Each ARC*n* process has a corresponding RFS for each standby destination. For example, if three ARC*n* processes are archiving to two standby databases, then Oracle Database establishes six RFS connections.

You transmit archived logs through a network to a remote location by using Oracle Net Services. Indicate a remote archival by specifying a Oracle Net service name as an attribute of the destination. Oracle Database then translates the service name, through the `tnsnames.ora` file, to a connect descriptor. The descriptor contains the information necessary for connecting to the remote database. The service name must have an associated database SID, so that the database correctly updates the log history of the control file for the standby database.

The RFS process, which runs on the destination node, acts as a network server to the ARC*n* client. Essentially, ARC*n* pushes information to RFS, which transmits it to the standby database.

The RFS process, which is required when archiving to a remote destination, is responsible for the following tasks:

- Consuming network I/O from the ARC*n* process
- Creating file names on the standby database by using the `STANDBY_ARCHIVE_DEST` parameter
- Populating the log files at the remote site
- Updating the standby database control file (which Recovery Manager can then use for recovery)

Archived redo logs are integral to maintaining a standby database, which is an exact replica of a database. You can operate your database in standby archiving mode, which automatically updates a standby database with archived redo logs from the original database.

See Also:

- *Oracle Data Guard Concepts and Administration*
- *Oracle Database Net Services Administrator's Guide* for information about connecting to a remote database using a service name

Managing Archive Destination Failure

Sometimes archive destinations can fail, causing problems when you operate in automatic archiving mode. Oracle Database provides procedures to help you minimize the problems associated with destination failure. These procedures are discussed in the sections that follow:

- Specifying the Minimum Number of Successful Destinations
- Rearchiving to a Failed Destination

Specifying the Minimum Number of Successful Destinations

The optional initialization parameter `LOG_ARCHIVE_MIN_SUCCEED_DEST=`*n* determines the minimum number of destinations to which the database must successfully archive a redo log group before it can reuse online log files. The default value is 1. Valid values for *n* are 1 to 2 if you are using duplexing, or 1 to 10 if you are multiplexing.

Specifying Mandatory and Optional Destinations

The `LOG_ARCHIVE_DEST_`*n* parameter lets you specify whether a destination is `OPTIONAL` (the default) or `MANDATORY`. The `LOG_ARCHIVE_MIN_SUCCEED_DEST=`*n* parameter uses all `MANDATORY` destinations plus some number of non-standby `OPTIONAL` destinations to determine whether LGWR can overwrite the online log. The following rules apply:

- Omitting the `MANDATORY` attribute for a destination is the same as specifying `OPTIONAL`.
- You must have at least one local destination, which you can declare `OPTIONAL` or `MANDATORY`.
- When you specify a value for `LOG_ARCHIVE_MIN_SUCCEED_DEST=`*n*, Oracle Database will treat at least one local destination as `MANDATORY`, because the minimum value for `LOG_ARCHIVE_MIN_SUCCEED_DEST` is 1.
- If any `MANDATORY` destination fails, including a `MANDATORY` standby destination, Oracle Database ignores the `LOG_ARCHIVE_MIN_SUCCEED_DEST` parameter.
- The `LOG_ARCHIVE_MIN_SUCCEED_DEST` value cannot be greater than the number of destinations, nor can it be greater than the number of `MANDATORY` destinations plus the number of `OPTIONAL` local destinations.
- If you `DEFER` a `MANDATORY` destination, and the database overwrites the online log without transferring the archived log to the standby site, then you must transfer the log to the standby manually.

If you are duplexing the archived logs, you can establish which destinations are mandatory or optional by using the `LOG_ARCHIVE_DEST` and `LOG_ARCHIVE_DUPLEX_DEST` parameters. The following rules apply:

- Any destination declared by `LOG_ARCHIVE_DEST` is mandatory.
- Any destination declared by `LOG_ARCHIVE_DUPLEX_DEST` is optional if `LOG_ARCHIVE_MIN_SUCCEED_DEST = 1` and mandatory if `LOG_ARCHIVE_MIN_SUCCEED_DEST = 2`.

Specifying the Number of Successful Destinations: Scenarios

You can see the relationship between the `LOG_ARCHIVE_DEST_`*n* and `LOG_ARCHIVE_MIN_SUCCEED_DEST` parameters most easily through sample scenarios.

Scenario for Archiving to Optional Local Destinations In this scenario, you archive to three local destinations, each of which you declare as `OPTIONAL`. Table 11–2 illustrates the possible values for `LOG_ARCHIVE_MIN_SUCCEED_DEST=`*n* in this case.

Table 11–2 LOG_ARCHIVE_MIN_SUCCEED_DEST Values for Scenario 1

Value	Meaning
1	The database can reuse log files only if at least one of the `OPTIONAL` destinations succeeds.
2	The database can reuse log files only if at least two of the `OPTIONAL` destinations succeed.
3	The database can reuse log files only if all of the `OPTIONAL` destinations succeed.
4 or greater	`ERROR`: The value is greater than the number of destinations.

This scenario shows that even though you do not explicitly set any of your destinations to `MANDATORY` using the `LOG_ARCHIVE_DEST_`*n* parameter, the database must successfully archive to one or more of these locations when `LOG_ARCHIVE_MIN_SUCCEED_DEST` is set to 1, 2, or 3.

Scenario for Archiving to Both Mandatory and Optional Destinations Consider a case in which:

- You specify two `MANDATORY` destinations.
- You specify two `OPTIONAL` destinations.
- No destination is a standby database.

Table 11–3 shows the possible values for `LOG_ARCHIVE_MIN_SUCCEED_DEST=`*n*.

Table 11–3 LOG_ARCHIVE_MIN_SUCCEED_DEST Values for Scenario 2

Value	Meaning
1	The database ignores the value and uses the number of `MANDATORY` destinations (in this example, 2).
2	The database can reuse log files even if no `OPTIONAL` destination succeeds.
3	The database can reuse logs only if at least one `OPTIONAL` destination succeeds.
4	The database can reuse logs only if both `OPTIONAL` destinations succeed.
5 or greater	`ERROR`: The value is greater than the number of destinations.

This case shows that the database must archive to the destinations you specify as `MANDATORY`, regardless of whether you set `LOG_ARCHIVE_MIN_SUCCEED_DEST` to archive to a smaller number of destinations.

Rearchiving to a Failed Destination

Use the REOPEN attribute of the LOG_ARCHIVE_DEST_*n* parameter to specify whether and when ARC*n* should attempt to rearchive to a failed destination following an error. REOPEN applies to all errors, not just OPEN errors.

REOPEN=*n* sets the minimum number of seconds before ARC*n* should try to reopen a failed destination. The default value for *n* is 300 seconds. A value of 0 is the same as turning off the REOPEN attribute; ARC*n* will not attempt to archive after a failure. If you do not specify the REOPEN keyword, ARC*n* will never reopen a destination following an error.

You cannot use REOPEN to specify the number of attempts ARC*n* should make to reconnect and transfer archived logs. The REOPEN attempt either succeeds or fails.

When you specify REOPEN for an OPTIONAL destination, the database can overwrite online logs if there is an error. If you specify REOPEN for a MANDATORY destination, the database stalls the production database when it cannot successfully archive. In this situation, consider the following options:

- Archive manually to the failed destination.
- Change the destination by deferring the destination, specifying the destination as optional, or changing the service.
- Drop the destination.

When using the REOPEN keyword, note the following:

- ARC*n* reopens a destination only when *starting* an archive operation from the beginning of the log file, never *during* a current operation. ARC*n* always retries the log copy from the beginning.
- If you specified REOPEN, either with a specified time the default, ARC*n* checks to see whether the time of the recorded error plus the REOPEN interval is less than the current time. If it is, ARC*n* retries the log copy.
- The REOPEN clause successfully affects the ACTIVE=TRUE destination state. The VALID and ENABLED states are not changed.

Controlling Trace Output Generated by the Archivelog Process

Background processes always write to a trace file when appropriate. (See the discussion of this topic in "Monitoring Errors with Trace Files and the Alert Log" on page 7-1.) In the case of the archivelog process, you can control the output that is generated to the trace file. You do this by setting the LOG_ARCHIVE_TRACE initialization parameter to specify a **trace level**. The following values can be specified:

Trace Level	Meaning
0	Disable archivelog tracing. This is the default.
1	Track archival of redo log file.
2	Track archival status for each archivelog destination.
4	Track archival operational phase.
8	Track archivelog destination activity.
16	Track detailed archivelog destination activity.
32	Track archivelog destination parameter modifications.

Trace Level	Meaning
64	Track ARC*n* process state activity.
128	Track FAL (fetch archived log) server related activities.
256	Supported in a future release.
512	Tracks asynchronous LGWR activity.
1024	RFS physical client tracking.
2048	ARC*n*/RFS heartbeat tracking.
4096	Track real-time apply
8192	Track redo apply activity (media recovery or physical standby)

You can combine tracing levels by specifying a value equal to the sum of the individual levels that you would like to trace. For example, setting `LOG_ARCHIVE_TRACE=12`, will generate trace level 8 and 4 output. You can set different values for the primary and any standby database.

The default value for the `LOG_ARCHIVE_TRACE` parameter is 0. At this level, the archivelog process generates appropriate alert and trace entries for error conditions.

You can change the value of this parameter dynamically using the `ALTER SYSTEM` statement. The database must be mounted but not open. For example:

```
ALTER SYSTEM SET LOG_ARCHIVE_TRACE=12;
```

Changes initiated in this manner will take effect at the start of the next archiving operation.

See Also: *Oracle Data Guard Concepts and Administration* for information about using this parameter with a standby database

Viewing Information About the Archived Redo Log

You can display information about the archived redo log using dynamic performance views or the `ARCHIVE LOG LIST` command.

This section contains the following topics:

- Archived Redo Logs Views
- The ARCHIVE LOG LIST Command

Archived Redo Logs Views

Several dynamic performance views contain useful information about archived redo logs, as summarized in the following table.

Dynamic Performance View	Description
`V$DATABASE`	Shows if the database is in `ARCHIVELOG` or `NOARCHIVELOG` mode and if `MANUAL` (archiving mode) has been specified.
`V$ARCHIVED_LOG`	Displays historical archived log information from the control file. If you use a recovery catalog, the `RC_ARCHIVED_LOG` view contains similar information.
`V$ARCHIVE_DEST`	Describes the current instance, all archive destinations, and the current value, mode, and status of these destinations.

Dynamic Performance View	Description
V$ARCHIVE_PROCESSES	Displays information about the state of the various archive processes for an instance.
V$BACKUP_REDOLOG	Contains information about any backups of archived logs. If you use a recovery catalog, the RC_BACKUP_REDOLOG contains similar information.
V$LOG	Displays all redo log groups for the database and indicates which need to be archived.
V$LOG_HISTORY	Contains log history information such as which logs have been archived and the SCN range for each archived log.

For example, the following query displays which redo log group requires archiving:

```
SELECT GROUP#, ARCHIVED
   FROM SYS.V$LOG;

GROUP#     ARC
--------   ---
       1   YES
       2   NO
```

To see the current archiving mode, query the V$DATABASE view:

```
SELECT LOG_MODE FROM SYS.V$DATABASE;

LOG_MODE
------------
NOARCHIVELOG
```

See Also: *Oracle Database Reference* for detailed descriptions of dynamic performance views

The ARCHIVE LOG LIST Command

The SQL*Plus command ARCHIVE LOG LIST displays archiving information for the connected instance. For example:

```
SQL> ARCHIVE LOG LIST

Database log mode              Archive Mode
Automatic archival             Enabled
Archive destination            D:\oracle\oradata\IDDB2\archive
Oldest online log sequence     11160
Next log sequence to archive   11163
Current log sequence           11163
```

This display tells you all the necessary information regarding the archived redo log settings for the current instance:

- The database is currently operating in ARCHIVELOG mode.
- Automatic archiving is enabled.
- The archived redo log destination is D:\oracle\oradata\IDDB2\archive.
- The oldest filled redo log group has a sequence number of 11160.
- The next filled redo log group to archive has a sequence number of 11163.
- The current redo log file has a sequence number of 11163.

See Also: *SQL*Plus User's Guide and Reference* for more information on the `ARCHIVE LOG LIST` command

12 Managing Tablespaces

This chapter describes the various aspects of tablespace management, and contains the following topics:

See Also: Chapter 15, "Using Oracle-Managed Files" for information about creating datafiles and tempfiles that are both created and managed by the Oracle Database server

Guidelines for Managing Tablespaces

Before working with tablespaces of an Oracle Database, familiarize yourself with the guidelines provided in the following sections:

- Using Multiple Tablespaces
- Assigning Tablespace Quotas to Users

See Also: *Oracle Database Concepts* for a complete discussion of database structure, space management, tablespaces, and datafiles

Using Multiple Tablespaces

Using multiple tablespaces allows you more flexibility in performing database operations. When a database has multiple tablespaces, you can:

- Separate user data from data dictionary data to reduce I/O contention.
- Separate data of one application from the data of another to prevent multiple applications from being affected if a tablespace must be taken offline.
- Store the datafiles of different tablespaces on different disk drives to reduce I/O contention.
- Take individual tablespaces offline while others remain online, providing better overall availability.
- Optimizing tablespace use by reserving a tablespace for a particular type of database use, such as high update activity, read-only activity, or temporary segment storage.
- Back up individual tablespaces.

Some operating systems set a limit on the number of files that can be open simultaneously. Such limits can affect the number of tablespaces that can be simultaneously online. To avoid exceeding your operating system limit, plan your tablespaces efficiently. Create only enough tablespaces to fulfill your needs, and create these tablespaces with as few files as possible. If you need to increase the size of a tablespace, add one or two large datafiles, or create datafiles with autoextension enabled, rather than creating many small datafiles.

Review your data in light of these factors and decide how many tablespaces you need for your database design.

Assigning Tablespace Quotas to Users

Grant to users who will be creating tables, clusters, materialized views, indexes, and other objects the privilege to create the object and a **quota** (space allowance or limit) in the tablespace intended to hold the object segment.

See Also: *Oracle Database Security Guide* for information about creating users and assigning tablespace quotas.

Creating Tablespaces

Before you can create a tablespace, you must create a database to contain it. The primary tablespace in any database is the `SYSTEM` tablespace, which contains information basic to the functioning of the database server, such as the data dictionary and the system rollback segment. The `SYSTEM` tablespace is the first tablespace created at database creation. It is managed as any other tablespace, but requires a higher level of privilege and is restricted in some ways. For example, you cannot rename or drop the `SYSTEM` tablespace or take it offline.

The `SYSAUX` tablespace, which acts as an auxiliary tablespace to the `SYSTEM` tablespace, is also always created when you create a database. It contains information about and the schemas used by various Oracle products and features, so that those products do not require their own tablespaces. As for the `SYSTEM` tablespace, management of the `SYSAUX` tablespace requires a higher level of security and you cannot rename or drop it. The management of the `SYSAUX` tablespace is discussed separately in "Managing the SYSAUX Tablespace" on page 12-24.

The steps for creating tablespaces vary by operating system, but the first step is always to use your operating system to create a directory structure in which your datafiles will be allocated. On most operating systems, you specify the size and fully specified filenames of datafiles when you create a new tablespace or alter an existing tablespace by adding datafiles. Whether you are creating a new tablespace or modifying an existing one, the database automatically allocates and formats the datafiles as specified.

To create a new tablespace, use the SQL statement `CREATE TABLESPACE` or `CREATE TEMPORARY TABLESPACE`. You must have the `CREATE TABLESPACE` system privilege to create a tablespace. Later, you can use the `ALTER TABLESPACE` or `ALTER DATABASE` statements to alter the tablespace. You must have the `ALTER TABLESPACE` or `ALTER DATABASE` system privilege, correspondingly.

You can also use the `CREATE UNDO TABLESPACE` statement to create a special type of tablespace called an **undo tablespace**, which is specifically designed to contain undo records. These are records generated by the database that are used to roll back, or undo, changes to the database for recovery, read consistency, or as requested by a `ROLLBACK` statement. Creating and managing undo tablespaces is the subject of Chapter 14, "Managing Undo".

The creation and maintenance of permanent and temporary tablespaces are discussed in the following sections:

- Locally Managed Tablespaces
- Bigfile Tablespaces
- Encrypted Tablespaces
- Temporary Tablespaces
- Multiple Temporary Tablespaces: Using Tablespace Groups

See Also:

- Chapter 2, "Creating and Configuring an Oracle Database" and your Oracle Database installation documentation for your operating system for information about tablespaces that are created at database creation
- *Oracle Database SQL Language Reference* for more information about the syntax and semantics of the `CREATE TABLESPACE`, `CREATE TEMPORARY TABLESPACE`, `ALTER TABLESPACE`, and `ALTER DATABASE` statements.
- "Specifying Database Block Sizes" on page 2-23 for information about initialization parameters necessary to create tablespaces with nonstandard block sizes

Locally Managed Tablespaces

Locally managed tablespaces track all extent information in the tablespace itself by using bitmaps, resulting in the following benefits:

- Fast, concurrent space operations. Space allocations and deallocations modify locally managed resources (bitmaps stored in header files).
- Enhanced performance
- Readable standby databases are allowed, because locally managed temporary tablespaces do not generate any undo or redo.

- Space allocation is simplified, because when the AUTOALLOCATE clause is specified, the database automatically selects the appropriate extent size.
- User reliance on the data dictionary is reduced, because the necessary information is stored in file headers and bitmap blocks.
- Coalescing free extents is unnecessary for locally managed tablespaces.

All tablespaces, including the SYSTEM tablespace, can be locally managed.

The DBMS_SPACE_ADMIN package provides maintenance procedures for locally managed tablespaces.

See Also:

- "Creating a Locally Managed SYSTEM Tablespace" on page 2-11, "Migrating the SYSTEM Tablespace to a Locally Managed Tablespace" on page 12-28, and "Diagnosing and Repairing Locally Managed Tablespace Problems" on page 12-26
- "Bigfile Tablespaces" on page 12-6 for information about creating another type of locally managed tablespace that contains only a single datafile or tempfile.
- *Oracle Database PL/SQL Packages and Types Reference* for information on the DBMS_SPACE_ADMIN package

Creating a Locally Managed Tablespace

Create a locally managed tablespace by specifying LOCAL in the EXTENT MANAGEMENT clause of the CREATE TABLESPACE statement. This is the default for new permanent tablespaces, but you must specify the EXTENT MANAGEMENT LOCAL clause if you want to specify either the AUTOALLOCATE clause or the UNIFORM clause. You can have the database manage extents for you automatically with the AUTOALLOCATE clause (the default), or you can specify that the tablespace is managed with uniform extents of a specific size (UNIFORM).

If you expect the tablespace to contain objects of varying sizes requiring many extents with different extent sizes, then AUTOALLOCATE is the best choice. AUTOALLOCATE is also a good choice if it is not important for you to have a lot of control over space allocation and deallocation, because it simplifies tablespace management. Some space may be wasted with this setting, but the benefit of having Oracle Database manage your space most likely outweighs this drawback.

If you want exact control over unused space, and you can predict exactly the space to be allocated for an object or objects and the number and size of extents, then UNIFORM is a good choice. This setting ensures that you will never have unusable space in your tablespace.

When you do not explicitly specify the type of extent management, Oracle Database determines extent management as follows:

- If the CREATE TABLESPACE statement omits the DEFAULT storage clause, then the database creates a locally managed autoallocated tablespace.
- If the CREATE TABLESPACE statement includes a DEFAULT storage clause, then the database considers the following:
  - If you specified the MINIMUM EXTENT clause, the database evaluates whether the values of MINIMUM EXTENT, INITIAL, and NEXT are equal and the value of PCTINCREASE is 0. If so, the database creates a locally managed uniform

tablespace with extent size = INITIAL. If the MINIMUM EXTENT, INITIAL, and NEXT parameters are not equal, or if PCTINCREASE is not 0, the database ignores any extent storage parameters you may specify and creates a locally managed, autoallocated tablespace.

– If you did not specify MINIMUM EXTENT clause, the database evaluates only whether the storage values of INITIAL and NEXT are equal and PCTINCREASE is 0. If so, the tablespace is locally managed and uniform. Otherwise, the tablespace is locally managed and autoallocated.

The following statement creates a locally managed tablespace named lmtbsb and specifies AUTOALLOCATE:

```
CREATE TABLESPACE lmtbsb DATAFILE '/u02/oracle/data/lmtbsb01.dbf' SIZE 50M
    EXTENT MANAGEMENT LOCAL AUTOALLOCATE;
```

AUTOALLOCATE causes the tablespace to be system managed with a minimum extent size of 64K.

The alternative to AUTOALLOCATE is UNIFORM. which specifies that the tablespace is managed with extents of uniform size. You can specify that size in the SIZE clause of UNIFORM. If you omit SIZE, then the default size is 1M.

The following example creates a tablespace with uniform 128K extents. (In a database with 2K blocks, each extent would be equivalent to 64 database blocks). Each 128K extent is represented by a bit in the extent bitmap for this file.

```
CREATE TABLESPACE lmtbsb DATAFILE '/u02/oracle/data/lmtbsb01.dbf' SIZE 50M
    EXTENT MANAGEMENT LOCAL UNIFORM SIZE 128K;
```

You cannot specify the DEFAULT storage clause, MINIMUM EXTENT, or TEMPORARY when you explicitly specify EXTENT MANAGEMENT LOCAL. If you want to create a temporary locally managed tablespace, use the CREATE TEMPORARY TABLESPACE statement.

Note: When you allocate a datafile for a locally managed tablespace, you should allow space for metadata used for space management (the extent bitmap or space header segment) which are part of user space. For example, if specify the UNIFORM clause in the extent management clause but you omit the SIZE parameter, then the default extent size is 1MB. In that case, the size specified for the datafile must be larger (at least one block plus space for the bitmap) than 1MB.

Specifying Segment Space Management in Locally Managed Tablespaces

In a locally managed tablespace, there are two methods that Oracle Database can use to manage segment space: automatic and manual. Manual segment space management uses linked lists called "freelists" to manage free space in the segment, while automatic segment space management uses bitmaps. Automatic segment space management is the more efficient method, and is the default for all new permanent, locally managed tablespaces.

Automatic segment space management delivers better space utilization than manual segment space management. It is also self-tuning, in that it scales with increasing number of users or instances. In an Oracle Real Application Clusters environment, automatic segment space management allows for a dynamic affinity of space to instances. In addition, for many standard workloads, application performance with automatic segment space management is better than the performance of a well-tuned application using manual segment space management.

Although automatic segment space management is the default for all new permanent, locally managed tablespaces, you can explicitly enable it with the `SEGMENT SPACE MANAGEMENT AUTO` clause.

The following statement creates tablespace `lmtbsb` with automatic segment space management:

```
CREATE TABLESPACE lmtbsb DATAFILE '/u02/oracle/data/lmtbsb01.dbf' SIZE 50M
    EXTENT MANAGEMENT LOCAL
    SEGMENT SPACE MANAGEMENT AUTO;
```

The `SEGMENT SPACE MANAGEMENT MANUAL` clause disables automatic segment space management.

The segment space management that you specify at tablespace creation time applies to all segments subsequently created in the tablespace. You cannot change the segment space management mode of a tablespace.

Notes:

- If you set extent management to `LOCAL UNIFORM`, then you must ensure that each extent contains at least 5 database blocks.
- If you set extent management to `LOCAL AUTOALLOCATE`, and if the database block size is 16K or greater, then Oracle manages segment space by creating extents with a minimum size of 5 blocks rounded up to 64K.

Locally managed tablespaces using automatic segment space management can be created as single-file or bigfile tablespaces, as described in "Bigfile Tablespaces" on page 12-6.

Bigfile Tablespaces

A **bigfile tablespace** is a tablespace with a single, but very large (up to 4G blocks) datafile. Traditional smallfile tablespaces, in contrast, can contain multiple datafiles, but the files cannot be as large. The benefits of bigfile tablespaces are the following:

- A bigfile tablespace with 8K blocks can contain a 32 terabyte datafile. A bigfile tablespace with 32K blocks can contain a 128 terabyte datafile. The maximum number of datafiles in an Oracle Database is limited (usually to 64K files). Therefore, bigfile tablespaces can significantly enhance the storage capacity of an Oracle Database.
- Bigfile tablespaces can reduce the number of datafiles needed for a database. An additional benefit is that the `DB_FILES` initialization parameter and `MAXDATAFILES` parameter of the `CREATE DATABASE` and `CREATE CONTROLFILE` statements can be adjusted to reduce the amount of SGA space required for datafile information and the size of the control file.
- Bigfile tablespaces simplify database management by providing datafile transparency. SQL syntax for the `ALTER TABLESPACE` statement lets you perform operations on tablespaces, rather than the underlying individual datafiles.

Bigfile tablespaces are supported only for locally managed tablespaces with automatic segment space management, with three exceptions: locally managed undo tablespaces, temporary tablespaces, and the `SYSTEM` tablespace.

Notes:

- Bigfile tablespaces are intended to be used with Automatic Storage Management (ASM) or other logical volume managers that supports striping or RAID, and dynamically extensible logical volumes.
- Avoid creating bigfile tablespaces on a system that does not support striping because of negative implications for parallel query execution and RMAN backup parallelization.
- Using bigfile tablespaces on platforms that do not support large file sizes is not recommended and can limit tablespace capacity. Refer to your operating system specific documentation for information about maximum supported file sizes.

Creating a Bigfile Tablespace

To create a bigfile tablespace, specify the `BIGFILE` keyword of the `CREATE TABLESPACE` statement (`CREATE BIGFILE TABLESPACE` ...). Oracle Database automatically creates a locally managed tablespace with automatic segment space management. You can, but need not, specify `EXTENT MANAGEMENT LOCAL` and `SEGMENT SPACE MANAGEMENT AUTO` in this statement. However, the database returns an error if you specify `EXTENT MANAGEMENT DICTIONARY` or `SEGMENT SPACE MANAGEMENT MANUAL`. The remaining syntax of the statement is the same as for the `CREATE TABLESPACE` statement, but you can only specify one datafile. For example:

```
CREATE BIGFILE TABLESPACE bigtbs
    DATAFILE '/u02/oracle/data/bigtbs01.dbf' SIZE 50G
...
```

You can specify `SIZE` in kilobytes (K), megabytes (M), gigabytes (G), or terabytes (T).

If the default tablespace type was set to `BIGFILE` at database creation, you need not specify the keyword `BIGFILE` in the `CREATE TABLESPACE` statement. A bigfile tablespace is created by default.

If the default tablespace type was set to `BIGFILE` at database creation, but you want to create a traditional (smallfile) tablespace, then specify a `CREATE SMALLFILE TABLESPACE` statement to override the default tablespace type for the tablespace that you are creating.

See Also: "Supporting Bigfile Tablespaces During Database Creation" on page 2-16

Identifying a Bigfile Tablespace

The following views contain a `BIGFILE` column that identifies a tablespace as a bigfile tablespace:

- `DBA_TABLESPACES`
- `USER_TABLESPACES`
- `V$TABLESPACE`

You can also identify a bigfile tablespace by the relative file number of its single datafile. That number is 1024 on most platforms, but 4096 on OS/390.

Encrypted Tablespaces

You can encrypt any permanent tablespace to protect sensitive data. Tablespace encryption is completely transparent to your applications, so no application modification is necessary. Encrypted tablespaces primarily protect your data from unauthorized access by means other than through the database. For example, when encrypted tablespaces are written to backup media for travel from one Oracle database to another or for travel to an off-site facility for storage, they remain encrypted. Also, encrypted tablespaces protect data from users who try to circumvent the security features of the database and access database files directly through the operating system file system.

Tablespace encryption does not address all security issues. It does not, for example, provide access control from within the database. Any user who is granted privileges on objects stored in an encrypted tablespace can access those objects without providing any kind of additional password or key.

When you encrypt a tablespace, all tablespace blocks are encrypted. All segment types are supported for encryption, including tables, clusters, indexes, LOBs (`BASICFILE` and `SECUREFILE`), table and index partitions, and so on.

Note: There is no need to use LOB encryption on `SECUREFILE` LOBs stored in an encrypted tablespace.

To maximize security, data from an encrypted tablespace is automatically encrypted when written to the undo tablespace, to the redo logs, and to any temporary tablespace. There is no need to explicitly create encrypted undo or temporary tablespaces, and in fact, you cannot specify encryption for those tablespace types.

For partitioned tables and indexes that have different partitions in different tablespaces, it is permitted to use both encrypted and non-encrypted tablespaces in the same table or index.

Tablespace encryption uses the transparent data encryption feature of Oracle Database, which requires that you create an *Oracle wallet* to store the master encryption key for the database. The wallet must be open before you can create the encrypted tablespace and before you can store or retrieve encrypted data. When you open the wallet, it is available to all session, and it remains open until you explicitly close it or until the database is shut down.

To encrypt a tablespace, you must open the database with the `COMPATIBLE` initialization parameter set to 11.1.0 or higher. The default setting for `COMPATIBLE` for a new Oracle Database 11*g* Release 1 installation is 11.1.0. Any user who can create a tablespace can create an encrypted tablespace.

Transparent data encryption supports industry-standard encryption algorithms, including the following Advanced Encryption Standard (AES) and Triple Data Encryption Standard (3DES) algorithms:

- 3DES168
- AES128
- AES192
- AES256

The encryption key length is implied by the algorithm name. For example, the AES128 algorithm uses 128-bit keys. You specify the algorithm to use when you create the tablespace, and different tablespaces can use different algorithms. Although longer key lengths theoretically provide greater security, there is a trade-off in CPU overhead. If you do not specify the algorithm in your `CREATE TABLESPACE` statement, AES128 is the default. There is no disk space overhead for encrypting a tablespace.

Examples

The following statement creates an encrypted tablespace with the default encryption algorithm:

```
CREATE TABLESPACE securespace
DATAFILE '/u01/app/oracle/oradata/orcl/secure01.dbf' SIZE 100M
ENCRYPTION
DEFAULT STORAGE(ENCRYPT);
```

The following statement creates the same tablespace with the AES256 algorithm:

```
CREATE TABLESPACE securespace
DATAFILE '/u01/app/oracle/oradata/orcl/secure01.dbf' SIZE 100M
ENCRYPTION USING 'AES256'
DEFAULT STORAGE(ENCRYPT);
```

Restrictions

The following are restrictions for encrypted tablespaces:

- You cannot encrypt an existing tablespace with an `ALTER TABLESPACE` statement. However, you can use Data Pump or SQL statements such as `CREATE TABLE AS SELECT` or `ALTER TABLE MOVE` to move existing table data into an encrypted tablespace.
- Encrypted tablespaces are subject to restrictions when transporting to another database. See "Limitations on Transportable Tablespace Use" on page 12-31.
- When recovering a database with encrypted tablespaces (for example after a `SHUTDOWN ABORT` or a catastrophic error that brings down the database instance), you must open the Oracle wallet after database mount and before database open, so the recovery process can decrypt data blocks and redo.

In addition, see *Oracle Database Advanced Security Administrator's Guide* for general restrictions for transparent data encryption.

Querying Tablespace Encryption Information

The `DBA_TABLESPACES` and `USER_TABLESPACES` data dictionary views include a column named `ENCRYPTED`. This column contains `YES` for encrypted tablespaces.

The view `V$ENCRYPTED_TABLESPACES` lists all currently encrypted tablespaces. The following query displays the name and encryption algorithm of encrypted tablespaces:

```
SELECT t.name, e.encryptionalg algorithm
FROM  v$tablespace t, v$encrypted_tablespaces e
WHERE t.ts# = e.ts#;

NAME                           ALGORITHM
------------------------------ ---------
SECURESPACE                    AES128
```

See Also:

- *Oracle Database 2 Day + Security Guide* for more information about transparent data encryption and for instructions for creating and opening wallets
- "Consider Encrypting Columns That Contain Sensitive Data" on page 18-6 for an alternative to encrypting an entire tablespace
- *Oracle Real Application Clusters Administration and Deployment Guide* for information on using an Oracle wallet in an Oracle Real Application Clusters environment
- *Oracle Database SQL Language Reference* for information about the `CREATE TABLESPACE` statement

Temporary Tablespaces

A **temporary tablespace** contains transient data that persists only for the duration of the session. Temporary tablespaces can improve the concurrency of multiple sort operations that do not fit in memory and can improve the efficiency of space management operations during sorts.

Temporary tablespaces are used to store the following:

- Intermediate sort results
- Temporary tables and temporary indexes
- Temporary LOBs
- Temporary B-trees

Within a temporary tablespace, all sort operations for a particular instance share a single *sort segment*, and sort segments exist for every instance that performs sort operations that require temporary space. A sort segment is created by the first statement after startup that uses the temporary tablespace for sorting, and is released only at shutdown.

By default, a single temporary tablespace named `TEMP` is created for each new Oracle Database installation. You can create additional temporary tablespaces with the `CREATE TABLESPACE` statement. You can assign a temporary tablespace to each database user with the `CREATE USER` or `ALTER USER` statement. A single temporary tablespace can be shared by multiple users.

You cannot explicitly create objects in a temporary tablespace.

Note: The exception to the preceding statement is a temporary table. When you create a temporary table, its rows are stored in your default temporary tablespace, unless you create the table in a new temporary tablespace. See "Creating a Temporary Table" on page 18-9 for more information.

Default Temporary Tablespace

Users who are not explicitly assigned a temporary tablespace use the database default temporary tablespace, which for new installations is `TEMP`. You can change the default temporary tablespace for the database with the following command:

```
ALTER DATABASE DEFAULT TEMPORARY TABLESPACE tablespace_name;
```

To determine the current default temporary tablespace for the database, run the following query:

```
SELECT PROPERTY_NAME, PROPERTY_VALUE FROM DATABASE_PROPERTIES WHERE
   PROPERTY_NAME='DEFAULT_TEMP_TABLESPACE';

PROPERTY_NAME              PROPERTY_VALUE
-------------------------- ------------------------------
DEFAULT_TEMP_TABLESPACE    TEMP
```

Space Allocation in a Temporary Tablespace

You can view the allocation and deallocation of space in a temporary tablespace sort segment using the V$SORT_SEGMENT view. The V$SORT_USAGE view identifies the current sort users in those segments.

When a sort operation that uses temporary space completes, allocated extents in the sort segment are not deallocated; they are just marked as free and available for reuse. The DBA_TEMP_FREE_SPACE view displays the total allocated and free space in each temporary tablespace. See "Viewing Space Usage for Temporary Tablespaces" on page 12-12 for more information. You can manually shrink a locally managed temporary tablespace that has a large amount of unused space. See "Shrinking a Locally Managed Temporary Tablespace" on page 12-22 for details.

See Also:

- *Oracle Database Security Guide* for information about creating users and assigning temporary tablespaces
- *Oracle Database Concepts* for more information about the default temporary tablespace
- *Oracle Database Reference* for more information about the V$SORT_SEGMENT, V$SORT_USAGE, and DBA_TEMP_FREE_SPACE views
- *Oracle Database Performance Tuning Guide* for a discussion on tuning sorts

Creating a Locally Managed Temporary Tablespace

Because space management is much simpler and more efficient in locally managed tablespaces, they are ideally suited for temporary tablespaces. Locally managed temporary tablespaces use **tempfiles**, which do not modify data outside of the temporary tablespace or generate any redo for temporary tablespace data. Because of this, they enable you to perform on-disk sorting operations in a read-only or standby database.

You also use different views for viewing information about tempfiles than you would for datafiles. The V$TEMPFILE and DBA_TEMP_FILES views are analogous to the V$DATAFILE and DBA_DATA_FILES views.

To create a locally managed temporary tablespace, you use the CREATE TEMPORARY TABLESPACE statement, which requires that you have the CREATE TABLESPACE system privilege.

The following statement creates a temporary tablespace in which each extent is 16M. Each 16M extent (which is the equivalent of 8000 blocks when the standard block size is 2K) is represented by a bit in the bitmap for the file.

```
CREATE TEMPORARY TABLESPACE lmtemp TEMPFILE '/u02/oracle/data/lmtemp01.dbf'
     SIZE 20M REUSE
```

```
    EXTENT MANAGEMENT LOCAL UNIFORM SIZE 16M;
```

The extent management clause is optional for temporary tablespaces because all temporary tablespaces are created with locally managed extents of a uniform size. The default for `SIZE` is 1M. But if you want to specify another value for `SIZE`, you can do so as shown in the preceding statement.

Note: On some operating systems, the database does not allocate space for the tempfile until the tempfile blocks are actually accessed. This delay in space allocation results in faster creation and resizing of tempfiles, but it requires that sufficient disk space is available when the tempfiles are later used. Please refer to your operating system documentation to determine whether the database allocates tempfile space in this way on your system.

Creating a Bigfile Temporary Tablespace

Just as for regular tablespaces, you can create single-file (bigfile) temporary tablespaces. Use the `CREATE BIGFILE TEMPORARY TABLESPACE` statement to create a single-tempfile tablespace. See the sections "Creating a Bigfile Tablespace" on page 12-7 and "Altering a Bigfile Tablespace" on page 12-21 for information about bigfile tablespaces, but consider that you are creating temporary tablespaces that use tempfiles instead of datafiles.

Viewing Space Usage for Temporary Tablespaces

The `DBA_TEMP_FREE_SPACE` dictionary view contains information about space usage for each temporary tablespace. The information includes the space allocated and the free space. You can query this view for these statistics using the following command.

```
SELECT * from DBA_TEMP_FREE_SPACE;

TABLESPACE_NAME                    TABLESPACE_SIZE ALLOCATED_SPACE FREE_SPACE
---------------------------------- --------------- --------------- ----------
TEMP                               250609664       250609664       249561088
```

Multiple Temporary Tablespaces: Using Tablespace Groups

A **tablespace group** enables a user to consume temporary space from multiple tablespaces. Using a tablespace group, rather than a single temporary tablespace, can alleviate problems caused where one tablespace is inadequate to hold the results of a sort, particularly on a table that has many partitions. A tablespace group enables parallel execution servers in a single parallel operation to use multiple temporary tablespaces.

A tablespace group has the following characteristics:

- It contains at least one tablespace. There is no explicit limit on the maximum number of tablespaces that are contained in a group.
- It shares the namespace of tablespaces, so its name cannot be the same as any tablespace.
- You can specify a tablespace group name wherever a tablespace name would appear when you assign a default temporary tablespace for the database or a temporary tablespace for a user.

You do not explicitly create a tablespace group. Rather, it is created implicitly when you assign the first temporary tablespace to the group. The group is deleted when the last temporary tablespace it contains is removed from it.

The view `DBA_TABLESPACE_GROUPS` lists tablespace groups and their member tablespaces.

> **See Also:** *Oracle Database Security Guide* for more information about assigning a temporary tablespace or tablespace group to a user

Creating a Tablespace Group

You create a tablespace group implicitly when you include the `TABLESPACE GROUP` clause in the `CREATE TEMPORARY TABLESPACE` or `ALTER TABLESPACE` statement and the specified tablespace group does not currently exist.

For example, if neither `group1` nor `group2` exists, then the following statements create those groups, each of which has only the specified tablespace as a member:

```
CREATE TEMPORARY TABLESPACE lmtemp2 TEMPFILE '/u02/oracle/data/lmtemp201.dbf'
     SIZE 50M
     TABLESPACE GROUP group1;

ALTER TABLESPACE lmtemp TABLESPACE GROUP group2;
```

Changing Members of a Tablespace Group

You can add a tablespace to an existing tablespace group by specifying the existing group name in the `TABLESPACE GROUP` clause of the `CREATE TEMPORARY TABLESPACE` or `ALTER TABLESPACE` statement.

The following statement adds a tablespace to an existing group. It creates and adds tablespace `lmtemp3` to `group1`, so that `group1` contains tablespaces `lmtemp2` and `lmtemp3`.

```
CREATE TEMPORARY TABLESPACE lmtemp3 TEMPFILE '/u02/oracle/data/lmtemp301.dbf'
     SIZE 25M
     TABLESPACE GROUP group1;
```

The following statement also adds a tablespace to an existing group, but in this case because tablespace `lmtemp2` already belongs to `group1`, it is in effect moved from `group1` to `group2`:

```
ALTER TABLESPACE lmtemp2 TABLESPACE GROUP group2;
```

Now `group2` contains both `lmtemp` and `lmtemp2`, while `group1` consists of only `tmtemp3`.

You can remove a tablespace from a group as shown in the following statement:

```
ALTER TABLESPACE lmtemp3 TABLESPACE GROUP '';
```

Tablespace `lmtemp3` no longer belongs to any group. Further, since there are no longer any members of `group1`, this results in the implicit deletion of `group1`.

Assigning a Tablespace Group as the Default Temporary Tablespace

Use the `ALTER DATABASE...DEFAULT TEMPORARY TABLESPACE` statement to assign a tablespace group as the default temporary tablespace for the database. For example:

```
ALTER DATABASE sample DEFAULT TEMPORARY TABLESPACE group2;
```

Any user who has not explicitly been assigned a temporary tablespace will now use tablespaces `lmtemp` and `lmtemp2`.

If a tablespace group is specified as the default temporary tablespace, you cannot drop any of its member tablespaces. You must first remove the tablespace from the tablespace group. Likewise, you cannot drop a single temporary tablespace as long as it is the default temporary tablespace.

Specifying Nonstandard Block Sizes for Tablespaces

You can create tablespaces with block sizes different from the standard database block size, which is specified by the `DB_BLOCK_SIZE` initialization parameter. This feature lets you transport tablespaces with unlike block sizes between databases.

Use the `BLOCKSIZE` clause of the `CREATE TABLESPACE` statement to create a tablespace with a block size different from the database standard block size. In order for the `BLOCKSIZE` clause to succeed, you must have already set the `DB_CACHE_SIZE` and at least one `DB_nK_CACHE_SIZE` initialization parameter. Further, and the integer you specify in the `BLOCKSIZE` clause must correspond with the setting of one DB_nK_CACHE_SIZE parameter setting. Although redundant, specifying a `BLOCKSIZE` equal to the standard block size, as specified by the `DB_BLOCK_SIZE` initialization parameter, is allowed.

The following statement creates tablespace `lmtbsb`, but specifies a block size that differs from the standard database block size (as specified by the `DB_BLOCK_SIZE` initialization parameter):

```
CREATE TABLESPACE lmtbsb DATAFILE '/u02/oracle/data/lmtbsb01.dbf' SIZE 50M
    EXTENT MANAGEMENT LOCAL UNIFORM SIZE 128K
    BLOCKSIZE 8K;
```

See Also:

- "Specifying Database Block Sizes" on page 2-23
- "Setting the Buffer Cache Initialization Parameters" on page 5-15 for information about the `DB_CACHE_SIZE` and `DB_nK_CACHE_SIZE` parameter settings
- "Transporting Tablespaces Between Databases" on page 12-29

Controlling the Writing of Redo Records

For some database operations, you can control whether the database generates redo records. Without redo, no media recovery is possible. However, suppressing redo generation can improve performance, and may be appropriate for easily recoverable operations. An example of such an operation is a `CREATE TABLE...AS SELECT` statement, which can be repeated in case of database or instance failure.

Specify the `NOLOGGING` clause in the `CREATE TABLESPACE` statement if you wish to suppress redo when these operations are performed for objects within the tablespace. If you do not include this clause, or if you specify `LOGGING` instead, then the database generates redo when changes are made to objects in the tablespace. Redo is never generated for temporary segments or in temporary tablespaces, regardless of the logging attribute.

The logging attribute specified at the tablespace level is the default attribute for objects created within the tablespace. You can override this default logging attribute by specifying LOGGING or NOLOGGING at the schema object level--for example, in a CREATE TABLE statement.

If you have a standby database, NOLOGGING mode causes problems with the availability and accuracy of the standby database. To overcome this problem, you can specify FORCE LOGGING mode. When you include the FORCE LOGGING clause in the CREATE TABLESPACE statement, you force the generation of redo records for all operations that make changes to objects in a tablespace. This overrides any specification made at the object level.

If you transport a tablespace that is in FORCE LOGGING mode to another database, the new tablespace will not maintain the FORCE LOGGING mode.

See Also:

- *Oracle Database SQL Language Reference* for information about operations that can be done in NOLOGGING mode
- "Specifying FORCE LOGGING Mode" on page 2-18 for more information about FORCE LOGGING mode and for information about the effects of the FORCE LOGGING clause used with the CREATE DATABASE statement

Altering Tablespace Availability

You can take an online tablespace offline so that it is temporarily unavailable for general use. The rest of the database remains open and available for users to access data. Conversely, you can bring an offline tablespace online to make the schema objects within the tablespace available to database users. The database must be open to alter the availability of a tablespace.

To alter the availability of a tablespace, use the ALTER TABLESPACE statement. You must have the ALTER TABLESPACE or MANAGE TABLESPACE system privilege.

See Also: "Altering Datafile Availability" on page 13-6 for information about altering the availability of individual datafiles within a tablespace

Taking Tablespaces Offline

You may want to take a tablespace offline for any of the following reasons:

- To make a portion of the database unavailable while allowing normal access to the remainder of the database
- To perform an offline tablespace backup (even though a tablespace can be backed up while online and in use)
- To make an application and its group of tables temporarily unavailable while updating or maintaining the application
- To rename or relocate tablespace datafiles

  See "Renaming and Relocating Datafiles" on page 13-8 for details.

When a tablespace is taken offline, the database takes all the associated files offline.

You cannot take the following tablespaces offline:

- SYSTEM
- The undo tablespace

- Temporary tablespaces

Before taking a tablespace offline, consider altering the tablespace allocation of any users who have been assigned the tablespace as a default tablespace. Doing so is advisable because those users will not be able to access objects in the tablespace while it is offline.

You can specify any of the following parameters as part of the `ALTER TABLESPACE...OFFLINE` statement:

Clause	Description
`NORMAL`	A tablespace can be taken offline normally if no error conditions exist for any of the datafiles of the tablespace. No datafile in the tablespace can be currently offline as the result of a write error. When you specify `OFFLINE NORMAL`, the database takes a checkpoint for all datafiles of the tablespace as it takes them offline. `NORMAL` is the default.
`TEMPORARY`	A tablespace can be taken offline temporarily, even if there are error conditions for one or more files of the tablespace. When you specify `OFFLINE TEMPORARY`, the database takes offline the datafiles that are not already offline, checkpointing them as it does so. If no files are offline, but you use the temporary clause, media recovery is not required to bring the tablespace back online. However, if one or more files of the tablespace are offline because of write errors, and you take the tablespace offline temporarily, the tablespace requires recovery before you can bring it back online.
`IMMEDIATE`	A tablespace can be taken offline immediately, without the database taking a checkpoint on any of the datafiles. When you specify `OFFLINE IMMEDIATE`, media recovery for the tablespace is required before the tablespace can be brought online. You cannot take a tablespace offline immediately if the database is running in `NOARCHIVELOG` mode.

Caution: If you must take a tablespace offline, use the `NORMAL` clause (the default) if possible. This setting guarantees that the tablespace will not require recovery to come back online, even if after incomplete recovery you reset the redo log sequence using an `ALTER DATABASE OPEN RESETLOGS` statement.

Specify `TEMPORARY` only when you cannot take the tablespace offline normally. In this case, only the files taken offline because of errors need to be recovered before the tablespace can be brought online. Specify `IMMEDIATE` only after trying both the normal and temporary settings.

The following example takes the `users` tablespace offline normally:

```
ALTER TABLESPACE users OFFLINE NORMAL;
```

Bringing Tablespaces Online

You can bring any tablespace in an Oracle Database online whenever the database is open. A tablespace is normally online so that the data contained within it is available to database users.

If a tablespace to be brought online was not taken offline "cleanly" (that is, using the `NORMAL` clause of the `ALTER TABLESPACE OFFLINE` statement), you must first perform media recovery on the tablespace before bringing it online. Otherwise, the database returns an error and the tablespace remains offline.

See Also: *Oracle Database Backup and Recovery User's Guide* for information about performing media recovery

The following statement brings the `users` tablespace online:

```
ALTER TABLESPACE users ONLINE;
```

Using Read-Only Tablespaces

Making a tablespace read-only prevents write operations on the datafiles in the tablespace. The primary purpose of read-only tablespaces is to eliminate the need to perform backup and recovery of large, static portions of a database. Read-only tablespaces also provide a way to protecting historical data so that users cannot modify it. Making a tablespace read-only prevents updates on all tables in the tablespace, regardless of a user's update privilege level.

Note: Making a tablespace read-only cannot in itself be used to satisfy archiving or data publishing requirements, because the tablespace can only be brought online in the database in which it was created. However, you can meet such requirements by using the transportable tablespace feature, as described in "Transporting Tablespaces Between Databases" on page 12-29.

You can drop items, such as tables or indexes, from a read-only tablespace, but you cannot create or alter objects in a read-only tablespace. You can execute statements that update the file description in the data dictionary, such as `ALTER TABLE...ADD` or `ALTER TABLE...MODIFY`, but you will not be able to utilize the new description until the tablespace is made read/write.

Read-only tablespaces can be transported to other databases. And, since read-only tablespaces can never be updated, they can reside on CD-ROM or WORM (Write Once-Read Many) devices.

The following topics are discussed in this section:

- Making a Tablespace Read-Only
- Making a Read-Only Tablespace Writable
- Creating a Read-Only Tablespace on a WORM Device
- Delaying the Opening of Datafiles in Read-Only Tablespaces

See Also: "Transporting Tablespaces Between Databases" on page 12-29

Making a Tablespace Read-Only

All tablespaces are initially created as read/write. Use the `READ ONLY` clause in the `ALTER TABLESPACE` statement to change a tablespace to read-only. You must have the `ALTER TABLESPACE` or `MANAGE TABLESPACE` system privilege.

Before you can make a tablespace read-only, the following conditions must be met.

- The tablespace must be online. This is necessary to ensure that there is no undo information that needs to be applied to the tablespace.
- The tablespace cannot be the active undo tablespace or `SYSTEM` tablespace.
- The tablespace must not currently be involved in an online backup, because the end of a backup updates the header file of all datafiles in the tablespace.

For better performance while accessing data in a read-only tablespace, you can issue a query that accesses all of the blocks of the tables in the tablespace just before making it read-only. A simple query, such as `SELECT COUNT (*)`, executed against each table ensures that the data blocks in the tablespace can be subsequently accessed most efficiently. This eliminates the need for the database to check the status of the transactions that most recently modified the blocks.

The following statement makes the `flights` tablespace read-only:

```
ALTER TABLESPACE flights READ ONLY;
```

You can issue the `ALTER TABLESPACE...READ ONLY` statement while the database is processing transactions. After the statement is issued, the tablespace is put into a transitional read-only state. No transactions are allowed to make further changes (using DML statements) to the tablespace. If a transaction attempts further changes, it is terminated and rolled back. However, transactions that already made changes and that attempt no further changes are allowed to commit or roll back.

When there are transactions waiting to commit, the `ALTER TABLESPACE...READ ONLY` statement does not return immediately. It waits for all transactions started before you issued the `ALTER TABLESPACE` statement to either commit or rollback.

Note: This transitional read-only state only occurs if the value of the initialization parameter `COMPATIBLE` is 8.1.0 or greater. If this parameter is set to a value less than 8.1.0, the `ALTER TABLESPACE...READ ONLY` statement fails if any active transactions exist.

If you find it is taking a long time for the `ALTER TABLESPACE` statement to complete, you can identify the transactions that are preventing the read-only state from taking effect. You can then notify the owners of those transactions and decide whether to terminate the transactions, if necessary.

The following example identifies the transaction entry for the `ALTER TABLESPACE...READ ONLY` statement and note its session address (`saddr`):

```
SELECT SQL_TEXT, SADDR
    FROM V$SQLAREA,V$SESSION
    WHERE V$SQLAREA.ADDRESS = V$SESSION.SQL_ADDRESS
        AND SQL_TEXT LIKE 'alter tablespace%';

SQL_TEXT                                 SADDR
---------------------------------------- --------
alter tablespace tbs1 read only          80034AF0
```

The start SCN of each active transaction is stored in the `V$TRANSACTION` view. Displaying this view sorted by ascending start SCN lists the transactions in execution order. From the preceding example, you already know the session address of the transaction entry for the read-only statement, and you can now locate it in the `V$TRANSACTION` view. All transactions with smaller start SCN, which indicates an earlier execution, can potentially hold up the quiesce and subsequent read-only state of the tablespace.

```
SELECT SES_ADDR, START_SCNB
    FROM V$TRANSACTION
    ORDER BY START_SCNB;

SES_ADDR START_SCNB
-------- ----------
800352A0       3621   --> waiting on this txn
80035A50       3623   --> waiting on this txn
80034AF0       3628   --> this is the ALTER TABLESPACE statement
80037910       3629   --> don't care about this txn
```

After making the tablespace read-only, it is advisable to back it up immediately. As long as the tablespace remains read-only, no further backups of the tablespace are necessary, because no changes can be made to it.

See Also: *Oracle Database Backup and Recovery User's Guide*

Making a Read-Only Tablespace Writable

Use the `READ WRITE` keywords in the `ALTER TABLESPACE` statement to change a tablespace to allow write operations. You must have the `ALTER TABLESPACE` or `MANAGE TABLESPACE` system privilege.

A prerequisite to making the tablespace read/write is that all of the datafiles in the tablespace, as well as the tablespace itself, must be online. Use the `DATAFILE...ONLINE` clause of the `ALTER DATABASE` statement to bring a datafile online. The `V$DATAFILE` view lists the current status of datafiles.

The following statement makes the `flights` tablespace writable:

```
ALTER TABLESPACE flights READ WRITE;
```

Making a read-only tablespace writable updates the control file entry for the datafiles, so that you can use the read-only version of the datafiles as a starting point for recovery.

Creating a Read-Only Tablespace on a WORM Device

Follow these steps to create a read-only tablespace on a CD-ROM or WORM (Write Once-Read Many) device.

1. Create a writable tablespace on another device. Create the objects that belong in the tablespace and insert your data.
2. Alter the tablespace to make it read-only.
3. Copy the datafiles of the tablespace onto the WORM device. Use operating system commands to copy the files.
4. Take the tablespace offline.
5. Rename the datafiles to coincide with the names of the datafiles you copied onto your WORM device. Use `ALTER TABLESPACE` with the `RENAME DATAFILE` clause. Renaming the datafiles changes their names in the control file.
6. Bring the tablespace back online.

Delaying the Opening of Datafiles in Read-Only Tablespaces

When substantial portions of a very large database are stored in read-only tablespaces that are located on slow-access devices or hierarchical storage, you should consider setting the `READ_ONLY_OPEN_DELAYED` initialization parameter to `TRUE`. This speeds certain operations, primarily opening the database, by causing datafiles in read-only tablespaces to be accessed for the first time only when an attempt is made to read data stored within them.

Setting `READ_ONLY_OPEN_DELAYED=TRUE` has the following side-effects:

- A missing or bad read-only file is not detected at open time. It is only discovered when there is an attempt to access it.
- `ALTER SYSTEM CHECK DATAFILES` does not check read-only files.
- `ALTER TABLESPACE...ONLINE` and `ALTER DATABASE DATAFILE...ONLINE` do not check read-only files. They are checked only upon the first access.
- `V$RECOVER_FILE`, `V$BACKUP`, and `V$DATAFILE_HEADER` do not access read-only files. Read-only files are indicated in the results list with the error "`DELAYED OPEN`", with zeroes for the values of other columns.
- `V$DATAFILE` does not access read-only files. Read-only files have a size of "0" listed.
- `V$RECOVER_LOG` does not access read-only files. Logs they could need for recovery are not added to the list.
- `ALTER DATABASE NOARCHIVELOG` does not access read-only files.It proceeds even if there is a read-only file that requires recovery.

Notes:

- `RECOVER DATABASE` and `ALTER DATABASE OPEN RESETLOGS` continue to access all read-only datafiles regardless of the parameter value. If you want to avoid accessing read-only files for these operations, those files should be taken offline.
- If a backup control file is used, the read-only status of some files may be inaccurate. This can cause some of these operations to return unexpected results. Care should be taken in this situation.

Altering and Maintaining Tablespaces

This section covers various subjects that relate to altering and maintaining tablespaces. Included are the following topics:

- Altering a Locally Managed Tablespace
- Altering a Bigfile Tablespace
- Altering a Locally Managed Temporary Tablespace
- Shrinking a Locally Managed Temporary Tablespace

Altering a Locally Managed Tablespace

You cannot alter a locally managed tablespace to a locally managed temporary tablespace, nor can you change its method of segment space management. Coalescing free extents is unnecessary for locally managed tablespaces. However, you can use the ALTER TABLESPACE statement on locally managed tablespaces for some operations, including the following:

- Adding a datafile. For example:

  ```
  ALTER TABLESPACE lmtbsb
     ADD DATAFILE '/u02/oracle/data/lmtbsb02.dbf' SIZE 1M;
  ```

- Altering tablespace availability (ONLINE/OFFLINE). See "Altering Tablespace Availability" on page 12-15.
- Making a tablespace read-only or read/write. See "Using Read-Only Tablespaces" on page 12-17.
- Renaming a datafile, or enabling or disabling the autoextension of the size of a datafile in the tablespace. See Chapter 13, "Managing Datafiles and Tempfiles".

Altering a Bigfile Tablespace

Two clauses of the ALTER TABLESPACE statement support datafile transparency when you are using bigfile tablespaces:

- RESIZE: The RESIZE clause lets you resize the single datafile in a bigfile tablespace to an absolute size, without referring to the datafile. For example:

  ```
  ALTER TABLESPACE bigtbs RESIZE 80G;
  ```

- AUTOEXTEND (used outside of the ADD DATAFILE clause):

  With a bigfile tablespace, you can use the AUTOEXTEND clause outside of the ADD DATAFILE clause. For example:

  ```
  ALTER TABLESPACE bigtbs AUTOEXTEND ON NEXT 20G;
  ```

An error is raised if you specify an ADD DATAFILE clause for a bigfile tablespace.

Altering a Locally Managed Temporary Tablespace

Note: You cannot use the ALTER TABLESPACE statement, with the TEMPORARY keyword, to change a locally managed permanent tablespace into a locally managed temporary tablespace. You must use the CREATE TEMPORARY TABLESPACE statement to create a locally managed temporary tablespace.

You can use ALTER TABLESPACE to add a tempfile, take a tempfile offline, or bring a tempfile online, as illustrated in the following examples:

```
ALTER TABLESPACE lmtemp
   ADD TEMPFILE '/u02/oracle/data/lmtemp02.dbf' SIZE 18M REUSE;

ALTER TABLESPACE lmtemp TEMPFILE OFFLINE;
ALTER TABLESPACE lmtemp TEMPFILE ONLINE;
```

Note: You cannot take a temporary tablespace offline. Instead, you take its tempfile offline. The view V$TEMPFILE displays online status for a tempfile.

The ALTER DATABASE statement can be used to alter tempfiles.

The following statements take offline and bring online tempfiles. They behave identically to the last two ALTER TABLESPACE statements in the previous example.

```
ALTER DATABASE TEMPFILE '/u02/oracle/data/lmtemp02.dbf' OFFLINE;
ALTER DATABASE TEMPFILE '/u02/oracle/data/lmtemp02.dbf' ONLINE;
```

The following statement resizes a tempfile:

```
ALTER DATABASE TEMPFILE '/u02/oracle/data/lmtemp02.dbf' RESIZE 18M;
```

The following statement drops a tempfile and deletes its operating system file:

```
ALTER DATABASE TEMPFILE '/u02/oracle/data/lmtemp02.dbf' DROP
    INCLUDING DATAFILES;
```

The tablespace to which this tempfile belonged remains. A message is written to the alert log for the tempfile that was deleted. If an operating system error prevents the deletion of the file, the statement still succeeds, but a message describing the error is written to the alert log.

It is also possible to use the ALTER DATABASE statement to enable or disable the automatic extension of an existing tempfile, and to rename (RENAME FILE) a tempfile. See *Oracle Database SQL Language Reference* for the required syntax.

Note: To rename a tempfile, you take the tempfile offline, use operating system commands to rename or relocate the tempfile, and then use the ALTER DATABASE RENAME FILE command to update the database controlfiles.

Shrinking a Locally Managed Temporary Tablespace

Large sort operations performed by the database may result in a temporary tablespace growing and occupying a considerable amount of disk space. After the sort operation completes, the extra space is not released; it is just marked as free and available for reuse. Therefore, a single large sort operation might result in a large amount of allocated temporary space that remains unused after the sort operation is complete. For this reason, the database enables you to shrink locally managed temporary tablespaces and release unused space.

You use the SHRINK SPACE clause of the ALTER TABLESPACE statement to shrink a temporary tablespace, or the SHRINK TEMPFILE clause of the ALTER TABLESPACE statement to shrink a specific tempfile of a temporary tablespace. Shrinking frees as much space as possible while maintaining the other attributes of the tablespace or tempfile. The optional KEEP clause defines a minimum size for the tablespace or tempfile.

Shrinking is an online operation, which means that user sessions can continue to allocate sort extents if needed, and already-running queries are not affected.

The following example shrinks the locally managed temporary tablespace lmtmp1 to a size of 20M.

```
ALTER TABLESPACE lmtemp1 SHRINK SPACE KEEP 20M;
```

The following example shrinks the tempfile lmtemp02.dbf of the locally managed temporary tablespace lmtmp2. Because the KEEP clause is omitted, the database attempts to shrink the tempfile to the minimum possible size.

```
ALTER TABLESPACE lmtemp2 SHRINK TEMPFILE '/u02/oracle/data/lmtemp02.dbf';
```

Renaming Tablespaces

Using the `RENAME TO` clause of the `ALTER TABLESPACE`, you can rename a permanent or temporary tablespace. For example, the following statement renames the `users` tablespace:

```
ALTER TABLESPACE users RENAME TO usersts;
```

When you rename a tablespace the database updates all references to the tablespace name in the data dictionary, control file, and (online) datafile headers. The database does not change the tablespace ID so if this tablespace were, for example, the default tablespace for a user, then the renamed tablespace would show as the default tablespace for the user in the `DBA_USERS` view.

The following affect the operation of this statement:

- The `COMPATIBLE` parameter must be set to 10.0.0 or higher.
- If the tablespace being renamed is the `SYSTEM` tablespace or the `SYSAUX` tablespace, then it will not be renamed and an error is raised.
- If any datafile in the tablespace is offline, or if the tablespace is offline, then the tablespace is not renamed and an error is raised.
- If the tablespace is read only, then datafile headers are not updated. This should not be regarded as corruption; instead, it causes a message to be written to the alert log indicating that datafile headers have not been renamed. The data dictionary and control file are updated.
- If the tablespace is the default temporary tablespace, then the corresponding entry in the database properties table is updated and the `DATABASE_PROPERTIES` view shows the new name.
- If the tablespace is an undo tablespace and if the following conditions are met, then the tablespace name is changed to the new tablespace name in the server parameter file (`SPFILE`).
  - The server parameter file was used to start up the database.
  - The tablespace name is specified as the `UNDO_TABLESPACE` for any instance.

  If a traditional initialization parameter file (`PFILE`) is being used then a message is written to the alert log stating that the initialization parameter file must be manually changed.

Dropping Tablespaces

You can drop a tablespace and its contents (the segments contained in the tablespace) from the database if the tablespace and its contents are no longer required. You must have the `DROP TABLESPACE` system privilege to drop a tablespace.

Caution: Once a tablespace has been dropped, the data in the tablespace is not recoverable. Therefore, make sure that all data contained in a tablespace to be dropped will not be required in the future. Also, immediately before and after dropping a tablespace from a database, back up the database completely. This is *strongly recommended* so that you can recover the database if you mistakenly drop a tablespace, or if the database experiences a problem in the future after the tablespace has been dropped.

When you drop a tablespace, the file pointers in the control file of the associated database are removed. You can optionally direct Oracle Database to delete the operating system files (datafiles) that constituted the dropped tablespace. If you do not direct the database to delete the datafiles at the same time that it deletes the tablespace, you must later use the appropriate commands of your operating system to delete them.

You cannot drop a tablespace that contains any active segments. For example, if a table in the tablespace is currently being used or the tablespace contains undo data needed to roll back uncommitted transactions, you cannot drop the tablespace. The tablespace can be online or offline, but it is best to take the tablespace offline before dropping it.

To drop a tablespace, use the `DROP TABLESPACE` statement. The following statement drops the `users` tablespace, including the segments in the tablespace:

```
DROP TABLESPACE users INCLUDING CONTENTS;
```

If the tablespace is empty (does not contain any tables, views, or other structures), you do not need to specify the `INCLUDING CONTENTS` clause. Use the `CASCADE CONSTRAINTS` clause to drop all referential integrity constraints from tables outside the tablespace that refer to primary and unique keys of tables inside the tablespace.

To delete the datafiles associated with a tablespace at the same time that the tablespace is dropped, use the `INCLUDING CONTENTS AND DATAFILES` clause. The following statement drops the `users` tablespace and its associated datafiles:

```
DROP TABLESPACE users INCLUDING CONTENTS AND DATAFILES;
```

A message is written to the alert log for each datafile that is deleted. If an operating system error prevents the deletion of a file, the `DROP TABLESPACE` statement still succeeds, but a message describing the error is written to the alert log.

See Also: "Dropping Datafiles" on page 13-11

Managing the SYSAUX Tablespace

The `SYSAUX` tablespace was installed as an auxiliary tablespace to the `SYSTEM` tablespace when you created your database. Some database components that formerly created and used separate tablespaces now occupy the `SYSAUX` tablespace.

If the `SYSAUX` tablespace becomes unavailable, core database functionality will remain operational. The database features that use the `SYSAUX` tablespace could fail, or function with limited capability.

Monitoring Occupants of the SYSAUX Tablespace

The list of registered occupants of the `SYSAUX` tablespace are discussed in "Creating the SYSAUX Tablespace" on page 2-12. These components can use the `SYSAUX` tablespace, and their installation provides the means of establishing their occupancy of the SYSAUX tablespace.

You can monitor the occupants of the SYSAUX tablespace using the V$SYSAUX_OCCUPANTS view. This view lists the following information about the occupants of the SYSAUX tablespace:

- Name of the occupant
- Occupant description
- Schema name
- Move procedure
- Current space usage

View information is maintained by the occupants.

> **See Also:** *Oracle Database Reference* for a detailed description of the V$SYSAUX_OCCUPANTS view

Moving Occupants Out Of or Into the SYSAUX Tablespace

You will have an option at component install time to specify that you do not want the component to reside in SYSAUX. Also, if you later decide that the component should be relocated to a designated tablespace, you can use the move procedure for that component, as specified in the V$SYSAUX_OCCUPANTS view, to perform the move.

For example, assume that you install Oracle Ultra Search into the default tablespace, which is SYSAUX. Later you discover that Ultra Search is using up too much space. To alleviate this space pressure on SYSAUX, you can call a PL/SQL move procedure specified in the V$SYSAUX_OCCUPANTS view to relocate Ultra Search to another tablespace.

The move procedure also lets you move a component from another tablespace into the SYSAUX tablespace.

Controlling the Size of the SYSAUX Tablespace

The SYSAUX tablespace is occupied by a number of database components (see Table 2–2), and its total size is governed by the space consumed by those components. The space consumed by the components, in turn, depends on which features or functionality are being used and on the nature of the database workload.

The largest portion of the SYSAUX tablespace is occupied by the Automatic Workload Repository (AWR). The space consumed by the AWR is determined by several factors, including the number of active sessions in the system at any given time, the snapshot interval, and the historical data retention period. A typical system with an average of 30 concurrent active sessions may require approximately 200 to 300 MB of space for its AWR data. You can control the size of the AWR by changing the snapshot interval and historical data retention period. For more information on managing the AWR snapshot interval and retention period, please refer to *Oracle Database Performance Tuning Guide*.

Another major occupant of the SYSAUX tablespace is the embedded Enterprise Manager (EM) repository. This repository is used by Oracle Enterprise Manager Database Control to store its metadata. The size of this repository depends on database activity and on configuration-related information stored in the repository.

Other database components in the SYSAUX tablespace will grow in size only if their associated features (for example, Oracle UltraSearch, Oracle Text, Oracle Streams) are in use. If the features are not used, then these components do not have any significant effect on the size of the SYSAUX tablespace.

Diagnosing and Repairing Locally Managed Tablespace Problems

Oracle Database includes the DBMS_SPACE_ADMIN package, which is a collection of aids for diagnosing and repairing problems in locally managed tablespaces.

DBMS_SPACE_ADMIN Package Procedures

The following table lists the DBMS_SPACE_ADMIN package procedures. See *Oracle Database PL/SQL Packages and Types Reference* for details on each procedure.

Procedure	Description
ASSM_SEGMENT_VERIFY	Verifies the integrity of segments created in tablespaces that have automatic segment space management enabled. Outputs a dump file named *sid*_ora_*process_id*.trc to the location that corresponds to the Diag Trace entry in the V$DIAG_INFO view. Use SEGMENT_VERIFY for tablespaces with manual segment space management.
ASSM_TABLESPACE_VERIFY	Verifies the integrity of tablespaces that have automatic segment space management enabled. Outputs a dump file named *sid*_ora_*process_id*.trc to the location that corresponds to the Diag Trace entry in the V$DIAG_INFO view. Use TABLESPACE_VERIFY for tablespaces with manual segment space management.
SEGMENT_CORRUPT	Marks the segment corrupt or valid so that appropriate error recovery can be done
SEGMENT_DROP_CORRUPT	Drops a segment currently marked corrupt (without reclaiming space)
SEGMENT_DUMP	Dumps the segment header and bitmap blocks of a specific segment to a dump file named *sid*_ora_*process_id*.trc in the location that corresponds to the Diag Trace entry in the V$DIAG_INFO view. Provides an option to select a slightly abbreviated dump, which includes segment header and includes bitmap block summaries, without percent-free states of each block.
SEGMENT_VERIFY	Verifies the consistency of the extent map of the segment
TABLESPACE_FIX_BITMAPS	Marks the appropriate DBA range (extent) as free or used in bitmap
TABLESPACE_FIX_SEGMENT_STATES	Fixes the state of the segments in a tablespace in which migration was stopped
TABLESPACE_MIGRATE_FROM_LOCAL	Migrates a locally managed tablespace to dictionary-managed tablespace
TABLESPACE_MIGRATE_TO_LOCAL	Migrates a dictionary-managed tablespace to a locally managed tablespace
TABLESPACE_REBUILD_BITMAPS	Rebuilds the appropriate bitmaps
TABLESPACE_REBUILD_QUOTAS	Rebuilds quotas for a specific tablespace
TABLESPACE_RELOCATE_BITMAPS	Relocates the bitmaps to the specified destination
TABLESPACE_VERIFY	Verifies that the bitmaps and extent maps for the segments in the tablespace are synchronized

The following scenarios describe typical situations in which you can use the DBMS_SPACE_ADMIN package to diagnose and resolve problems.

Note: Some of these procedures can result in lost and unrecoverable data if not used properly. You should work with Oracle Support Services if you have doubts about these procedures.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for details about the `DBMS_SPACE_ADMIN` package
- "Viewing ADR Locations with the V$DIAG_INFO View" on page 8-8

Scenario 1: Fixing Bitmap When Allocated Blocks are Marked Free (No Overlap)

The `TABLESPACE_VERIFY` procedure discovers that a segment has allocated blocks that are marked free in the bitmap, but no overlap between segments is reported.

In this scenario, perform the following tasks:

1. Call the `SEGMENT_DUMP` procedure to dump the ranges that the administrator allocated to the segment.
2. For each range, call the `TABLESPACE_FIX_BITMAPS` procedure with the `TABLESPACE_EXTENT_MAKE_USED` option to mark the space as used.
3. Call `TABLESPACE_REBUILD_QUOTAS` to rebuild quotas.

Scenario 2: Dropping a Corrupted Segment

You cannot drop a segment because the bitmap has segment blocks marked "free". The system has automatically marked the segment corrupted.

In this scenario, perform the following tasks:

1. Call the `SEGMENT_VERIFY` procedure with the `SEGMENT_VERIFY_EXTENTS_GLOBAL` option. If no overlaps are reported, then proceed with steps 2 through 5.
2. Call the `SEGMENT_DUMP` procedure to dump the DBA ranges allocated to the segment.
3. For each range, call `TABLESPACE_FIX_BITMAPS` with the `TABLESPACE_EXTENT_MAKE_FREE` option to mark the space as free.
4. Call `SEGMENT_DROP_CORRUPT` to drop the `SEG$` entry.
5. Call `TABLESPACE_REBUILD_QUOTAS` to rebuild quotas.

Scenario 3: Fixing Bitmap Where Overlap is Reported

The `TABLESPACE_VERIFY` procedure reports some overlapping. Some of the real data must be sacrificed based on previous internal errors.

After choosing the object to be sacrificed, in this case say, table `t1`, perform the following tasks:

1. Make a list of all objects that `t1` overlaps.
2. Drop table `t1`. If necessary, follow up by calling the `SEGMENT_DROP_CORRUPT` procedure.

3. Call the SEGMENT_VERIFY procedure on all objects that t1 overlapped. If necessary, call the TABLESPACE_FIX_BITMAPS procedure to mark appropriate bitmap blocks as used.
4. Rerun the TABLESPACE_VERIFY procedure to verify that the problem is resolved.

Scenario 4: Correcting Media Corruption of Bitmap Blocks

A set of bitmap blocks has media corruption.

In this scenario, perform the following tasks:

1. Call the TABLESPACE_REBUILD_BITMAPS procedure, either on all bitmap blocks, or on a single block if only one is corrupt.
2. Call the TABLESPACE_REBUILD_QUOTAS procedure to rebuild quotas.
3. Call the TABLESPACE_VERIFY procedure to verify that the bitmaps are consistent.

Scenario 5: Migrating from a Dictionary-Managed to a Locally Managed Tablespace

Use the TABLESPACE_MIGRATE_TO_LOCAL procedure to migrate a dictionary-managed tablespace to a locally managed tablespace. This operation is done online, but space management operations are blocked until the migration has been completed. This means that you can read or modify data while the migration is in progress, but if you are loading a large amount of data that requires the allocation of additional extents, then the operation may be blocked.

Assume that the database block size is 2K and the existing extent sizes in tablespace tbs_1 are 10, 50, and 10,000 blocks (used, used, and free). The MINIMUM EXTENT value is 20K (10 blocks). Allow the system to choose the bitmap allocation unit. The value of 10 blocks is chosen, because it is the highest common denominator and does not exceed MINIMUM EXTENT.

The statement to convert tbs_1 to a locally managed tablespace is as follows:

```
EXEC DBMS_SPACE_ADMIN.TABLESPACE_MIGRATE_TO_LOCAL ('tbs_1');
```

If you choose to specify an allocation unit size, it must be a factor of the unit size calculated by the system.

Migrating the SYSTEM Tablespace to a Locally Managed Tablespace

Use the DBMS_SPACE_ADMIN package to migrate the SYSTEM tablespace from dictionary-managed to locally managed. The following statement performs the migration:

```
SQL> EXECUTE DBMS_SPACE_ADMIN.TABLESPACE_MIGRATE_TO_LOCAL('SYSTEM');
```

Before performing the migration the following conditions must be met:

- The database has a default temporary tablespace that is not SYSTEM.
- There are no rollback segments in the dictionary-managed tablespace.
- There is at least one online rollback segment in a locally managed tablespace, or if using automatic undo management, an undo tablespace is online.
- All tablespaces other than the tablespace containing the undo space (that is, the tablespace containing the rollback segment or the undo tablespace) are in read-only mode.

- The system is in restricted mode.
- There is a cold backup of the database.

All of these conditions, except for the cold backup, are enforced by the `TABLESPACE_MIGRATE_TO_LOCAL` procedure.

Note: After the `SYSTEM` tablespace is migrated to locally managed, any dictionary-managed tablespaces in the database cannot be made read/write. If you want to be able to use the dictionary-managed tablespaces in read/write mode, then Oracle recommends that you first migrate these tablespaces to locally managed before migrating the `SYSTEM` tablespace.

Transporting Tablespaces Between Databases

This section describes how to transport tablespaces between databases, and contains the following topics:

- Introduction to Transportable Tablespaces
- About Transporting Tablespaces Across Platforms
- Limitations on Transportable Tablespace Use
- Compatibility Considerations for Transportable Tablespaces
- Transporting Tablespaces Between Databases: A Procedure and Example
- Using Transportable Tablespaces: Scenarios

Note: You must be using the Enterprise Edition of Oracle8*i* or later to generate a transportable tablespace set. However, you can use any edition of Oracle8*i* or later to import a transportable tablespace set into an Oracle Database on the same platform. To import a transportable tablespace set into an Oracle Database on a different platform, both databases must have compatibility set to at least 10.0. Please refer to "Compatibility Considerations for Transportable Tablespaces" on page 12-33 for a discussion of database compatibility for transporting tablespaces across release levels.

Introduction to Transportable Tablespaces

You can use the Transportable Tablespaces feature to copy a set of tablespaces from one Oracle Database to another.

Note: This method for transporting tablespaces requires that you place the tablespaces to be transported in read-only mode until you complete the transporting process. If this is undesirable, you can use the Transportable Tablespaces from Backup feature, described in *Oracle Database Backup and Recovery User's Guide*.

The tablespaces being transported can be either dictionary managed or locally managed. Starting with Oracle9*i*, the transported tablespaces are not required to be of the same block size as the target database standard block size.

Moving data using transportable tablespaces is much faster than performing either an export/import or unload/load of the same data. This is because the datafiles containing all of the actual data are just copied to the destination location, and you use Data Pump to transfer only the metadata of the tablespace objects to the new database.

Note: Beginning with Oracle Database 11g Release 1, you must use Data Pump for transportable tablespaces. The only circumstance under which you can use the original import and export utilities, IMP and EXP, is for a backward migration of XMLType data to a database version 10*g* Release 2 or earlier. Refer to *Oracle Database Utilities* for more information on these utilities and to *Oracle XML DB Developer's Guide* for more information on XMLTypes.

The transportable tablespace feature is useful in a number of scenarios, including:

- Exporting and importing partitions in data warehousing tables
- Publishing structured data on CDs
- Copying multiple read-only versions of a tablespace on multiple databases
- Archiving historical data
- Performing tablespace point-in-time-recovery (TSPITR)

These scenarios are discussed in "Using Transportable Tablespaces: Scenarios" on page 12-41.

There are two ways to transport a tablespace:

- Manually, following the steps described in this section. This involves issuing commands to SQL*Plus, RMAN, and Data Pump.
- Using the Transport Tablespaces Wizard in Enterprise Manager

  To run the Transport Tablespaces Wizard:

  1. Log in to Enterprise Manager with a user that has the `EXP_FULL_DATABASE` role.
  2. Click the **Maintenance** link to go to the Maintenance tab.
  3. Under the heading Move Database Files, click **Transport Tablespaces**.

See Also: *Oracle Database Data Warehousing Guide* for information about using transportable tablespaces in a data warehousing environment

About Transporting Tablespaces Across Platforms

Starting with Oracle Database 11*g*, you can transport tablespaces across platforms. This functionality can be used to:

- Allow a database to be migrated from one platform to another
- Provide an easier and more efficient means for content providers to publish structured data and distribute it to customers running Oracle Database on different platforms
- Simplify the distribution of data from a data warehouse environment to data marts, which are often running on smaller platforms

- Enable the sharing of read-only tablespaces between Oracle Database installations on different operating systems or platforms, assuming that your storage system is accessible from those platforms and the platforms all have the same endianness, as described in the sections that follow

Many, but not all, platforms are supported for cross-platform tablespace transport. You can query the `V$TRANSPORTABLE_PLATFORM` view to see the platforms that are supported, and to determine each platform's endian format (byte ordering). The following query displays the platforms that support cross-platform tablespace transport:

```
SQL> COLUMN PLATFORM_NAME FORMAT A32
SQL> SELECT * FROM V$TRANSPORTABLE_PLATFORM;

PLATFORM_ID PLATFORM_NAME                    ENDIAN_FORMAT
----------- -------------------------------- --------------
          1 Solaris[tm] OE (32-bit)          Big
          2 Solaris[tm] OE (64-bit)          Big
          7 Microsoft Windows IA (32-bit)    Little
         10 Linux IA (32-bit)                Little
          6 AIX-Based Systems (64-bit)       Big
          3 HP-UX (64-bit)                   Big
          5 HP Tru64 UNIX                    Little
          4 HP-UX IA (64-bit)                Big
         11 Linux IA (64-bit)                Little
         15 HP Open VMS                      Little
          8 Microsoft Windows IA (64-bit)    Little
          9 IBM zSeries Based Linux          Big
         13 Linux 64-bit for AMD             Little
         16 Apple Mac OS                     Big
         12 Microsoft Windows 64-bit for AMD Little
         17 Solaris Operating System (x86)   Little

16 rows selected.
```

If the source platform and the target platform are of different endianness, then an additional step must be done on either the source or target platform to convert the tablespace being transported to the target format. If they are of the same endianness, then no conversion is necessary and tablespaces can be transported as if they were on the same platform.

Before a tablespace can be transported to a different platform, the datafile header must identify the platform to which it belongs. In an Oracle Database with compatibility set to 10.0.0 or later, you can accomplish this by making the datafile read/write at least once.

Limitations on Transportable Tablespace Use

Be aware of the following limitations as you plan to transport tablespaces:

- The source and target database must use the same character set and national character set.
- You cannot transport a tablespace to a target database in which a tablespace with the same name already exists. However, you can rename either the tablespace to be transported or the destination tablespace before the transport operation.
- Objects with underlying objects (such as materialized views) or contained objects (such as partitioned tables) are not transportable unless all of the underlying or contained objects are in the tablespace set.

- Encrypted tablespaces have the following the limitations:
  - Before transporting an encrypted tablespace, you must copy the Oracle wallet manually to the destination database, unless the master encryption key is stored in a Hardware Security Module (HSM) device instead of an Oracle wallet. When copying the wallet, the wallet password remains the same in the destination database. However, it is recommended that you change the password on the destination database so that each database has its own wallet password. See *Oracle Database Advanced Security Administrator's Guide* for information about HSM devices, about determining the location of the Oracle wallet, and about changing the wallet password with Oracle Wallet Manager.
  - You cannot transport an encrypted tablespace to a database that already has an Oracle wallet for transparent data encryption. In this case, you must use Oracle Data Pump to export the tablespace's schema objects and then import them to the destination database. You can optionally take advantage of Oracle Data Pump features that enable you to maintain encryption for the data while it is being exported and imported. See *Oracle Database Utilities* for more information.
  - You cannot transport an encrypted tablespace to a platform with different endianness.
- Tablespaces that do not use block encryption but that contain tables with encrypted columns cannot be transported. You must use Oracle Data Pump to export and import the tablespace's schema objects. You can take advantage of Oracle Data Pump features that enable you to maintain encryption for the data while it is being exported and imported. See *Oracle Database Utilities* for more information.
- Beginning with Oracle Database 10*g* Release 2, you can transport tablespaces that contain XMLTypes. Beginning with Oracle Database 11*g* Release 1, you must use only Data Pump to export and import the tablespace metadata for tablespaces that contain XMLTypes.

  The following query returns a list of tablespaces that contain XMLTypes:

  ```
  select distinct p.tablespace_name from dba_tablespaces p,
    dba_xml_tables x, dba_users u, all_all_tables t where
    t.table_name=x.table_name and t.tablespace_name=p.tablespace_name
    and x.owner=u.username
  ```

  See *Oracle XML DB Developer's Guide* for information on XMLTypes.

  Transporting tablespaces with XMLTypes has the following limitations:

  - The target database must have XML DB installed.
  - Schemas referenced by XMLType tables cannot be the XML DB standard schemas.
  - Schemas referenced by XMLType tables cannot have cyclic dependencies.
  - XMLType tables with row level security are not supported, because they cannot be exported or imported.
  - If the schema for a transported XMLType table is not present in the target database, it is imported and registered. If the schema already exists in the target database, an error is returned unless the `ignore=y` option is set.
  - If an XMLType table uses a schema that is dependent on another schema, the schema that is depended on is not exported. The import succeeds only if that schema is already in the target database.

Additional limitations include the following:

Advanced Queues Transportable tablespaces do not support 8.0-compatible advanced queues with multiple recipients.

SYSTEM Tablespace Objects You cannot transport the SYSTEM tablespace or objects owned by the user SYS. Some examples of such objects are PL/SQL, Java classes, callouts, views, synonyms, users, privileges, dimensions, directories, and sequences.

Opaque Types Types whose interpretation is application-specific and opaque to the database (such as `RAW`, `BFILE`, and the AnyTypes) can be transported, but they are not converted as part of the cross-platform transport operation. Their actual structure is known only to the application, so the application must address any endianness issues after these types are moved to the new platform. Types and objects that use these opaque types, either directly or indirectly, are also subject to this limitation.

Floating-Point Numbers `BINARY_FLOAT` and `BINARY_DOUBLE` types are transportable using Data Pump.

Compatibility Considerations for Transportable Tablespaces

When you create a transportable tablespace set, Oracle Database computes the lowest compatibility level at which the target database must run. This is referred to as the compatibility level of the transportable set. Beginning with Oracle Database 11*g*, a tablespace can always be transported to a database with the same or higher compatibility setting, whether the target database is on the same or a different platform. The database signals an error if the compatibility level of the transportable set is higher than the compatibility level of the target database.

The following table shows the minimum compatibility requirements of the source and target tablespace in various scenarios. The source and target database need not have the same compatibility setting.

Table 12–1 Minimum Compatibility Requirements

	Minimum Compatibility Setting	
Transport Scenario	**Source Database**	**Target Database**
Databases on the same platform	8.0	8.0
Tablespace with different database block size than the target database	9.0	9.0
Databases on different platforms	10.0	10.0

Transporting Tablespaces Between Databases: A Procedure and Example

The following steps summarize the process of transporting a tablespace. Details for each step are provided in the subsequent example.

1. For cross-platform transport, check the endian format of both platforms by querying the `V$TRANSPORTABLE_PLATFORM` view.

   Ignore this step if you are transporting your tablespace set to the same platform.

2. Pick a self-contained set of tablespaces.

3. Generate a transportable tablespace set.

A **transportable tablespace set** (or **transportable set**) consists of datafiles for the set of tablespaces being transported and an export file containing structural information (metadata) for the set of tablespaces. You use Data Pump to perform the export.

If you are transporting the tablespace set to a platform with different endianness from the source platform, you must convert the tablespace set to the endianness of the target platform. You can perform a source-side conversion at this step in the procedure, or you can perform a target-side conversion as part of step 4.

Note: This method of generating a transportable tablespace requires that you temporarily make the tablespace read-only. If this is undesirable, you can use the alternate method known as transportable tablespace from backup. See *Oracle Database Backup and Recovery User's Guide* for details.

---

4. Transport the tablespace set.

   Copy the datafiles and the export file to a place that is accessible to the target database.

   If you have transported the tablespace set to a platform with different endianness from the source platform, and you have not performed a source-side conversion to the endianness of the target platform, you should perform a target-side conversion now.

5. Import the tablespace set.

   Invoke the Data Pump utility to import the metadata for the set of tablespaces into the target database.

Example

The steps for transporting a tablespace are illustrated more fully in the example that follows, where it is assumed the following datafiles and tablespaces exist:

Tablespace	Datafile
`sales_1`	/u01/oracle/oradata/salesdb/sales_101.dbf
`sales_2`	/u01/oracle/oradata/salesdb/sales_201.dbf

Step 1: Determine if Platforms are Supported and Determine Endianness

This step is only necessary if you are transporting the tablespace set to a platform different from the source platform.

If you are transporting the tablespace set to a platform different from the source platform, then determine if cross-platform tablespace transport is supported for both the source and target platforms, and determine the endianness of each platform. If both platforms have the same endianness, no conversion is necessary. Otherwise you must do a conversion of the tablespace set either at the source or target database.

If you are transporting `sales_1` and `sales_2` to a different platform, you can execute the following query on each platform. If the query returns a row, the platform supports cross-platform tablespace transport.

```
SELECT d.PLATFORM_NAME, ENDIAN_FORMAT
     FROM V$TRANSPORTABLE_PLATFORM tp, V$DATABASE d
     WHERE tp.PLATFORM_NAME = d.PLATFORM_NAME;
```

The following is the query result from the source platform:

```
PLATFORM_NAME            ENDIAN_FORMAT
------------------------ --------------
Solaris[tm] OE (32-bit)  Big
```

The following is the result from the target platform:

```
PLATFORM_NAME            ENDIAN_FORMAT
------------------------ --------------
Microsoft Windows NT     Little
```

You can see that the endian formats are different and thus a conversion is necessary for transporting the tablespace set.

Step 2: Pick a Self-Contained Set of Tablespaces

There may be logical or physical dependencies between objects in the transportable set and those outside of the set. You can only transport a set of tablespaces that is self-contained. In this context "self-contained" means that there are no references from inside the set of tablespaces pointing outside of the tablespaces. Some examples of self contained tablespace violations are:

- An index inside the set of tablespaces is for a table outside of the set of tablespaces.

  Note: It is not a violation if a corresponding index for a table is outside of the set of tablespaces.

- A partitioned table is partially contained in the set of tablespaces.

  The tablespace set you want to copy must contain either all partitions of a partitioned table, or none of the partitions of a partitioned table. If you want to transport a subset of a partition table, you must exchange the partitions into tables.
- A referential integrity constraint points to a table across a set boundary.

  When transporting a set of tablespaces, you can choose to include referential integrity constraints. However, doing so can affect whether or not a set of tablespaces is self-contained. If you decide not to transport constraints, then the constraints are not considered as pointers.
- A table inside the set of tablespaces contains a `LOB` column that points to `LOB`s outside the set of tablespaces.
- An XML DB schema (*.xsd) that was registered by user A imports a global schema that was registered by user B, and the following is true: the default tablespace for user A is tablespace A, the default tablespace for user B is tablespace B, and only tablespace A is included in the set of tablespaces.

To determine whether a set of tablespaces is self-contained, you can invoke the `TRANSPORT_SET_CHECK` procedure in the Oracle supplied package `DBMS_TTS`. You must have been granted the `EXECUTE_CATALOG_ROLE` role (initially signed to `SYS`) to execute this procedure.

When you invoke the `DBMS_TTS` package, you specify the list of tablespaces in the transportable set to be checked for self containment. You can optionally specify if constraints must be included. For strict or full containment, you must additionally set the `TTS_FULL_CHECK` parameter to `TRUE`.

The strict or full containment check is for cases that require capturing not only references going outside the transportable set, but also those coming into the set. Tablespace Point-in-Time Recovery (TSPITR) is one such case where dependent objects must be fully contained or fully outside the transportable set.

For example, it is a violation to perform TSPITR on a tablespace containing a table `t` but not its index `i` because the index and data will be inconsistent after the transport. A full containment check ensures that there are no dependencies going outside or coming into the transportable set. See the example for TSPITR in the *Oracle Database Backup and Recovery User's Guide*.

Note: The default for transportable tablespaces is to check for self containment rather than full containment.

The following statement can be used to determine whether tablespaces `sales_1` and `sales_2` are self-contained, with referential integrity constraints taken into consideration (indicated by `TRUE`).

```
EXECUTE DBMS_TTS.TRANSPORT_SET_CHECK('sales_1,sales_2', TRUE);
```

After invoking this PL/SQL package, you can see all violations by selecting from the `TRANSPORT_SET_VIOLATIONS` view. If the set of tablespaces is self-contained, this view is empty. The following example illustrates a case where there are two violations: a foreign key constraint, `dept_fk`, across the tablespace set boundary, and a partitioned table, `jim.sales`, that is partially contained in the tablespace set.

```
SQL> SELECT * FROM TRANSPORT_SET_VIOLATIONS;

VIOLATIONS
---------------------------------------------------------------------------
Constraint DEPT_FK between table JIM.EMP in tablespace SALES_1 and table
JIM.DEPT in tablespace OTHER
Partitioned table JIM.SALES is partially contained in the transportable set
```

These violations must be resolved before `sales_1` and `sales_2` are transportable. As noted in the next step, one choice for bypassing the integrity constraint violation is to not export the integrity constraints.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for more information about the `DBMS_TTS` package
- *Oracle Database Backup and Recovery User's Guide* for information specific to using the `DBMS_TTS` package for TSPITR

Step 3: Generate a Transportable Tablespace Set

Any privileged user can perform this step. However, you must have been assigned the `EXP_FULL_DATABASE` role to perform a transportable tablespace export operation.

Note: This method of generating a transportable tablespace requires that you temporarily make the tablespace read-only. If this is undesirable, you can use the alternate method known as transportable tablespace from backup. See *Oracle Database Backup and Recovery User's Guide* for details.

After ensuring you have a self-contained set of tablespaces that you want to transport, generate a transportable tablespace set by performing the following actions:

1. Make all tablespaces in the set you are copying read-only.

   ```
   SQL> ALTER TABLESPACE sales_1 READ ONLY;

   Tablespace altered.

   SQL> ALTER TABLESPACE sales_2 READ ONLY;

   Tablespace altered.
   ```

2. Invoke the Data Pump export utility on the host system and specify which tablespaces are in the transportable set.

   ```
   SQL> HOST

   $ EXPDP system/password DUMPFILE=expdat.dmp DIRECTORY=dpump_dir
           TRANSPORT_TABLESPACES = sales_1,sales_2
   ```

   You must always specify `TRANSPORT_TABLESPACES`, which determines the mode of the export operation. In this example:

   - The `DUMPFILE` parameter specifies the name of the structural information export file to be created, `expdat.dmp`.
   - The `DIRECTORY` parameter specifies the default directory object that points to the operating system or Automatic Storage Management location of the dump file. You must create the `DIRECTORY` object before invoking Data Pump, and you must grant the `READ` and `WRITE` object privileges on the directory to `PUBLIC`. See *Oracle Database SQL Language Reference* for information on the `CREATE DIRECTORY` command.
   - Triggers and indexes are included in the export operation by default.

   If you want to perform a transport tablespace operation with a strict containment check, use the `TRANSPORT_FULL_CHECK` parameter, as shown in the following example:

   ```
   EXPDP system/password DUMPFILE=expdat.dmp DIRECTORY = dpump_dir
         TRANSPORT_TABLESPACES=sales_1,sales_2 TRANSPORT_FULL_CHECK=Y
   ```

   In this example, the Data Pump export utility verifies that there are no dependencies between the objects inside the transportable set and objects outside the transportable set. If the tablespace set being transported is not self-contained, then the export fails and indicates that the transportable set is not self-contained. You must then return to Step 1 to resolve all violations.

   Notes: The Data Pump utility is used to export only data dictionary structural information (metadata) for the tablespaces. No actual data is unloaded, so this operation goes relatively quickly even for large tablespace sets.

3. When finished, exit back to SQL*Plus:

   ```
   $ EXIT
   ```

   See Also: *Oracle Database Utilities* for information about using the Data Pump utility

If sales_1 and sales_2 are being transported to a different platform, and the endianness of the platforms is different, and if you want to convert before transporting the tablespace set, then convert the datafiles composing the sales_1 and sales_2 tablespaces:

4. From SQL*Plus, return to the host system:

```
SQL> HOST
```

5. The RMAN CONVERT command is used to do the conversion. Start RMAN and connect to the target database:

```
$ RMAN TARGET /

Recovery Manager: Release 10.1.0.0.0

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connected to target database: salesdb (DBID=3295731590)
```

6. Convert the datafiles into a temporary location on the source platform. In this example, assume that the temporary location, directory /temp, has already been created. The converted datafiles are assigned names by the system.

```
RMAN> CONVERT TABLESPACE sales_1,sales_2
2> TO PLATFORM 'Microsoft Windows NT'
3> FORMAT '/temp/%U';

Starting backup at 08-APR-03
using target database control file instead of recovery catalog
allocated channel: ORA_DISK_1
channel ORA_DISK_1: sid=11 devtype=DISK
channel ORA_DISK_1: starting datafile conversion
input datafile fno=00005 name=/u01/oracle/oradata/salesdb/sales_101.dbf
converted datafile=/temp/data_D-10_I-3295731590_TS-ADMIN_TBS_FNO-5_05ek24v5
channel ORA_DISK_1: datafile conversion complete, elapsed time: 00:00:15
channel ORA_DISK_1: starting datafile conversion
input datafile fno=00004 name=/u01/oracle/oradata/salesdb/sales_101.dbf
converted datafile=/temp/data_D-10_I-3295731590_TS-EXAMPLE_FNO-4_06ek24vl
channel ORA_DISK_1: datafile conversion complete, elapsed time: 00:00:45
Finished backup at 08-APR-03
```

> **See Also:** *Oracle Database Backup and Recovery Reference* for a description of the RMAN CONVERT command

7. Exit Recovery Manager:

```
RMAN> exit
Recovery Manager complete.
```

Step 4: Transport the Tablespace Set

Transport *both the datafiles and the export file* of the tablespaces to a place that is accessible to the target database.

If both the source and destination are files systems, you can use:

- Any facility for copying flat files (for example, an operating system copy utility or ftp)
- The DBMS_FILE_TRANSFER package
- RMAN

- Any facility for publishing on CDs

If either the source or destination is an Automatic Storage Management (ASM) disk group, you can use:

- ftp to or from the `/sys/asm` virtual folder in the XML DB repository

  See *Oracle Database Storage Administrator's Guide* for more information.

- The `DBMS_FILE_TRANSFER` package
- RMAN

> **Caution:** Exercise caution when using the UNIX `dd` utility to copy raw-device files between databases. The `dd` utility can be used to copy an entire source raw-device file, or it can be invoked with options that instruct it to copy only a specific range of blocks from the source raw-device file.
>
> It is difficult to ascertain actual datafile size for a raw-device file because of hidden control information that is stored as part of the datafile. Thus, it is advisable when using the `dd` utility to specify copying the entire source raw-device file contents.

If you are transporting the tablespace set to a platform with endianness that is different from the source platform, and you have not yet converted the tablespace set, you must do so now. This example assumes that you have completed the following steps before the transport:

1. Set the source tablespaces to be transported to be read-only.
2. Use the export utility to create an export file (in our example, expdat.dmp).

Datafiles that are to be converted on the target platform can be moved to a temporary location on the target platform. However, all datafiles, whether already converted or not, must be moved to a designated location on the target database.

Now use RMAN to convert the necessary transported datafiles to the endian format of the destination host format and deposit the results in /orahome/dbs, as shown in this hypothetical example:

```
RMAN> CONVERT DATAFILE
2> '/hq/finance/work/tru/tbs_31.f',
3> '/hq/finance/work/tru/tbs_32.f',
4> '/hq/finance/work/tru/tbs_41.f'
5> TO PLATFORM="Solaris[tm] OE (32-bit)"
6> FROM PLATFORM="HP TRu64 UNIX"
7> DB_FILE_NAME_CONVERT=
8> "/hq/finance/work/tru/", "/hq/finance/dbs/tru"
9> PARALLELISM=5;
```

You identify the datafiles by filename, not by tablespace name. Until the tablespace metadata is imported, the local instance has no way of knowing the desired tablespace names. The source and destination platforms are optional. RMAN determines the source platform by examining the datafile, and the target platform defaults to the platform of the host running the conversion.

See Also: "Copying Files Using the Database Server" on page 13-12 for information about using the DBMS_FILE_TRANSFER package to copy the files that are being transported and their metadata

Step 5: Import the Tablespace Set

Note: If you are transporting a tablespace of a different block size than the standard block size of the database receiving the tablespace set, then you must first have a DB_*n*K_CACHE_SIZE initialization parameter entry in the receiving database parameter file.

For example, if you are transporting a tablespace with an 8K block size into a database with a 4K standard block size, then you must include a DB_8K_CACHE_SIZE initialization parameter entry in the parameter file. If it is not already included in the parameter file, this parameter can be set using the ALTER SYSTEM SET statement.

See *Oracle Database Reference* for information about specifying values for the DB_*n*K_CACHE_SIZE initialization parameter.

Any privileged user can perform this step. To import a tablespace set, perform the following tasks:

1. Import the tablespace metadata using the Data Pump Import utility, impdp:

```
IMPDP system/password DUMPFILE=expdat.dmp DIRECTORY=dpump_dir
   TRANSPORT_DATAFILES=
   /salesdb/sales_101.dbf,
   /salesdb/sales_201.dbf
   REMAP_SCHEMA=(dcranney:smith) REMAP_SCHEMA=(jfee:williams)
```

   In this example we specify the following:

   - The DUMPFILE parameter specifies the exported file containing the metadata for the tablespaces to be imported.
   - The DIRECTORY parameter specifies the directory object that identifies the location of the dump file.
   - The TRANSPORT_DATAFILES parameter identifies all of the datafiles containing the tablespaces to be imported.
   - The REMAP_SCHEMA parameter changes the ownership of database objects. If you do not specify REMAP_SCHEMA, all database objects (such as tables and indexes) are created in the same user schema as in the source database, and those users must already exist in the target database. If they do not exist, then the import utility returns an error. In this example, objects in the tablespace set owned by dcranney in the source database will be owned by smith in the target database after the tablespace set is imported. Similarly, objects owned by jfee in the source database will be owned by williams in the target database. In this case, the target database is not required to have users dcranney and jfee, but must have users smith and williams.

   After this statement executes successfully, all tablespaces in the set being copied remain in read-only mode. Check the import logs to ensure that no error has occurred.

When dealing with a large number of datafiles, specifying the list of datafile names in the statement line can be a laborious process. It can even exceed the statement line limit. In this situation, you can use an import parameter file. For example, you can invoke the Data Pump import utility as follows:

```
IMPDP system/password PARFILE='par.f'
```

where the parameter file, `par.f` contains the following:

```
DIRECTORY=dpump_dir
DUMPFILE=expdat.dmp
TRANSPORT_DATAFILES="'/db/sales_jan','/db/sales_feb'"
REMAP_SCHEMA=dcranney:smith
REMAP_SCHEMA=jfee:williams
```

> **See Also:** *Oracle Database Utilities* for information about using the import utility

2. If required, put the tablespaces into read/write mode as follows:

```
ALTER TABLESPACE sales_1 READ WRITE;
ALTER TABLESPACE sales_2 READ WRITE;
```

Using Transportable Tablespaces: Scenarios

The following sections describe some uses for transportable tablespaces:

- Transporting and Attaching Partitions for Data Warehousing
- Publishing Structured Data on CDs
- Mounting the Same Tablespace Read-Only on Multiple Databases
- Archiving Historical Data Using Transportable Tablespaces
- Using Transportable Tablespaces to Perform TSPITR

Transporting and Attaching Partitions for Data Warehousing

Typical enterprise data warehouses contain one or more large fact tables. These fact tables can be partitioned by date, making the enterprise data warehouse a historical database. You can build indexes to speed up star queries. Oracle recommends that you build local indexes for such historically partitioned tables to avoid rebuilding global indexes every time you drop the oldest partition from the historical database.

Suppose every month you would like to load one month of data into the data warehouse. There is a large fact table in the data warehouse called `sales`, which has the following columns:

```
CREATE TABLE sales (invoice_no NUMBER,
   sale_year  INT NOT NULL,
   sale_month INT NOT NULL,
   sale_day   INT NOT NULL)
   PARTITION BY RANGE (sale_year, sale_month, sale_day)
     (partition jan98 VALUES LESS THAN (1998, 2, 1),
      partition feb98 VALUES LESS THAN (1998, 3, 1),
      partition mar98 VALUES LESS THAN (1998, 4, 1),
      partition apr98 VALUES LESS THAN (1998, 5, 1),
      partition may98 VALUES LESS THAN (1998, 6, 1),
      partition jun98 VALUES LESS THAN (1998, 7, 1));
```

You create a local non-prefixed index:

```
CREATE INDEX sales_index ON sales(invoice_no) LOCAL;
```

Initially, all partitions are empty, and are in the same default tablespace. Each month, you want to create one partition and attach it to the partitioned `sales` table.

Suppose it is July 1998, and you would like to load the July sales data into the partitioned table. In a staging database, you create a new tablespace, `ts_jul`. You also create a table, `jul_sales`, in that tablespace with exactly the same column types as the `sales` table. You can create the table `jul_sales` using the `CREATE TABLE ... AS SELECT` statement. After creating and populating `jul_sales`, you can also create an index, `jul_sale_index`, for the table, indexing the same column as the local index in the `sales` table. After building the index, transport the tablespace `ts_jul` to the data warehouse.

In the data warehouse, add a partition to the `sales` table for the July sales data. This also creates another partition for the local non-prefixed index:

```
ALTER TABLE sales ADD PARTITION jul98 VALUES LESS THAN (1998, 8, 1);
```

Attach the transported table `jul_sales` to the table `sales` by exchanging it with the new partition:

```
ALTER TABLE sales EXCHANGE PARTITION jul98 WITH TABLE jul_sales
   INCLUDING INDEXES
   WITHOUT VALIDATION;
```

This statement places the July sales data into the new partition `jul98`, attaching the new data to the partitioned table. This statement also converts the index `jul_sale_index` into a partition of the local index for the `sales` table. This statement should return immediately, because it only operates on the structural information and it simply switches database pointers. If you know that the data in the new partition does not overlap with data in previous partitions, you are advised to specify the `WITHOUT VALIDATION` clause. Otherwise, the statement goes through all the new data in the new partition in an attempt to validate the range of that partition.

If all partitions of the `sales` table came from the same staging database (the staging database is never destroyed), the exchange statement always succeeds. In general, however, if data in a partitioned table comes from different databases, it is possible that the exchange operation may fail. For example, if the `jan98` partition of `sales` did not come from the same staging database, the preceding exchange operation can fail, returning the following error:

```
ORA-19728: data object number conflict between table JUL_SALES and partition JAN98
in table SALES
```

To resolve this conflict, move the offending partition by issuing the following statement:

```
ALTER TABLE sales MOVE PARTITION jan98;
```

Then retry the exchange operation.

After the exchange succeeds, you can safely drop `jul_sales` and `jul_sale_index` (both are now empty). Thus you have successfully loaded the July sales data into your data warehouse.

Publishing Structured Data on CDs

Transportable tablespaces provide a way to publish structured data on CDs. A data provider can load a tablespace with data to be published, generate the transportable set, and copy the transportable set to a CD. This CD can then be distributed.

When customers receive this CD, they can add the CD contents to an existing database without having to copy the datafiles from the CD to disk storage. For example, suppose on a Windows NT machine D: drive is the CD drive. You can import a transportable set with datafile `catalog.f` and export file `expdat.dmp` as follows:

```
IMPDP system/password DUMPFILE=expdat.dmp DIRECTORY=dpump_dir
   TRANSPORT_DATAFILES='D:\catalog.f'
```

You can remove the CD while the database is still up. Subsequent queries to the tablespace return an error indicating that the database cannot open the datafiles on the CD. However, operations to other parts of the database are not affected. Placing the CD back into the drive makes the tablespace readable again.

Removing the CD is the same as removing the datafiles of a read-only tablespace. If you shut down and restart the database, the database indicates that it cannot find the removed datafile and does not open the database (unless you set the initialization parameter `READ_ONLY_OPEN_DELAYED` to `TRUE`). When `READ_ONLY_OPEN_DELAYED` is set to `TRUE`, the database reads the file only when someone queries the transported tablespace. Thus, when transporting a tablespace from a CD, you should always set the `READ_ONLY_OPEN_DELAYED` initialization parameter to `TRUE`, unless the CD is permanently attached to the database.

Mounting the Same Tablespace Read-Only on Multiple Databases

You can use transportable tablespaces to mount a tablespace read-only on multiple databases. In this way, separate databases can share the same data on disk instead of duplicating data on separate disks. The tablespace datafiles must be accessible by all databases. To avoid database corruption, the tablespace must remain read-only in all the databases mounting the tablespace.

The following are two scenarios for mounting the same tablespace read-only on multiple databases:

- The tablespace originates in a database that is separate from the databases that will share the tablespace.

  You generate a transportable set in the source database, put the transportable set onto a disk that is accessible to all databases, and then import the metadata into each database on which you want to mount the tablespace.

- The tablespace already belongs to one of the databases that will share the tablespace.

  It is assumed that the datafiles are already on a shared disk. In the database where the tablespace already exists, you make the tablespace read-only, generate the transportable set, and then import the tablespace into the other databases, leaving the datafiles in the same location on the shared disk.

You can make a disk accessible by multiple computers in several ways. You can use either a cluster file system or raw disk. You can also use network file system (NFS), but be aware that if a user queries the shared tablespace while NFS is down, the database will hang until the NFS operation times out.

Later, you can drop the read-only tablespace in some of the databases. Doing so does not modify the datafiles for the tablespace. Thus, the drop operation does not corrupt the tablespace. Do not make the tablespace read/write unless only one database is mounting the tablespace.

Archiving Historical Data Using Transportable Tablespaces

Since a transportable tablespace set is a self-contained set of files that can be imported into any Oracle Database, you can archive old/historical data in an enterprise data warehouse using the transportable tablespace procedures described in this chapter.

> **See Also:** *Oracle Database Data Warehousing Guide* for more details

Using Transportable Tablespaces to Perform TSPITR

You can use transportable tablespaces to perform tablespace point-in-time recovery (TSPITR).

> **See Also:** *Oracle Database Backup and Recovery User's Guide* for information about how to perform TSPITR using transportable tablespaces

Moving Databases Across Platforms Using Transportable Tablespaces

You can use the transportable tablespace feature to migrate a database to a different platform by creating a new database on the destination platform and performing a transport of all the user tablespaces. See *Oracle Database Backup and Recovery User's Guide* for more information.

You cannot transport the `SYSTEM` tablespace. Therefore, objects such as sequences, PL/SQL packages, and other objects that depend on the `SYSTEM` tablespace are not transported. You must either create these objects manually on the destination database, or use Data Pump to transport the objects that are not moved by transportable tablespace.

Tablespace Data Dictionary Views

The following data dictionary and dynamic performance views provide useful information about the tablespaces of a database.

View	Description
`V$TABLESPACE`	Name and number of all tablespaces from the control file.
`V$ENCRYPTED_TABLESPACES`	Name and encryption algorithm of all encrypted tablespaces.
`DBA_TABLESPACES`, `USER_TABLESPACES`	Descriptions of all (or user accessible) tablespaces.
`DBA_TABLESPACE_GROUPS`	Displays the tablespace groups and the tablespaces that belong to them.
`DBA_SEGMENTS`, `USER_SEGMENTS`	Information about segments within all (or user accessible) tablespaces.
`DBA_EXTENTS`, `USER_EXTENTS`	Information about data extents within all (or user accessible) tablespaces.
`DBA_FREE_SPACE`, `USER_FREE_SPACE`	Information about free extents within all (or user accessible) tablespaces.
`DBA_TEMP_FREE_SPACE`	Displays the total allocated and free space in each temporary tablespace.
`V$DATAFILE`	Information about all datafiles, including tablespace number of owning tablespace.
`V$TEMPFILE`	Information about all tempfiles, including tablespace number of owning tablespace.

View	Description
`DBA_DATA_FILES`	Shows files (datafiles) belonging to tablespaces.
`DBA_TEMP_FILES`	Shows files (tempfiles) belonging to temporary tablespaces.
`V$TEMP_EXTENT_MAP`	Information for all extents in all locally managed temporary tablespaces.
`V$TEMP_EXTENT_POOL`	For locally managed temporary tablespaces: the state of temporary space cached and used for by each instance.
`V$TEMP_SPACE_HEADER`	Shows space used/free for each tempfile.
`DBA_USERS`	Default and temporary tablespaces for all users.
`DBA_TS_QUOTAS`	Lists tablespace quotas for all users.
`V$SORT_SEGMENT`	Information about every sort segment in a given instance. The view is only updated when the tablespace is of the `TEMPORARY` type.
`V$TEMPSEG_USAGE`	Describes temporary (sort) segment usage by user for temporary or permanent tablespaces.

The following are just a few examples of using some of these views.

See Also: *Oracle Database Reference* for complete description of these views

Example 1: Listing Tablespaces and Default Storage Parameters

To list the names and default storage parameters of all tablespaces in a database, use the following query on the `DBA_TABLESPACES` view:

```
SELECT TABLESPACE_NAME "TABLESPACE",
   INITIAL_EXTENT "INITIAL_EXT",
   NEXT_EXTENT "NEXT_EXT",
   MIN_EXTENTS "MIN_EXT",
   MAX_EXTENTS "MAX_EXT",
   PCT_INCREASE
   FROM DBA_TABLESPACES;

TABLESPACE  INITIAL_EXT  NEXT_EXT  MIN_EXT   MAX_EXT    PCT_INCREASE
----------  -----------  --------  -------   -------    ------------
RBS             1048576   1048576        2        40               0
SYSTEM           106496    106496        1        99               1
TEMP             106496    106496        1        99               0
TESTTBS           57344     16384        2        10               1
USERS             57344     57344        1        99               1
```

Example 2: Listing the Datafiles and Associated Tablespaces of a Database

To list the names, sizes, and associated tablespaces of a database, enter the following query on the `DBA_DATA_FILES` view:

```
SELECT  FILE_NAME, BLOCKS, TABLESPACE_NAME
   FROM DBA_DATA_FILES;

FILE_NAME                                       BLOCKS  TABLESPACE_NAME
------------                                ----------  -------------------
/U02/ORACLE/IDDB3/DBF/RBS01.DBF                   1536  RBS
/U02/ORACLE/IDDB3/DBF/SYSTEM01.DBF                6586  SYSTEM
/U02/ORACLE/IDDB3/DBF/TEMP01.DBF                  6400  TEMP
```

```
/U02/ORACLE/IDDB3/DBF/TESTTBS01.DBF             6400  TESTTBS
/U02/ORACLE/IDDB3/DBF/USERS01.DBF                384  USERS
```

Example 3: Displaying Statistics for Free Space (Extents) of Each Tablespace

To produce statistics about free extents and coalescing activity for each tablespace in the database, enter the following query:

```
SELECT TABLESPACE_NAME "TABLESPACE", FILE_ID,
   COUNT(*)    "PIECES",
   MAX(blocks) "MAXIMUM",
   MIN(blocks) "MINIMUM",
   AVG(blocks) "AVERAGE",
   SUM(blocks) "TOTAL"
   FROM DBA_FREE_SPACE
GROUP BY TABLESPACE_NAME, FILE_ID;

TABLESPACE    FILE_ID  PIECES   MAXIMUM    MINIMUM  AVERAGE    TOTAL
----------    -------  ------   -------    -------  -------   ------
RBS                 2       1       955        955      955      955
SYSTEM              1       1       119        119      119      119
TEMP                4       1      6399       6399     6399     6399
TESTTBS             5       5      6364          3     1278     6390
USERS               3       1       363        363      363      363
```

`PIECES` shows the number of free space extents in the tablespace file, `MAXIMUM` and `MINIMUM` show the largest and smallest contiguous area of space in database blocks, `AVERAGE` shows the average size in blocks of a free space extent, and `TOTAL` shows the amount of free space in each tablespace file in blocks. This query is useful when you are going to create a new object or you know that a segment is about to extend, and you want to make sure that there is enough space in the containing tablespace.

13 Managing Datafiles and Tempfiles

This chapter describes the various aspects of datafile and tempfile management, and contains the following topics:

See Also: Chapter 15, "Using Oracle-Managed Files" for information about creating datafiles and tempfiles that are both created and managed by the Oracle Database server

Guidelines for Managing Datafiles

Datafiles are physical files of the operating system that store the data of all logical structures in the database. They must be explicitly created for each tablespace.

Note: Tempfiles are a special class of datafiles that are associated only with temporary tablespaces. Information in this chapter applies to both datafiles and tempfiles except where differences are noted. Tempfiles are further described in "Creating a Locally Managed Temporary Tablespace" on page 12-11

Oracle Database assigns each datafile two associated file numbers, an absolute file number and a relative file number, that are used to uniquely identify it. These numbers are described in the following table:

Type of File Number	Description
Absolute	Uniquely identifies a datafile *in the database*. This file number can be used in many SQL statements that reference datafiles in place of using the file name. The absolute file number can be found in the `FILE#` column of the `V$DATAFILE` or `V$TEMPFILE` view, or in the `FILE_ID` column of the `DBA_DATA_FILES` or `DBA_TEMP_FILES` view.
Relative	Uniquely identifies a datafile *within a tablespace*. For small and medium size databases, relative file numbers usually have the same value as the absolute file number. However, when the number of datafiles in a database exceeds a threshold (typically 1023), the relative file number differs from the absolute file number. In a bigfile tablespace, the relative file number is always 1024 (4096 on OS/390 platform).

This section describes aspects of managing datafiles, and contains the following topics:

- Determine the Number of Datafiles
- Determine the Size of Datafiles
- Place Datafiles Appropriately
- Store Datafiles Separate from Redo Log Files

Determine the Number of Datafiles

At least one datafile is required for the `SYSTEM` and `SYSAUX` tablespaces of a database. Your database should contain several other tablespaces with their associated datafiles or tempfiles. The number of datafiles that you anticipate creating for your database can affect the settings of initialization parameters and the specification of `CREATE DATABASE` statement clauses.

Be aware that your operating system might impose limits on the number of datafiles contained in your Oracle Database. Also consider that the number of datafiles, and how and where they are allocated can affect the performance of your database.

Note: One means of controlling the number of datafiles in your database and simplifying their management is to use bigfile tablespaces. Bigfile tablespaces comprise a single, very large datafile and are especially useful in ultra large databases and where a logical volume manager is used for managing operating system files. Bigfile tablespaces are discussed in "Bigfile Tablespaces" on page 12-6.

Consider the following guidelines when determining the number of datafiles for your database.

Determine a Value for the DB_FILES Initialization Parameter

When starting an Oracle Database instance, the `DB_FILES` initialization parameter indicates the amount of SGA space to reserve for datafile information and thus, the maximum number of datafiles that can be created for the instance. This limit applies for the life of the instance. You can change the value of `DB_FILES` (by changing the initialization parameter setting), but the new value does not take effect until you shut down and restart the instance.

When determining a value for DB_FILES, take the following into consideration:

- If the value of DB_FILES is too low, you cannot add datafiles beyond the DB_FILES limit without first shutting down the database.
- If the value of DB_FILES is too high, memory is unnecessarily consumed.

Consider Possible Limitations When Adding Datafiles to a Tablespace

You can add datafiles to traditional smallfile tablespaces, subject to the following limitations:

- Operating systems often impose a limit on the number of files a process can open simultaneously. More datafiles cannot be created when the operating system limit of open files is reached.
- Operating systems impose limits on the number and size of datafiles.
- The database imposes a maximum limit on the number of datafiles for any Oracle Database opened by any instance. This limit is operating system specific.
- You cannot exceed the number of datafiles specified by the DB_FILES initialization parameter.
- When you issue CREATE DATABASE or CREATE CONTROLFILE statements, the MAXDATAFILES parameter specifies an initial size of the datafile portion of the control file. However, if you attempt to add a new file whose number is greater than MAXDATAFILES, but less than or equal to DB_FILES, the control file will expand automatically so that the datafiles section can accommodate more files.

Consider the Performance Impact

The number of datafiles contained in a tablespace, and ultimately the database, can have an impact upon performance.

Oracle Database allows more datafiles in the database than the operating system defined limit. The database DBW*n* processes can open all online datafiles. Oracle Database is capable of treating open file descriptors as a cache, automatically closing files when the number of open file descriptors reaches the operating system-defined limit. This can have a negative performance impact. When possible, adjust the operating system limit on open file descriptors so that it is larger than the number of online datafiles in the database.

See Also:

- Your operating system specific Oracle documentation for more information on operating system limits
- *Oracle Database SQL Language Reference* for more information about the MAXDATAFILES parameter of the CREATE DATABASE or CREATE CONTROLFILE statement

Determine the Size of Datafiles

When creating a tablespace, you should estimate the potential size of database objects and create sufficient datafiles. Later, if needed, you can create additional datafiles and add them to a tablespace to increase the total amount of disk space allocated to it, and consequently the database. Preferably, place datafiles on multiple devices to ensure that data is spread evenly across all devices.

Place Datafiles Appropriately

Tablespace location is determined by the physical location of the datafiles that constitute that tablespace. Use the hardware resources of your computer appropriately.

For example, if several disk drives are available to store the database, consider placing potentially contending datafiles on separate disks.This way, when users query information, both disk drives can work simultaneously, retrieving data at the same time.

> **See Also:** *Oracle Database Performance Tuning Guide* for information about I/O and the placement of datafiles

Store Datafiles Separate from Redo Log Files

Datafiles should not be stored on the same disk drive that stores the database redo log files. If the datafiles and redo log files are stored on the same disk drive and that disk drive fails, the files cannot be used in your database recovery procedures.

If you multiplex your redo log files, then the likelihood of losing all of your redo log files is low, so you can store datafiles on the same drive as some redo log files.

Creating Datafiles and Adding Datafiles to a Tablespace

You can create datafiles and associate them with a tablespace using any of the statements listed in the following table. In all cases, you can either specify the file specifications for the datafiles being created, or you can use the Oracle-managed files feature to create files that are created and managed by the database server. The table includes a brief description of the statement, as used to create datafiles, and references the section of this book where use of the statement is specifically described:

SQL Statement	Description	Additional Information
`CREATE TABLESPACE`	Creates a tablespace and the datafiles that comprise it	"Creating Tablespaces" on page 12-2
`CREATE TEMPORARY TABLESPACE`	Creates a locally-managed temporary tablespace and the *tempfiles* (tempfiles are a special kind of datafile) that comprise it	"Creating a Locally Managed Temporary Tablespace" on page 12-11
`ALTER TABLESPACE ... ADD DATAFILE`	Creates and adds a datafile to a tablespace	"Altering a Locally Managed Temporary Tablespace" on page 12-21
`ALTER TABLESPACE ... ADD TEMPFILE`	Creates and adds a tempfile to a temporary tablespace	"Creating a Locally Managed Temporary Tablespace" on page 12-11
`CREATE DATABASE`	Creates a database and associated datafiles	"Manually Creating an Oracle Database" on page 2-2
`ALTER DATABASE ... CREATE DATAFILE`	Creates a new empty datafile in place of an old one--useful to re-create a datafile that was lost with no backup.	See *Oracle Database Backup and Recovery User's Guide*.

If you add new datafiles to a tablespace and do not fully specify the filenames, the database creates the datafiles in the default database directory or the current directory, depending upon your operating system. Oracle recommends you always specify a fully qualified name for a datafile. Unless you want to reuse existing files, make sure the new filenames do not conflict with other files. Old files that have been previously dropped will be overwritten.

If a statement that creates a datafile fails, the database removes any created operating system files. However, because of the large number of potential errors that can occur with file systems and storage subsystems, there can be situations where you must manually remove the files using operating system commands.

Changing Datafile Size

This section describes the various ways to alter the size of a datafile, and contains the following topics:

- Enabling and Disabling Automatic Extension for a Datafile
- Manually Resizing a Datafile

Enabling and Disabling Automatic Extension for a Datafile

You can create datafiles or alter existing datafiles so that they automatically increase in size when more space is needed in the database. The file size increases in specified increments up to a specified maximum.

Setting your datafiles to extend automatically provides these advantages:

- Reduces the need for immediate intervention when a tablespace runs out of space
- Ensures applications will not halt or be suspended because of failures to allocate extents

To determine whether a datafile is auto-extensible, query the `DBA_DATA_FILES` view and examine the `AUTOEXTENSIBLE` column.

You can specify automatic file extension by specifying an `AUTOEXTEND ON` clause when you create datafiles using the following SQL statements:

- `CREATE DATABASE`
- `ALTER DATABASE`
- `CREATE TABLESPACE`
- `ALTER TABLESPACE`

You can enable or disable automatic file extension for existing datafiles, or manually resize a datafile, using the `ALTER DATABASE` statement. For a bigfile tablespace, you are able to perform these operations using the `ALTER TABLESPACE` statement.

The following example enables automatic extension for a datafile added to the `users` tablespace:

```
ALTER TABLESPACE users
    ADD DATAFILE '/u02/oracle/rbdb1/users03.dbf' SIZE 10M
      AUTOEXTEND ON
      NEXT 512K
      MAXSIZE 250M;
```

The value of `NEXT` is the minimum size of the increments added to the file when it extends. The value of `MAXSIZE` is the maximum size to which the file can automatically extend.

The next example disables the automatic extension for the datafile.

```
ALTER DATABASE DATAFILE '/u02/oracle/rbdb1/users03.dbf'
    AUTOEXTEND OFF;
```

See Also: *Oracle Database SQL Language Reference* for more information about the SQL statements for creating or altering datafiles

Manually Resizing a Datafile

You can manually increase or decrease the size of a datafile using the `ALTER DATABASE` statement. This enables you to add more space to your database without adding more datafiles. This is beneficial if you are concerned about reaching the maximum number of datafiles allowed in your database.

For a bigfile tablespace you can use the `ALTER TABLESPACE` statement to resize a datafile. You are not allowed to add a datafile to a bigfile tablespace.

Manually reducing the sizes of datafiles enables you to reclaim unused space in the database. This is useful for correcting errors in estimates of space requirements.

In the next example, assume that the datafile `/u02/oracle/rbdb1/stuff01.dbf` has extended up to 250M. However, because its tablespace now stores smaller objects, the datafile can be reduced in size.

The following statement decreases the size of datafile `/u02/oracle/rbdb1/stuff01.dbf`:

```
ALTER DATABASE DATAFILE '/u02/oracle/rbdb1/stuff01.dbf'
   RESIZE 100M;
```

Note: It is not always possible to decrease the size of a file to a specific value. It could be that the file contains data beyond the specified decreased size, in which case the database will return an error.

Altering Datafile Availability

You can alter the availability of individual datafiles or tempfiles by taking them offline or bringing them online. Offline datafiles are unavailable to the database and cannot be accessed until they are brought back online.

Reasons for altering datafile availability include the following:

- You want to perform an offline backup of a datafile.
- You want to rename or relocate a datafile. You must first take it offline or take the tablespace offline.
- The database has problems writing to a datafile and automatically takes the datafile offline. Later, after resolving the problem, you can bring the datafile back online manually.
- A datafile becomes missing or corrupted. You must take it offline before you can open the database.

The datafiles of a read-only tablespace can be taken offline or brought online, but bringing a file online does not affect the read-only status of the tablespace. You cannot write to the datafile until the tablespace is returned to the read/write state.

Note: You can make all datafiles of a tablespace temporarily unavailable by taking the tablespace itself offline. You *must* leave these files in the tablespace to bring the tablespace back online, although you can relocate or rename them following procedures similar to those shown in "Renaming and Relocating Datafiles" on page 13-8.

For more information, see "Taking Tablespaces Offline" on page 12-15.

To take a datafile offline or bring it online, you must have the `ALTER DATABASE` system privilege. To take all datafiles or tempfiles offline using the `ALTER TABLESPACE` statement, you must have the `ALTER TABLESPACE` or `MANAGE TABLESPACE` system privilege. In an Oracle Real Application Clusters environment, the database must be open in exclusive mode.

This section describes ways to alter datafile availability, and contains the following topics:

- Bringing Datafiles Online or Taking Offline in ARCHIVELOG Mode
- Taking Datafiles Offline in NOARCHIVELOG Mode
- Altering the Availability of All Datafiles or Tempfiles in a Tablespace

Bringing Datafiles Online or Taking Offline in ARCHIVELOG Mode

To bring an individual datafile online, issue the `ALTER DATABASE` statement and include the `DATAFILE` clause.The following statement brings the specified datafile online:

```
ALTER DATABASE DATAFILE '/u02/oracle/rbdb1/stuff01.dbf' ONLINE;
```

To take the same file offline, issue the following statement:

```
ALTER DATABASE DATAFILE '/u02/oracle/rbdb1/stuff01.dbf' OFFLINE;
```

Note: To use this form of the `ALTER DATABASE` statement, the database must be in `ARCHIVELOG` mode. This requirement prevents you from accidentally losing the datafile, since taking the datafile offline while in `NOARCHIVELOG` mode is likely to result in losing the file.

Taking Datafiles Offline in NOARCHIVELOG Mode

To take a datafile offline when the database is in `NOARCHIVELOG` mode, use the `ALTER DATABASE` statement with both the `DATAFILE` and `OFFLINE FOR DROP` clauses.

- The `OFFLINE` keyword causes the database to mark the datafile `OFFLINE`, whether or not it is corrupted, so that you can open the database.
- The `FOR DROP` keywords mark the datafile for subsequent dropping. Such a datafile can no longer be brought back online.

Note: This operation does not actually drop the datafile. It remains in the data dictionary, and you must drop it yourself using one of the following methods:

- An `ALTER TABLESPACE` ... `DROP DATAFILE` statement.

  After an `OFFLINE FOR DROP`, this method works for dictionary managed tablespaces only.
- A `DROP TABLESPACE` ... `INCLUDING CONTENTS AND DATAFILES` statement
- If the preceding methods fail, an operating system command to delete the datafile. This is the least desirable method, as it leaves references to the datafile in the data dictionary and control files.

The following statement takes the specified datafile offline and marks it to be dropped:

```
ALTER DATABASE DATAFILE '/u02/oracle/rbdb1/users03.dbf' OFFLINE FOR DROP;
```

Altering the Availability of All Datafiles or Tempfiles in a Tablespace

Clauses of the `ALTER TABLESPACE` statement allow you to change the online or offline status of all of the datafiles or tempfiles within a tablespace. Specifically, the statements that affect online/offline status are:

- `ALTER TABLESPACE` ... `DATAFILE {ONLINE|OFFLINE}`
- `ALTER TABLESPACE` ... `TEMPFILE {ONLINE|OFFLINE}`

You are required only to enter the tablespace name, not the individual datafiles or tempfiles. All of the datafiles or tempfiles are affected, but the online/offline status of the tablespace itself is not changed.

In most cases the preceding `ALTER TABLESPACE` statements can be issued whenever the database is mounted, even if it is not open. However, the database *must not* be open if the tablespace is the `SYSTEM` tablespace, an undo tablespace, or the default temporary tablespace. The `ALTER DATABASE DATAFILE` and `ALTER DATABASE TEMPFILE` statements also have `ONLINE/OFFLINE` clauses, however in those statements you must enter all of the filenames for the tablespace.

The syntax is different from the `ALTER TABLESPACE...ONLINE|OFFLINE` statement that alters tablespace availability, because that is a different operation. The `ALTER TABLESPACE` statement takes datafiles offline as well as the tablespace, but it cannot be used to alter the status of a temporary tablespace or its tempfile(s).

Renaming and Relocating Datafiles

You can rename datafiles to either change their names or relocate them. Some possible procedures for doing this are described in the following sections:

- Procedures for Renaming and Relocating Datafiles in a Single Tablespace
- Procedure for Renaming and Relocating Datafiles in Multiple Tablespaces

When you rename and relocate datafiles with these procedures, only the pointers to the datafiles, as recorded in the database control file, are changed. The procedures do not physically rename any operating system files, nor do they copy files at the operating system level. Renaming and relocating datafiles involves several steps. Read the steps and examples carefully before performing these procedures.

Procedures for Renaming and Relocating Datafiles in a Single Tablespace

The section suggests some procedures for renaming and relocating datafiles that can be used for a single tablespace. You must have `ALTER TABLESPACE` system privileges.

> **See Also:** "Taking Tablespaces Offline" on page 12-15 for more information about taking tablespaces offline in preparation for renaming or relocating datafiles

Procedure for Renaming Datafiles in a Single Tablespace

To rename datafiles in a single tablespace, complete the following steps:

1. Take the tablespace that contains the datafiles offline. The database must be open.

   For example:

   ```
   ALTER TABLESPACE users OFFLINE NORMAL;
   ```

2. Rename the datafiles using the operating system.
3. Use the `ALTER TABLESPACE` statement with the `RENAME DATAFILE` clause to change the filenames within the database.

   For example, the following statement renames the datafiles `/u02/oracle/rbdb1/user1.dbf` and `/u02/oracle/rbdb1/user2.dbf` to `/u02/oracle/rbdb1/users01.dbf` and `/u02/oracle/rbdb1/users02.dbf`, respectively:

   ```
   ALTER TABLESPACE users
       RENAME DATAFILE '/u02/oracle/rbdb1/user1.dbf',
                       '/u02/oracle/rbdb1/user2.dbf'
                    TO '/u02/oracle/rbdb1/users01.dbf',
                       '/u02/oracle/rbdb1/users02.dbf';
   ```

   Always provide complete filenames (including their paths) to properly identify the old and new datafiles. In particular, specify the old datafile name exactly as it appears in the `DBA_DATA_FILES` view of the data dictionary.

4. Back up the database. After making any structural changes to a database, always perform an immediate and complete backup.

Procedure for Relocating Datafiles in a Single Tablespace

Here is a sample procedure for relocating a datafile.

Assume the following conditions:

- An open database has a tablespace named `users` that is made up of datafiles all located on the same disk.
- The datafiles of the `users` tablespace are to be relocated to different and separate disk drives.
- You are currently connected with administrator privileges to the open database.
- You have a current backup of the database.

Complete the following steps:

1. If you do not know the specific file names or sizes, you can obtain this information by issuing the following query of the data dictionary view `DBA_DATA_FILES`:

   ```
   SQL> SELECT FILE_NAME, BYTES FROM DBA_DATA_FILES
     2> WHERE TABLESPACE_NAME = 'USERS';

   FILE_NAME                                  BYTES
   ------------------------------------------ ----------------
   /u02/oracle/rbdb1/users01.dbf              102400000
   /u02/oracle/rbdb1/users02.dbf              102400000
   ```

2. Take the tablespace containing the datafiles offline:

   ```
   ALTER TABLESPACE users OFFLINE NORMAL;
   ```

3. Copy the datafiles to their new locations and rename them using the operating system. You can copy the files using the `DBMS_FILE_TRANSFER` package discussed in "Copying Files Using the Database Server" on page 13-12.

   Note: You can temporarily exit SQL*Plus to execute an operating system command to copy a file by using the SQL*Plus `HOST` command.

4. Rename the datafiles within the database.

   The datafile pointers for the files that make up the `users` tablespace, recorded in the control file of the associated database, must now be changed from the old names to the new names.

   Use the `ALTER TABLESPACE...RENAME DATAFILE` statement.

   ```
   ALTER TABLESPACE users
       RENAME DATAFILE '/u02/oracle/rbdb1/users01.dbf',
                       '/u02/oracle/rbdb1/users02.dbf'
                    TO '/u03/oracle/rbdb1/users01.dbf',
                       '/u04/oracle/rbdb1/users02.dbf';
   ```

5. Back up the database. After making any structural changes to a database, always perform an immediate and complete backup.

Procedure for Renaming and Relocating Datafiles in Multiple Tablespaces

You can rename and relocate datafiles in one or more tablespaces using the `ALTER DATABASE RENAME FILE` statement. This method is the only choice if you want to rename or relocate datafiles of several tablespaces in one operation. You must have the `ALTER DATABASE` system privilege.

Note: To rename or relocate datafiles of the `SYSTEM` tablespace, the default temporary tablespace, or the active undo tablespace you must use this `ALTER DATABASE` method because you cannot take these tablespaces offline.

To rename datafiles in multiple tablespaces, follow these steps.

1. Ensure that the database is mounted but closed.

Note: Optionally, the database does not have to be closed, but the datafiles (or tempfiles) must be offline.

---

2. Copy the datafiles to be renamed to their new locations and new names, using the operating system. You can copy the files using the `DBMS_FILE_TRANSFER` package discussed in "Copying Files Using the Database Server" on page 13-12.
3. Use `ALTER DATABASE` to rename the file pointers in the database control file.

   For example, the following statement renames the datafiles`/u02/oracle/rbdb1/sort01.dbf` and `/u02/oracle/rbdb1/user3.dbf` to `/u02/oracle/rbdb1/temp01.dbf` and `/u02/oracle/rbdb1/users03.dbf`, respectively:

   ```
   ALTER DATABASE
       RENAME FILE '/u02/oracle/rbdb1/sort01.dbf',
                   '/u02/oracle/rbdb1/user3.dbf'
                TO '/u02/oracle/rbdb1/temp01.dbf',
                   '/u02/oracle/rbdb1/users03.dbf;
   ```

   Always provide complete filenames (including their paths) to properly identify the old and new datafiles. In particular, specify the old datafile names exactly as they appear in the `DBA_DATA_FILES` view.
4. Back up the database. After making any structural changes to a database, always perform an immediate and complete backup.

Dropping Datafiles

You use the `DROP DATAFILE` and `DROP TEMPFILE` clauses of the `ALTER TABLESPACE` command to drop a single datafile or tempfile. The datafile must be empty. (A datafile is considered to be empty when no extents remain allocated from it.) When you drop a datafile or tempfile, references to the datafile or tempfile are removed from the data dictionary and control files, and the physical file is deleted from the file system or Automatic Storage Management (ASM) disk group.

The following example drops the datafile identified by the alias `example_df3.f` in the ASM disk group `DGROUP1`. The datafile belongs to the `example` tablespace.

```
ALTER TABLESPACE example DROP DATAFILE '+DGROUP1/example_df3.f';
```

The next example drops the tempfile `lmtemp02.dbf`, which belongs to the `lmtemp` tablespace.

```
ALTER TABLESPACE lmtemp DROP TEMPFILE '/u02/oracle/data/lmtemp02.dbf';
```

This is equivalent to the following statement:

```
ALTER DATABASE TEMPFILE '/u02/oracle/data/lmtemp02.dbf' DROP
     INCLUDING DATAFILES;
```

See *Oracle Database SQL Language Reference* for `ALTER TABLESPACE` syntax details.

Restrictions for Dropping Datafiles

The following are restrictions for dropping datafiles and tempfiles:

- The database must be open.
- If a datafile is not empty, it cannot be dropped.

If you must remove a datafile that is not empty and that cannot be made empty by dropping schema objects, you must drop the tablespace that contains the datafile.

- You cannot drop the first or only datafile in a tablespace.

  This means that DROP DATAFILE cannot be used with a bigfile tablespace.
- You cannot drop datafiles in a read-only tablespace.
- You cannot drop datafiles in the SYSTEM tablespace.
- If a datafile in a locally managed tablespace is offline, it cannot be dropped.

See Also: Dropping Tablespaces on page 12-23

Verifying Data Blocks in Datafiles

If you want to configure the database to use checksums to verify data blocks, set the initialization parameter DB_BLOCK_CHECKSUM to TYPICAL (the default). This causes the DBW*n* process and the direct loader to calculate a checksum for each block and to store the checksum in the block header when writing the block to disk.

The checksum is verified when the block is read, but only if DB_BLOCK_CHECKSUM is TRUE and the last write of the block stored a checksum. If corruption is detected, the database returns message ORA-01578 and writes information about the corruption to the alert log.

The value of the DB_BLOCK_CHECKSUM parameter can be changed dynamically using the ALTER SYSTEM statement. Regardless of the setting of this parameter, checksums are always used to verify data blocks in the SYSTEM tablespace.

See Also: *Oracle Database Reference* for more information about the DB_BLOCK_CHECKSUM initialization parameter

Copying Files Using the Database Server

You do not necessarily have to use the operating system to copy a file within a database, or transfer a file between databases as you would do when using the transportable tablespace feature. You can use the DBMS_FILE_TRANSFER package, or you can use Streams propagation. Using Streams is not discussed in this book, but an example of using the DBMS_FILE_TRANSFER package is shown in "Copying a File on a Local File System" on page 13-13.

The DBMS_FILE_TRANSFER package can use a local file system or an Automatic Storage Management (ASM) disk group as the source or destination for a file transfer. Only Oracle database files (datafiles, tempfiles, controlfiles, and so on) can be involved in transfers to and from ASM.

Caution: Do not use the DBMS_FILE_TRANSFER package to copy or transfer a file that is being modified by a database because doing so may result in an inconsistent file.

On UNIX systems, the owner of a file created by the DBMS_FILE_TRANSFER package is the owner of the shadow process running the instance. Normally, this owner is ORACLE. A file created using DBMS_FILE_TRANSFER is always writable and readable by all processes in the database, but non privileged users who need to read or write such a file directly may need access from a system administrator.

This section contains the following topics:

- Copying a File on a Local File System
- Third-Party File Transfer
- File Transfer and the DBMS_SCHEDULER Package
- Advanced File Transfer Mechanisms

See Also:

- *Oracle Streams Concepts and Administration*
- "Transporting Tablespaces Between Databases" on page 12-29
- *Oracle Database PL/SQL Packages and Types Reference* for a description of the `DBMS_FILE_TRANSFER` package.

Copying a File on a Local File System

This section includes an example that uses the `COPY_FILE` procedure in the `DBMS_FILE_TRANSFER` package to copy a file on a local file system. The following example copies a binary file named `db1.dat` from the `/usr/admin/source` directory to the `/usr/admin/destination` directory as `db1_copy.dat` on a local file system:

1. In SQL*Plus, connect as an administrative user who can grant privileges and create directory objects using SQL.
2. Use the SQL command `CREATE DIRECTORY` to create a directory object for the directory from which you want to copy the file. A directory object is similar to an alias for the directory. For example, to create a directory object called `SOURCE_DIR` for the `/usr/admin/source` directory on your computer system, execute the following statement:

   ```
   CREATE DIRECTORY SOURCE_DIR AS '/usr/admin/source';
   ```

3. Use the SQL command `CREATE DIRECTORY` to create a directory object for the directory into which you want to copy the binary file. For example, to create a directory object called `DEST_DIR` for the `/usr/admin/destination` directory on your computer system, execute the following statement:

   ```
   CREATE DIRECTORY DEST_DIR AS '/usr/admin/destination';
   ```

4. Grant the required privileges to the user who will run the `COPY_FILE` procedure. In this example, the `strmadmin` user runs the procedure.

   ```
   GRANT EXECUTE ON DBMS_FILE_TRANSFER TO strmadmin;

   GRANT READ ON DIRECTORY source_dir TO strmadmin;

   GRANT WRITE ON DIRECTORY dest_dir TO strmadmin;
   ```

5. Connect as `strmadmin` user:

   ```
   CONNECT strmadmin/strmadminpw
   ```

6. Run the `COPY_FILE` procedure to copy the file:

   ```
   BEGIN
     DBMS_FILE_TRANSFER.COPY_FILE(
           source_directory_object       =>  'SOURCE_DIR',
           source_file_name              =>  'db1.dat',
   ```

```
        destination_directory_object  =>  'DEST_DIR',
        destination_file_name         =>  'db1_copy.dat');
END;
/
```

Caution: Do not use the DBMS_FILE_TRANSFER package to copy or transfer a file that is being modified by a database because doing so may result in an inconsistent file.

Third-Party File Transfer

Although the procedures in the `DBMS_FILE_TRANSFER` package typically are invoked as local procedure calls, they can also be invoked as remote procedure calls. A remote procedure call lets you copy a file within a database even when you are connected to a different database. For example, you can make a copy of a file on database `DB`, even if you are connected to another database, by executing the following remote procedure call:

```
DBMS_FILE_TRANSFER.COPY_FILE@DB(...)
```

Using remote procedure calls enables you to copy a file between two databases, even if you are not connected to either database. For example, you can connect to database `A` and then transfer a file from database `B` to database `C`. In this example, database `A` is the third party because it is neither the source of nor the destination for the transferred file.

A third-party file transfer can both push and pull a file. Continuing with the previous example, you can perform a third-party file transfer if you have a database link from `A` to either `B` or `C`, and that database has a database link to the other database. Database `A` does not need a database link to both `B` and `C`.

For example, if you have a database link from `A` to `B`, and another database link from `B` to `C`, then you can run the following procedure at `A` to transfer a file from `B` to `C`:

```
DBMS_FILE_TRANSFER.PUT_FILE@B(...)
```

This configuration pushes the file.

Alternatively, if you have a database link from `A` to `C`, and another database link from `C` to `B`, then you can run the following procedure at database `A` to transfer a file from `B` to `C`:

```
DBMS_FILE_TRANSFER.GET_FILE@C(...)
```

This configuration pulls the file.

File Transfer and the DBMS_SCHEDULER Package

You can use the `DBMS_SCHEDULER` package to transfer files automatically within a single database and between databases. Third-party file transfers are also supported by the `DBMS_SCHEDULER` package. You can monitor a long-running file transfer done by the Scheduler using the `V$SESSION_LONGOPS` dynamic performance view at the databases reading or writing the file. Any database links used by a Scheduler job must be fixed user database links.

You can use a restartable Scheduler job to improve the reliability of file transfers automatically, especially if there are intermittent failures. If a file transfer fails before the destination file is closed, then you can restart the file transfer from the beginning once the database has removed any partially written destination file. Hence you should consider using a restartable Scheduler job to transfer a file if the rest of the job is restartable. See Chapter 27, "Scheduling Jobs with Oracle Scheduler" for more information on Scheduler jobs.

Note: If a single restartable job transfers several files, then you should consider restart scenarios in which some of the files have been transferred already and some have not been transferred yet.

Advanced File Transfer Mechanisms

You can create more sophisticated file transfer mechanisms using both the `DBMS_FILE_TRANSFER` package and the `DBMS_SCHEDULER` package. For example, when several databases have a copy of the file you want to transfer, you can consider factors such as source availability, source load, and communication bandwidth to the destination database when deciding which source database to contact first and which source databases to try if failures occur. In this case, the information about these factors must be available to you, and you must create the mechanism that considers these factors.

As another example, when early completion time is more important than load, you can submit a number of Scheduler jobs to transfer files in parallel. As a final example, knowing something about file layout on the source and destination databases enables you to minimize disk contention by performing or scheduling simultaneous transfers only if they use different I/O devices.

Mapping Files to Physical Devices

In an environment where datafiles are simply file system files or are created directly on a raw device, it is relatively straight forward to see the association between a tablespace and the underlying device. Oracle Database provides views, such as `DBA_TABLESPACES`, `DBA_DATA_FILES`, and `V$DATAFILE`, that provide a mapping of files onto devices. These mappings, along with device statistics can be used to evaluate I/O performance.

However, with the introduction of host based Logical Volume Managers (LVM), and sophisticated storage subsystems that provide RAID (Redundant Array of Inexpensive Disks) features, it is not easy to determine file to device mapping. This poses a problem because it becomes difficult to determine your "hottest" files when they are hidden behind a "black box". This section presents the Oracle Database approach to resolving this problem.

The following topics are contained in this section:

- Overview of Oracle Database File Mapping Interface
- How the Oracle Database File Mapping Interface Works
- Using the Oracle Database File Mapping Interface
- File Mapping Examples

Note: This section presents an overview of the Oracle Database file mapping interface and explains how to use the `DBMS_STORAGE_MAP` package and dynamic performance views to expose the mapping of files onto physical devices. You can more easily access this functionality through the Oracle Enterprise Manager (EM). It provides an easy to use graphical interface for mapping files to physical devices.

Overview of Oracle Database File Mapping Interface

To acquire an understanding of I/O performance, one must have detailed knowledge of the storage hierarchy in which files reside. Oracle Database provides a mechanism to show a complete mapping of a file to intermediate layers of logical volumes to actual physical devices. This is accomplished though a set of dynamic performance views (`V$` views). Using these views, you can locate the exact disk on which any block of a file resides.

To build these views, storage vendors must provide mapping libraries that are responsible for mapping their particular I/O stack elements. The database communicates with these libraries through an external non-Oracle Database process that is spawned by a background process called FMON. FMON is responsible for managing the mapping information. Oracle provides a PL/SQL package, `DBMS_STORAGE_MAP`, that you use to invoke mapping operations that populate the mapping views.

Note: The file mapping interface is not available on Windows platforms.

How the Oracle Database File Mapping Interface Works

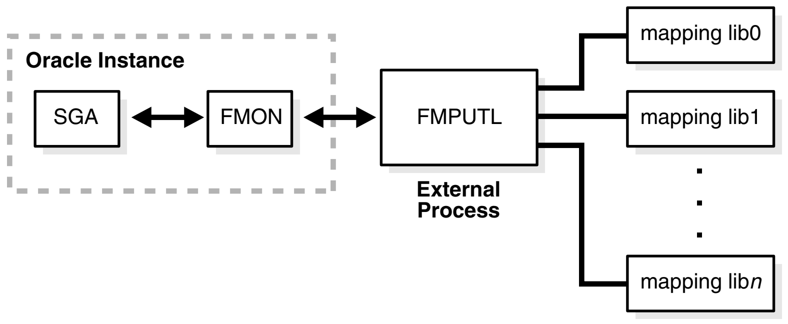
This section describes the components of the Oracle Database file mapping interface and how the interface works. It contains the following topics:

- Components of File Mapping
- Mapping Structures
- Example of Mapping Structures
- Configuration ID

Components of File Mapping

The following figure shows the components of the file mapping mechanism.

Figure 13–1 Components of File Mapping



The following sections briefly describes these components and how they work together to populate the mapping views:

- FMON
- External Process (FMPUTL)
- Mapping Libraries

FMON FMON is a background process started by the database whenever the `FILE_MAPPING` initialization parameter is set to `TRUE`. FMON is responsible for:

- Building mapping information, which is stored in the SGA. This information is composed of the following structures:
  - Files
  - File system extents
  - Elements
  - Subelements

  These structures are explained in "Mapping Structures" on page 13-18.
- Refreshing mapping information when a change occurs because of:
  - Changes to datafiles (size)
  - Addition or deletion of datafiles
  - Changes to the storage configuration (not frequent)
- Saving mapping information in the data dictionary to maintain a view of the information that is persistent across startup and shutdown operations
- Restoring mapping information into the SGA at instance startup. This avoids the need for a potentially expensive complete rebuild of the mapping information on every instance startup.

You help control this mapping using procedures that are invoked with the `DBMS_STORAGE_MAP` package.

External Process (FMPUTL) FMON spawns an external non-Oracle Database process called `FMPUTL`, that communicates directly with the vendor supplied mapping libraries. This process obtains the mapping information through all levels of the I/O stack, assuming that mapping libraries exist for all levels. On some platforms the external process requires that the `SETUID` bit is set to `ON` because root privileges are needed to map through all levels of the I/O mapping stack.

The external process is responsible for discovering the mapping libraries and dynamically loading them into its address space.

Mapping Libraries Oracle Database uses mapping libraries to discover mapping information for the elements that are owned by a particular mapping library. Through these mapping libraries information about individual I/O stack elements is communicated. This information is used to populate dynamic performance views that can be queried by users.

Mapping libraries need to exist for all levels of the stack for the mapping to be complete, and different libraries may own their own parts of the I/O mapping stack. For example, a VERITAS VxVM library would own the stack elements related to the VERITAS Volume Manager, and an EMC library would own all EMC storage specific layers of the I/O mapping stack.

Mapping libraries are vendor supplied. However, Oracle currently supplies a mapping library for EMC storage. The mapping libraries available to a database server are identified in a special file named filemap.ora.

Mapping Structures

The mapping structures and the Oracle Database representation of these structures are described in this section. You will need to understand this information in order to interpret the information in the mapping views.

The following are the primary structures that compose the mapping information:

- Files

  A file mapping structure provides a set of attributes for a file, including file size, number of file system extents that the file is composed of, and the file type.

- File system extents

  A file system extent mapping structure describes a contiguous chunk of blocks residing on one element. This includes the device offset, the extent size, the file offset, the type (data or parity), and the name of the element where the extent resides.

  Note: File system extents are not the same as Oracle Database extents. File system extents are physical contiguous blocks of data written to a device as managed by the file system. Oracle Database extents are logical structures managed by the database, such as tablespace extents.

- Elements

  An element mapping structure is the abstract mapping structure that describes a storage component within the I/O stack. Elements may be mirrors, stripes, partitions, RAID5, concatenated elements, and disks. These structures are the mapping building blocks.

- Subelements

  A subelement mapping structure describes the link between an element and the next elements in the I/O mapping stack. This structure contains the subelement number, size, the element name where the subelement exists, and the element offset.

All of these mapping structures are illustrated in the following example.

Example of Mapping Structures

Consider an Oracle Database which is composed of two data files X and Y. Both files X and Y reside on a file system mounted on volume A. File X is composed of two extents while file Y is composed of only one extent.

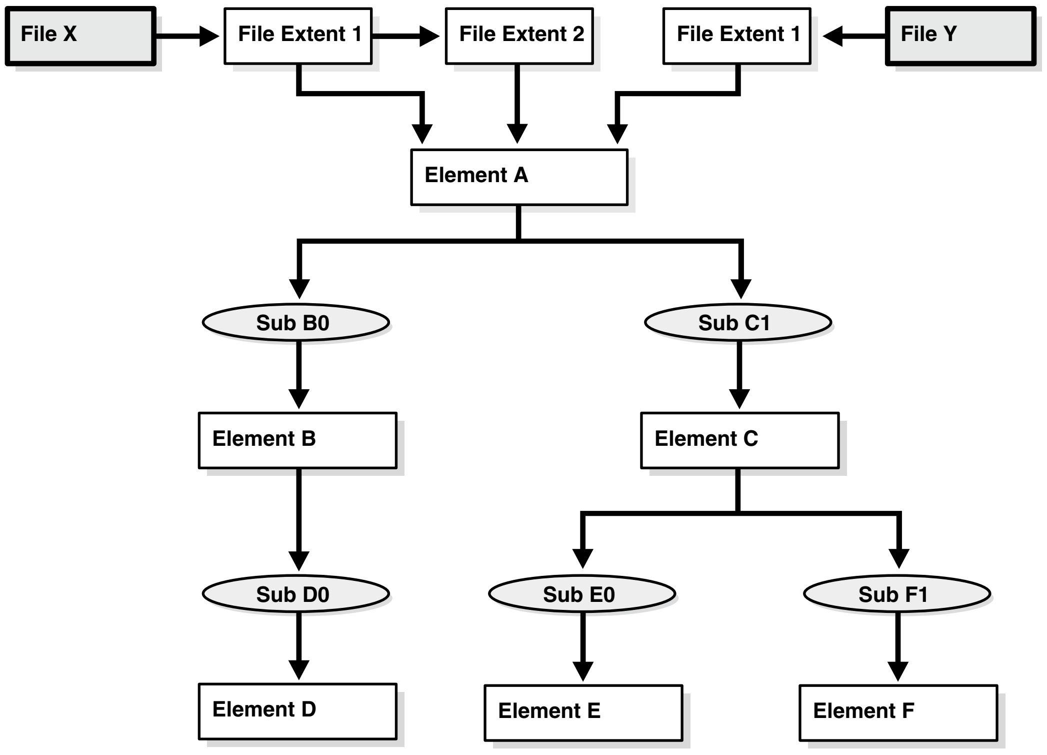
The two extents of File X and the one extent of File Y both map to Element A. Element A is striped to Elements B and C. Element A maps to Elements B and C by way of Subelements B0 and C1, respectively.

Element B is a partition of Element D (a physical disk), and is mapped to Element D by way of subelement D0.

Element C is mirrored over Elements E and F (both physical disks), and is mirrored to those physical disks by way of Subelements E0 and F1, respectively.

All of the mapping structures are illustrated in Figure 13–2.

Figure 13–2 Illustration of Mapping Structures



Note that the mapping structures represented are sufficient to describe the entire mapping information for the Oracle Database instance and consequently to map every logical block within the file into a (element name, element offset) tuple (or more in case of mirroring) at each level within the I/O stack.

Configuration ID

The configuration ID captures the version information associated with elements or files. The vendor library provides the configuration ID and updates it whenever a change occurs. Without a configuration ID, there is no way for the database to tell whether the mapping has changed.

There are two kinds of configuration IDs:

- Persistent

  These configuration IDs are persistent across instance shutdown

- Non-persistent

  The configuration IDs are not persistent across instance shutdown. The database is only capable of refreshing the mapping information while the instance is up.

Using the Oracle Database File Mapping Interface

This section discusses how to use the Oracle Database file mapping interface. It contains the following topics:

- Enabling File Mapping
- Using the DBMS_STORAGE_MAP Package
- Obtaining Information from the File Mapping Views

Enabling File Mapping

The following steps enable the file mapping feature:

1. Ensure that a valid filemap.ora file exists in the /opt/ORCLfmap/prot1_32/etc directory for 32-bit platforms, or in the /opt/ORCLfmap/prot1_64/etc directory for 64-bit platforms.

   Caution: While the format and content of the filemap.ora file is discussed here, it is for informational reasons only. The filemap.ora file is created by the database when your system is installed. Until such time that vendors supply there own libraries, there will be only one entry in the filemap.ora file, and that is the Oracle-supplied EMC library. This file should be modified manually by uncommenting this entry *only* if an EMC Symmetrix array is available.

   The filemap.ora file is the configuration file that describes all of the available mapping libraries. FMON requires that a filemap.ora file exists and that it points to a valid path to mapping libraries. Otherwise, it will not start successfully.

   The following row needs to be included in filemap.ora for each library:

   ```
   lib=vendor_name:mapping_library_path
   ```

   where:

   - *vendor_name* should be `Oracle` for the EMC Symmetric library
   - *mapping_library_path* is the full path of the mapping library

   Note that the ordering of the libraries in this file is extremely important. The libraries are queried based on their order in the configuration file.

   The file mapping service can be even started even if no mapping libraries are available. The filemap.ora file still needs to be present even though it is empty. In this case, the mapping service is constrained in the sense that new mapping information cannot be discovered. Only restore and drop operations are allowed in such a configuration.

2. Set the `FILE_MAPPING` initialization parameter to `TRUE`.

The instance does not have to be shut down to set this parameter. You can set it using the following `ALTER SYSTEM` statement:

```
ALTER SYSTEM SET FILE_MAPPING=TRUE;
```

3. Invoke the appropriate `DBMS_STORAGE_MAP` mapping procedure. You have two options:

   - In a cold startup scenario, the Oracle Database is just started and no mapping operation has been invoked yet. You execute the `DBMS_STORAGE_MAP.MAP_ALL` procedure to build the mapping information for the entire I/O subsystem associated with the database.
   - In a warm start scenario where the mapping information is already built, you have the option to invoke the `DBMS_STORAGE_MAP.MAP_SAVE` procedure to save the mapping information in the data dictionary. (Note that this procedure is invoked in `DBMS_STORAGE_MAP.MAP_ALL()` by default.) This forces all of the mapping information in the SGA to be flushed to disk.

     Once you restart the database, use `DBMS_STORAGE_MAP.RESTORE()` to restore the mapping information into the SGA. If needed, `DBMS_STORAGE_MAP.MAP_ALL()` can be called to refresh the mapping information.

Using the DBMS_STORAGE_MAP Package

The `DBMS_STORAGE_MAP` package enables you to control the mapping operations. The various procedures available to you are described in the following table.

Procedure	**Use to:**
`MAP_OBJECT`	Build the mapping information for the database object identified by object name, owner, and type
`MAP_ELEMENT`	Build mapping information for the specified element
`MAP_FILE`	Build mapping information for the specified filename
`MAP_ALL`	Build entire mapping information for all types of database files (excluding archive logs)
`DROP_ELEMENT`	Drop the mapping information for a specified element
`DROP_FILE`	Drop the file mapping information for the specified filename
`DROP_ALL`	Drop all mapping information in the SGA for this instance
`SAVE`	Save into the data dictionary the required information needed to regenerate the entire mapping
`RESTORE`	Load the entire mapping information from the data dictionary into the shared memory of the instance
`LOCK_MAP`	Lock the mapping information in the SGA for this instance
`UNLOCK_MAP`	Unlock the mapping information in the SGA for this instance

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for a description of the `DBMS_STORAGE_MAP` package
- "File Mapping Examples" on page 13-23 for an example of using the `DBMS_STORAGE_MAP` package

Obtaining Information from the File Mapping Views

Mapping information generated by DBMS_STORAGE_MAP package is captured in dynamic performance views. Brief descriptions of these views are presented here.

View	Description
V$MAP_LIBRARY	Contains a list of all mapping libraries that have been dynamically loaded by the external process
V$MAP_FILE	Contains a list of all file mapping structures in the shared memory of the instance
V$MAP_FILE_EXTENT	Contains a list of all file system extent mapping structures in the shared memory of the instance
V$MAP_ELEMENT	Contains a list of all element mapping structures in the SGA of the instance
V$MAP_EXT_ELEMENT	Contains supplementary information for all element mapping
V$MAP_SUBELEMENT	Contains a list of all subelement mapping structures in the shared memory of the instance
V$MAP_COMP_LIST	Contains supplementary information for all element mapping structures.
V$MAP_FILE_IO_STACK	The hierarchical arrangement of storage containers for the file displayed as a series of rows. Each row represents a level in the hierarchy.

See Also: *Oracle Database Reference* for a complete description of the dynamic performance views

However, the information generated by the DBMS_STORAGE_MAP.MAP_OBJECT procedure is captured in a global temporary table named MAP_OBJECT. This table displays the hierarchical arrangement of storage containers for objects. Each row in the table represents a level in the hierarchy. A description of the MAP_OBJECT table follows.

Column	Datatype	Description
OBJECT_NAME	VARCHAR2(2000)	Name of the object
OBJECT_OWNER	VARCHAR2(2000)	Owner of the object
OBJECT_TYPE	VARCHAR2(2000)	Object type
FILE_MAP_IDX	NUMBER	File index (corresponds to FILE_MAP_IDX in V$MAP_FILE)
DEPTH	NUMBER	Element depth within the I/O stack
ELEM_IDX	NUMBER	Index corresponding to element
CU_SIZE	NUMBER	Contiguous set of logical blocks of the file, in HKB (half KB) units, that is resident contiguously on the element
STRIDE	NUMBER	Number of HKB between contiguous units (CU) in the file that are contiguous on this element. Used in RAID5 and striped files.
NUM_CU	NUMBER	Number of contiguous units that are adjacent to each other on this element that are separated by STRIDE HKB in the file. In RAID5, the number of contiguous units also include the parity stripes.

Column	Datatype	Description
ELEM_OFFSET	NUMBER	Element offset in HKB units
FILE_OFFSET	NUMBER	Offset in HKB units from the start of the file to the first byte of the contiguous units
DATA_TYPE	VARCHAR2(2000)	Datatype (DATA, PARITY, or DATA AND PARITY)
PARITY_POS	NUMBER	Position of the parity. Only for RAID5. This field is needed to distinguish the parity from the data part.
PARITY_PERIOD	NUMBER	Parity period. Only for RAID5.

File Mapping Examples

The following examples illustrates some of the powerful capabilities of the Oracle Database file mapping feature. This includes:

- The ability to map all the database files that span a particular device
- The ability to map a particular file into its corresponding devices
- The ability to map a particular database object, including its block distribution at all levels within the I/O stack

Consider an Oracle Database instance which is composed of two datafiles:

- `t_db1.f`
- `t_db2.f`

These files are created on a Solaris UFS file system mounted on a VERITAS VxVM host based striped volume, `/dev/vx/dsk/ipfdg/ipf-vol1`, that consists of the following host devices as externalized from an EMC Symmetrix array:

- `/dev/vx/rdmp/c2t1d0s2`
- `/dev/vx/rdmp/c2t1d1s2`

Note that the following examples require the execution of a `MAP_ALL()` operation.

Example 1: Map All Database Files that Span a Device

The following query returns all Oracle Database files associated with the `/dev/vx/rdmp/c2t1d1s2` host device:

```
SELECT UNIQUE me.ELEM_NAME, mf.FILE_NAME
   FROM V$MAP_FILE_IO_STACK fs, V$MAP_FILE mf, V$MAP_ELEMENT me
   WHERE mf.FILE_MAP_IDX = fs.FILE_MAP_IDX
   AND me.ELEM_IDX = fs.ELEM_IDX
   AND me.ELEM_NAME = '/dev/vx/rdmp/c2t1d1s2';
```

The query results are:

```
ELEM_NAME                 FILE_NAME
------------------------  --------------------------------
/dev/vx/rdmp/c2t1d1s2     /oracle/dbs/t_db1.f
/dev/vx/rdmp/c2t1d1s2     /oracle/dbs/t_db2.f
```

Example 2: Map a File into Its Corresponding Devices

The following query displays a topological graph of the `/oracle/dbs/t_db1.f` datafile:

```
WITH fv AS
```

```
  (SELECT FILE_MAP_IDX, FILE_NAME FROM V$MAP_FILE
   WHERE FILE_NAME = '/oracle/dbs/t_db1.f')
SELECT fv.FILE_NAME, LPAD(' ', 4 * (LEVEL - 1)) || el.ELEM_NAME ELEM_NAME
   FROM V$MAP_SUBELEMENT sb, V$MAP_ELEMENT el, fv,
     (SELECT UNIQUE ELEM_IDX FROM V$MAP_FILE_IO_STACK io, fv
      WHERE io.FILE_MAP_IDX = fv.FILE_MAP_IDX) fs
   WHERE el.ELEM_IDX = sb.CHILD_IDX
   AND fs.ELEM_IDX = el.ELEM_IDX
   START WITH sb.PARENT_IDX IN
     (SELECT DISTINCT ELEM_IDX
      FROM V$MAP_FILE_EXTENT fe, fv
      WHERE fv.FILE_MAP_IDX = fe.FILE_MAP_IDX)
   CONNECT BY PRIOR sb.CHILD_IDX = sb.PARENT_IDX;
```

The resulting topological graph is:

```
FILE_NAME                     ELEM_NAME
-----------------------       ------------------------------------------------
/oracle/dbs/t_db1.f           _sym_plex_/dev/vx/rdsk/ipfdg/ipf-vol1_-1_-1
/oracle/dbs/t_db1.f               _sym_subdisk_/dev/vx/rdsk/ipfdg/ipf-vol1_0_0_0
/oracle/dbs/t_db1.f                   /dev/vx/rdmp/c2t1d0s2
/oracle/dbs/t_db1.f                       _sym_symdev_000183600407_00C
/oracle/dbs/t_db1.f                           _sym_hyper_000183600407_00C_0
/oracle/dbs/t_db1.f                           _sym_hyper_000183600407_00C_1
/oracle/dbs/t_db1.f               _sym_subdisk_/dev/vx/rdsk/ipfdg/ipf-vol1_0_1_0
/oracle/dbs/t_db1.f                   /dev/vx/rdmp/c2t1d1s2
/oracle/dbs/t_db1.f                       _sym_symdev_000183600407_00D
/oracle/dbs/t_db1.f                           _sym_hyper_000183600407_00D_0
/oracle/dbs/t_db1.f                           _sym_hyper_000183600407_00D_1
```

Example 3: Map a Database Object

This example displays the block distribution at all levels within the I/O stack for the `scott.bonus` table.

A `MAP_OBJECT()` operation must first be executed as follows:

```
EXECUTE DBMS_STORAGE_MAP.MAP_OBJECT('BONUS','SCOTT','TABLE');
```

The query is as follows:

```
SELECT io.OBJECT_NAME o_name, io.OBJECT_OWNER o_owner, io.OBJECT_TYPE o_type,
       mf.FILE_NAME, me.ELEM_NAME, io.DEPTH,
      (SUM(io.CU_SIZE * (io.NUM_CU - DECODE(io.PARITY_PERIOD, 0, 0,
                        TRUNC(io.NUM_CU / io.PARITY_PERIOD)))) / 2) o_size
   FROM MAP_OBJECT io, V$MAP_ELEMENT me, V$MAP_FILE mf
   WHERE io.OBJECT_NAME =  'BONUS'
   AND   io.OBJECT_OWNER = 'SCOTT'
   AND   io.OBJECT_TYPE =  'TABLE'
   AND   me.ELEM_IDX = io.ELEM_IDX
   AND   mf.FILE_MAP_IDX = io.FILE_MAP_IDX
   GROUP BY io.ELEM_IDX, io.FILE_MAP_IDX, me.ELEM_NAME, mf.FILE_NAME, io.DEPTH,
         io.OBJECT_NAME, io.OBJECT_OWNER, io.OBJECT_TYPE
   ORDER BY io.DEPTH;
```

The following is the result of the query. Note that the `o_size` column is expressed in KB.

```
O_NAME O_OWNER O_TYPE  FILE_NAME            ELEM_NAME                      DEPTH   O_SIZE
------ ------- ------  -------------------  ----------------------------  ------  ------
BONUS  SCOTT   TABLE   /oracle/dbs/t_db1.f  /dev/vx/dsk/ipfdg/ipf-vol1          0      20
BONUS  SCOTT   TABLE   /oracle/dbs/t_db1.f  _sym_plex_/dev/vx/rdsk/ipf          1      20
```

```
                                      pdg/if-vol1_-1_-1
BONUS  SCOTT   TABLE   /oracle/dbs/t_db1.f  _sym_subdisk_/dev/vx/rdsk/         2      12
                                      ipfdg/ipf-vol1_0_1_0
BONUS  SCOTT   TABLE   /oracle/dbs/t_db1.f  _sym_subdisk_/dev/vx/rdsk/ipf      2       8
                                      dg/ipf-vol1_0_2_0
BONUS  SCOTT   TABLE   /oracle/dbs/t_db1.f  /dev/vx/rdmp/c2t1d1s2              3      12
BONUS  SCOTT   TABLE   /oracle/dbs/t_db1.f  /dev/vx/rdmp/c2t1d2s2              3       8
BONUS  SCOTT   TABLE   /oracle/dbs/t_db1.f  _sym_symdev_000183600407_00D       4      12
BONUS  SCOTT   TABLE   /oracle/dbs/t_db1.f  _sym_symdev_000183600407_00E       4       8
BONUS  SCOTT   TABLE   /oracle/dbs/t_db1.f  _sym_hyper_000183600407_00D_0      5      12
BONUS  SCOTT   TABLE   /oracle/dbs/t_db1.f  _sym_hyper_000183600407_00D_1      5      12
BONUS  SCOTT   TABLE   /oracle/dbs/t_db1.f  _sym_hyper_000183600407_00E_0      6       8
BONUS  SCOTT   TABLE   /oracle/dbs/t_db1.f  _sym_hyper_000183600407_00E_1      6       8
```

Datafiles Data Dictionary Views

The following data dictionary views provide useful information about the datafiles of a database:

View	Description
DBA_DATA_FILES	Provides descriptive information about each datafile, including the tablespace to which it belongs and the file ID. The file ID can be used to join with other views for detail information.
DBA_EXTENTS USER_EXTENTS	DBA view describes the extents comprising all segments in the database. Contains the file ID of the datafile containing the extent. USER view describes extents of the segments belonging to objects owned by the current user.
DBA_FREE_SPACE USER_FREE_SPACE	DBA view lists the free extents in all tablespaces. Includes the file ID of the datafile containing the extent. USER view lists the free extents in the tablespaces accessible to the current user.
V$DATAFILE	Contains datafile information from the control file
V$DATAFILE_HEADER	Contains information from datafile headers

This example illustrates the use of one of these views, V$DATAFILE.

```
SELECT NAME,
    FILE#,
    STATUS,
    CHECKPOINT_CHANGE# "CHECKPOINT"
  FROM   V$DATAFILE;

NAME                                     FILE#     STATUS       CHECKPOINT
--------------------------------         -----     -------       ----------
/u01/oracle/rbdb1/system01.dbf               1     SYSTEM             3839
/u02/oracle/rbdb1/temp01.dbf                 2     ONLINE             3782
/u02/oracle/rbdb1/users03.dbf                3     OFFLINE            3782
```

FILE# lists the file number of each datafile; the first datafile in the SYSTEM tablespace created with the database is always file 1. STATUS lists other information about a datafile. If a datafile is part of the SYSTEM tablespace, its status is SYSTEM (unless it requires recovery). If a datafile in a non-SYSTEM tablespace is online, its status is ONLINE. If a datafile in a non-SYSTEM tablespace is offline, its status can be either OFFLINE or RECOVER. CHECKPOINT lists the final SCN (system change number) written for the most recent checkpoint of a datafile.

See Also: *Oracle Database Reference* for complete descriptions of these views

14 Managing Undo

Beginning with Release 11*g*, for a default installation, Oracle Database automatically manages undo. There is typically no need for DBA intervention. However, if your installation uses Oracle Flashback operations, you may need to perform some undo management tasks to ensure the success of these operations.

This section provides background information and instructions for managing undo data. It contains the following topics:

See Also: Chapter 15, "Using Oracle-Managed Files"for information about creating an undo tablespace whose datafiles are both created and managed by Oracle Database.

What Is Undo?

Oracle Database creates and manages information that is used to roll back, or undo, changes to the database. Such information consists of records of the actions of transactions, primarily before they are committed. These records are collectively referred to as **undo**.

Undo records are used to:

- Roll back transactions when a `ROLLBACK` statement is issued
- Recover the database
- Provide read consistency
- Analyze data as of an earlier point in time by using Oracle Flashback Query
- Recover from logical corruptions using Oracle Flashback features

When a `ROLLBACK` statement is issued, undo records are used to undo changes that were made to the database by the uncommitted transaction. During database recovery, undo records are used to undo any uncommitted changes applied from the redo log to the datafiles. Undo records provide read consistency by maintaining the before image of the data for users who are accessing the data at the same time that another user is changing it.

Introduction to Automatic Undo Management

This section introduces the concepts of Automatic Undo Management and discusses the following topics:

- Overview of Automatic Undo Management
- About the Undo Retention Period

Overview of Automatic Undo Management

Oracle provides a fully automated mechanism, referred to as automatic undo management, for managing undo information and space. With automatic undo management, the database manages undo segments in an undo tablespace. Beginning with Release 11*g*, automatic undo management is the default mode for a newly installed database. An auto-extending undo tablespace named `UNDOTBS1` is automatically created when you create the database with Database Configuration Assistant (DBCA).

An undo tablespace can also be created explicitly. The methods of creating an undo tablespace are explained in "Creating an Undo Tablespace" on page 14-8.

When the instance starts, the database automatically selects the first available undo tablespace. If no undo tablespace is available, the instance starts without an undo tablespace and stores undo records in the `SYSTEM` tablespace. This is not recommended, and an alert message is written to the alert log file to warn that the system is running without an undo tablespace.

If the database contains multiple undo tablespaces, you can optionally specify at startup that you want to use a specific undo tablespace. This is done by setting the `UNDO_TABLESPACE` initialization parameter, as shown in this example:

```
UNDO_TABLESPACE = undotbs_01
```

If the tablespace specified in the initialization parameter does not exist, the `STARTUP` command fails. The `UNDO_TABLESPACE` parameter can be used to assign a specific undo tablespace to an instance in an Oracle Real Application Clusters environment.

The database can also run in *manual undo management mode*. In this mode, undo space is managed through rollback segments, and no undo tablespace is used.

Note: Space management for rollback segments is complex. Oracle strongly recommends leaving the database in automatic undo management mode.

The following is a summary of the initialization parameters for undo management:

Initialization Parameter	Description
`UNDO_MANAGEMENT`	If `AUTO` or null, enables automatic undo management. If `MANUAL`, sets manual undo management mode. The default is `AUTO`.

Initialization Parameter	Description
`UNDO_TABLESPACE`	Optional, and valid only in automatic undo management mode. Specifies the name of an undo tablespace. Use only when the database has multiple undo tablespaces and you want to direct the database instance to use a particular undo tablespace.

When automatic undo management is enabled, if the initialization parameter file contains parameters relating to manual undo management, they are ignored.

Note: Earlier releases of Oracle Database default to manual undo management mode. To change to automatic undo management, you must first create an undo tablespace and then change the `UNDO_MANAGEMENT` initialization parameter to `AUTO`. If your Oracle Database is release 9*i* or later and you want to change to automatic undo management, see *Oracle Database Upgrade Guide* for instructions.

A null `UNDO_MANAGEMENT` initialization parameter defaults to automatic undo management mode in Release 11*g* and later, but defaults to manual undo management mode in earlier releases. You must therefore use caution when upgrading a previous release to Release 11g. *Oracle Database Upgrade Guide* describes the correct method of migrating to automatic undo management mode, including information on how to size the undo tablespace.

See Also: *Oracle Database Reference* for complete descriptions of initialization parameters used in undo management

About the Undo Retention Period

After a transaction is committed, undo data is no longer needed for rollback or transaction recovery purposes. However, for consistent read purposes, long-running queries may require this old undo information for producing older images of data blocks. Furthermore, the success of several Oracle Flashback features can also depend upon the availability of older undo information. For these reasons, it is desirable to retain the old undo information for as long as possible.

When automatic undo management is enabled, there is always a current **undo retention period**, which is the minimum amount of time that Oracle Database attempts to retain old undo information before overwriting it. Old (committed) undo information that is older than the current undo retention period is said to be *expired* and its space is available to be overwritten by new transactions. Old undo information with an age that is less than the current undo retention period is said to be *unexpired* and is retained for consistent read and Oracle Flashback operations.

Oracle Database automatically tunes the undo retention period based on undo tablespace size and system activity. You can optionally specify a minimum undo retention period (in seconds) by setting the `UNDO_RETENTION` initialization parameter. The exact impact this parameter on undo retention is as follows:

- The `UNDO_RETENTION` parameter is ignored for a fixed size undo tablespace. The database always tunes the undo retention period for the best possible retention, based on system activity and undo tablespace size. See "Automatic Tuning of Undo Retention" on page 14-4 for more information.

- For an undo tablespace with the AUTOEXTEND option enabled, the database attempts to honor the minimum retention period specified by UNDO_RETENTION. When space is low, instead of overwriting unexpired undo information, the tablespace auto-extends. If the MAXSIZE clause is specified for an auto-extending undo tablespace, when the maximum size is reached, the database may begin to overwrite unexpired undo information. The UNDOTBS1 tablespace that is automatically created by DBCA is auto-extending.

Automatic Tuning of Undo Retention

Oracle Database automatically tunes the undo retention period based on how the undo tablespace is configured.

- If the undo tablespace is configured with the AUTOEXTEND option, the database dynamically tunes the undo retention period to be somewhat longer than the longest-running active query on the system. However, this retention period may be insufficient to accommodate Oracle Flashback operations. Oracle Flashback operations resulting in snapshot too old errors are the indicator that you must intervene to ensure that sufficient undo data is retained to support these operations. To better accommodate Oracle Flashback features, you can either set the UNDO_RETENTION parameter to a value equal to the longest expected Oracle Flashback operation, or you can change the undo tablespace to fixed size.
- If the undo tablespace is fixed size, the database dynamically tunes the undo retention period for the best possible retention for that tablespace size and the current system load. This best possible retention time is typically significantly greater than the duration of the longest-running active query.

  If you decide to change the undo tablespace to fixed-size, you must choose a tablespace size that is sufficiently large. If you choose an undo tablespace size that is too small, the following two errors could occur:

  - DML could fail because there is not enough space to accommodate undo for new transactions.
  - Long-running queries could fail with a snapshot too old error, which means that there was insufficient undo data for read consistency.

  See "Sizing a Fixed-Size Undo Tablespace" on page 14-6 for more information.

Note: Automatic tuning of undo retention is not supported for LOBs. This is because undo information for LOBs is stored in the segment itself and not in the undo tablespace. For LOBs, the database attempts to honor the minimum undo retention period specified by UNDO_RETENTION. However, if space becomes low, unexpired LOB undo information may be overwritten.

See Also: "Setting the Minimum Undo Retention Period" on page 14-6

Retention Guarantee

To guarantee the success of long-running queries or Oracle Flashback operations, you can enable retention guarantee. If retention guarantee is enabled, the specified minimum undo retention is guaranteed; the database never overwrites unexpired undo data even if it means that transactions fail due to lack of space in the undo tablespace. If retention guarantee is not enabled, the database can overwrite unexpired undo when space is low, thus lowering the undo retention for the system. This option is disabled by default.

WARNING: Enabling retention guarantee can cause multiple DML operations to fail. Use with caution.

You enable retention guarantee by specifying the RETENTION GUARANTEE clause for the undo tablespace when you create it with either the CREATE DATABASE or CREATE UNDO TABLESPACE statement. Or, you can later specify this clause in an ALTER TABLESPACE statement. You disable retention guarantee with the RETENTION NOGUARANTEE clause.

You can use the DBA_TABLESPACES view to determine the retention guarantee setting for the undo tablespace. A column named RETENTION contains a value of GUARANTEE, NOGUARANTEE, or NOT APPLY, where NOT APPLY is used for tablespaces other than the undo tablespace.

Undo Retention Tuning and Alert Thresholds

For a fixed-size undo tablespace, the database calculates the best possible retention based on database statistics and on the size of the undo tablespace. For optimal undo management, rather than tuning based on 100% of the tablespace size, the database tunes the undo retention period based on 85% of the tablespace size, or on the warning alert threshold percentage for space used, whichever is lower. (The warning alert threshold defaults to 85%, but can be changed.) Therefore, if you set the warning alert threshold of the undo tablespace below 85%, this may reduce the tuned size of the undo retention period. For more information on tablespace alert thresholds, see "Managing Tablespace Alerts" on page 17-1.

Tracking the Tuned Undo Retention Period

You can determine the current retention period by querying the TUNED_UNDORETENTION column of the V$UNDOSTAT view. This view contains one row for each 10-minute statistics collection interval over the last 4 days. (Beyond 4 days, the data is available in the DBA_HIST_UNDOSTAT view.) TUNED_UNDORETENTION is given in seconds.

```
select to_char(begin_time, 'DD-MON-RR HH24:MI') begin_time,
to_char(end_time, 'DD-MON-RR HH24:MI') end_time, tuned_undoretention
from v$undostat order by end_time;

BEGIN_TIME      END_TIME        TUNED_UNDORETENTION
--------------- --------------- -------------------
04-FEB-05 00:01 04-FEB-05 00:11               12100
      ...
07-FEB-05 23:21 07-FEB-05 23:31               86700
07-FEB-05 23:31 07-FEB-05 23:41               86700
07-FEB-05 23:41 07-FEB-05 23:51               86700
07-FEB-05 23:51 07-FEB-05 23:52               86700

576 rows selected.
```

See *Oracle Database Reference* for more information about V$UNDOSTAT.

Setting the Minimum Undo Retention Period

You specify the minimum undo retention period (in seconds) by setting the `UNDO_RETENTION` initialization parameter. As described in "About the Undo Retention Period" on page 14-3, the current undo retention period may be automatically tuned to be greater than `UNDO_RETENTION`, or, unless retention guarantee is enabled, less than `UNDO_RETENTION` if space in the undo tablespace is low.

To set the minimum undo retention period:

- Do one of the following:
  - Set `UNDO_RETENTION` in the initialization parameter file.

    ```
    UNDO_RETENTION = 1800
    ```

  - Change `UNDO_RETENTION` at any time using the `ALTER SYSTEM` statement:

    ```
    ALTER SYSTEM SET UNDO_RETENTION = 2400;
    ```

The effect of an `UNDO_RETENTION` parameter change is immediate, but it can only be honored if the current undo tablespace has enough space.

Sizing a Fixed-Size Undo Tablespace

If you have decided on a fixed-size undo tablespace, the Undo Advisor can help you estimate needed capacity. You can access the Undo Advisor through Enterprise Manager or through the `DBMS_ADVISOR` PL/SQL package. Enterprise Manager is the preferred method of accessing the advisor. For more information on using the Undo Advisor through Enterprise Manager, see *Oracle Database 2 Day DBA*.

The Undo Advisor relies for its analysis on data collected in the Automatic Workload Repository (AWR). It is therefore important that the AWR have adequate workload statistics available so that the Undo Advisor can make accurate recommendations. For newly created databases, adequate statistics may not be available immediately. In such cases, an auto-extending undo tablespace can be used.

An adjustment to the collection interval and retention period for AWR statistics can affect the precision and the type of recommendations that the advisor produces. See *Oracle Database Performance Tuning Guide* for more information.

To use the Undo Advisor, you first estimate these two values:

- The length of your expected longest running query

  After the database has completed a workload cycle, you can view the Longest Running Query field on the System Activity subpage of the Automatic Undo Management page.

- The longest interval that you will require for Oracle Flashback operations

  For example, if you expect to run Oracle Flashback queries for up to 48 hours in the past, your Oracle Flashback requirement is 48 hours.

You then take the maximum of these two values and use that value as input to the Undo Advisor.

Running the Undo Advisor does not alter the size of the undo tablespace. The advisor just returns a recommendation. You must use `ALTER DATABASE` statements to change the tablespace datafiles to fixed sizes.

The following example assumes that the undo tablespace has one auto-extending datafile named `undotbs.dbf`. The example changes the tablespace to a fixed size of 300MB.

```
ALTER DATABASE DATAFILE '/oracle/dbs/undotbs.dbf' RESIZE 300M;
ALTER DATABASE DATAFILE '/oracle/dbs/undotbs.dbf' AUTOEXTEND OFF;
```

Note: If you want to make the undo tablespace fixed-size, Oracle suggests that you first allow enough time after database creation to run a full workload, thus allowing the undo tablespace to grow to its minimum required size to handle the workload. Then, you can use the Undo Advisor to determine, if desired, how much larger to set the size of the undo tablespace to allow for long-running queries and Oracle Flashback operations.

The Undo Advisor PL/SQL Interface

You can activate the Undo Advisor by creating an undo advisor task through the advisor framework. The following example creates an undo advisor task to evaluate the undo tablespace. The name of the advisor is 'Undo Advisor'. The analysis is based on Automatic Workload Repository snapshots, which you must specify by setting parameters `START_SNAPSHOT` and `END_SNAPSHOT`. In the following example, the `START_SNAPSHOT` is "1" and `END_SNAPSHOT` is "2".

```
DECLARE
   tid    NUMBER;
   tname  VARCHAR2(30);
   oid    NUMBER;
   BEGIN
   DBMS_ADVISOR.CREATE_TASK('Undo Advisor', tid, tname, 'Undo Advisor Task');
   DBMS_ADVISOR.CREATE_OBJECT(tname, 'UNDO_TBS', null, null, null, 'null', oid);
   DBMS_ADVISOR.SET_TASK_PARAMETER(tname, 'TARGET_OBJECTS', oid);
   DBMS_ADVISOR.SET_TASK_PARAMETER(tname, 'START_SNAPSHOT', 1);
   DBMS_ADVISOR.SET_TASK_PARAMETER(tname, 'END_SNAPSHOT', 2);
   DBMS_ADVISOR.SET_TASK_PARAMETER(name, 'INSTANCE', 1);
   DBMS_ADVISOR.execute_task(tname);
   end;
/
```

After you have created the advisor task, you can view the output and recommendations in the Automatic Database Diagnostic Monitor in Enterprise Manager. This information is also available in the `DBA_ADVISOR_*` data dictionary views.

See Also:

- "Using the Segment Advisor" on page 17-16 for an example of creating an advisor task for a different advisor
- *Oracle Database Reference* for information about the `DBA_ADVISOR_*` data dictionary views

Managing Undo Tablespaces

This section describes the various steps involved in undo tablespace management and contains the following sections:

- Creating an Undo Tablespace

- Altering an Undo Tablespace
- Dropping an Undo Tablespace
- Switching Undo Tablespaces
- Establishing User Quotas for Undo Space
- Undo Space Data Dictionary Views

Creating an Undo Tablespace

Although Database Configuration Assistant (DBCA) automatically creates an undo tablespace for new installations of Oracle Database Release 11*g*, there may be occasions when you want to manually create an undo tablespace.

There are two methods of creating an undo tablespace. The first method creates the undo tablespace when the `CREATE DATABASE` statement is issued. This occurs when you are creating a new database, and the instance is started in automatic undo management mode (`UNDO_MANAGEMENT = AUTO`). The second method is used with an existing database. It uses the `CREATE UNDO TABLESPACE` statement.

You cannot create database objects in an undo tablespace. It is reserved for system-managed undo data.

Oracle Database enables you to create a single-file undo tablespace. Single-file, or bigfile, tablespaces are discussed in "Bigfile Tablespaces" on page 12-6.

Using CREATE DATABASE to Create an Undo Tablespace

You can create a specific undo tablespace using the `UNDO TABLESPACE` clause of the `CREATE DATABASE` statement.

The following statement illustrates using the `UNDO TABLESPACE` clause in a `CREATE DATABASE` statement. The undo tablespace is named `undotbs_01` and one datafile, `/u01/oracle/rbdb1/undo0101.dbf`, is allocated for it.

```
CREATE DATABASE rbdb1
     CONTROLFILE REUSE
     .
     .
     .
     UNDO TABLESPACE undotbs_01 DATAFILE '/u01/oracle/rbdb1/undo0101.dbf';
```

If the undo tablespace cannot be created successfully during `CREATE DATABASE`, the entire `CREATE DATABASE` operation fails. You must clean up the database files, correct the error and retry the `CREATE DATABASE` operation.

The `CREATE DATABASE` statement also lets you create a single-file undo tablespace at database creation. This is discussed in "Supporting Bigfile Tablespaces During Database Creation" on page 2-16.

> **See Also:** *Oracle Database SQL Language Reference* for the syntax for using the `CREATE DATABASE` statement to create an undo tablespace

Using the CREATE UNDO TABLESPACE Statement

The `CREATE UNDO TABLESPACE` statement is the same as the `CREATE TABLESPACE` statement, but the `UNDO` keyword is specified. The database determines most of the attributes of the undo tablespace, but you can specify the `DATAFILE` clause.

This example creates the `undotbs_02` undo tablespace with the `AUTOEXTEND` option:

```
CREATE UNDO TABLESPACE undotbs_02
     DATAFILE '/u01/oracle/rbdb1/undo0201.dbf' SIZE 2M REUSE AUTOEXTEND ON;
```

You can create more than one undo tablespace, but only one of them can be active at any one time.

> **See Also:** *Oracle Database SQL Language Reference* for the syntax for using the `CREATE UNDO TABLESPACE` statement to create an undo tablespace

Altering an Undo Tablespace

Undo tablespaces are altered using the `ALTER TABLESPACE` statement. However, since most aspects of undo tablespaces are system managed, you need only be concerned with the following actions:

- Adding a datafile
- Renaming a datafile
- Bringing a datafile online or taking it offline
- Beginning or ending an open backup on a datafile
- Enabling and disabling undo retention guarantee

These are also the only attributes you are permitted to alter.

If an undo tablespace runs out of space, or you want to prevent it from doing so, you can add more files to it or resize existing datafiles.

The following example adds another datafile to undo tablespace undotbs_01:

```
ALTER TABLESPACE undotbs_01
     ADD DATAFILE '/u01/oracle/rbdb1/undo0102.dbf' AUTOEXTEND ON NEXT 1M
         MAXSIZE UNLIMITED;
```

You can use the `ALTER DATABASE...DATAFILE` statement to resize or extend a datafile.

> **See Also:**
>
> - "Changing Datafile Size" on page 13-5
> - *Oracle Database SQL Language Reference* for `ALTER TABLESPACE` syntax

Dropping an Undo Tablespace

Use the `DROP TABLESPACE` statement to drop an undo tablespace. The following example drops the undo tablespace `undotbs_01`:

```
DROP TABLESPACE undotbs_01;
```

An undo tablespace can only be dropped if it is not currently used by any instance. If the undo tablespace contains any outstanding transactions (for example, a transaction died but has not yet been recovered), the `DROP TABLESPACE` statement fails. However, since `DROP TABLESPACE` drops an undo tablespace even if it contains unexpired undo information (within retention period), you must be careful not to drop an undo tablespace if undo information is needed by some existing queries.

DROP TABLESPACE for undo tablespaces behaves like DROP TABLESPACE...INCLUDING CONTENTS. All contents of the undo tablespace are removed.

> **See Also:** *Oracle Database SQL Language Reference* for DROP TABLESPACE syntax

Switching Undo Tablespaces

You can switch from using one undo tablespace to another. Because the UNDO_TABLESPACE initialization parameter is a dynamic parameter, the ALTER SYSTEM SET statement can be used to assign a new undo tablespace.

The following statement switches to a new undo tablespace:

```
ALTER SYSTEM SET UNDO_TABLESPACE = undotbs_02;
```

Assuming undotbs_01 is the current undo tablespace, after this command successfully executes, the instance uses undotbs_02 in place of undotbs_01 as its undo tablespace.

If any of the following conditions exist for the tablespace being switched to, an error is reported and no switching occurs:

- The tablespace does not exist
- The tablespace is not an undo tablespace
- The tablespace is already being used by another instance (in a RAC environment only)

The database is online while the switch operation is performed, and user transactions can be executed while this command is being executed. When the switch operation completes successfully, all transactions started after the switch operation began are assigned to transaction tables in the new undo tablespace.

The switch operation does not wait for transactions in the old undo tablespace to commit. If there are any pending transactions in the old undo tablespace, the old undo tablespace enters into a PENDING OFFLINE mode (status). In this mode, existing transactions can continue to execute, but undo records for new user transactions cannot be stored in this undo tablespace.

An undo tablespace can exist in this PENDING OFFLINE mode, even after the switch operation completes successfully. A PENDING OFFLINE undo tablespace cannot be used by another instance, nor can it be dropped. Eventually, after all active transactions have committed, the undo tablespace automatically goes from the PENDING OFFLINE mode to the OFFLINE mode. From then on, the undo tablespace is available for other instances (in an Oracle Real Application Cluster environment).

If the parameter value for UNDO TABLESPACE is set to '' (two single quotes), then the current undo tablespace is switched out and the next available undo tablespace is switched in. Use this statement with care because there may be no undo tablespace available.

The following example unassigns the current undo tablespace:

```
ALTER SYSTEM SET UNDO_TABLESPACE = '';
```

Establishing User Quotas for Undo Space

The Oracle Database Resource Manager can be used to establish user quotas for undo space. The Database Resource Manager directive `UNDO_POOL` allows DBAs to limit the amount of undo space consumed by a group of users (resource consumer group).

You can specify an undo pool for each consumer group. An undo pool controls the amount of total undo that can be generated by a consumer group. When the total undo generated by a consumer group exceeds its undo limit, the current `UPDATE` transaction generating the undo is terminated. No other members of the consumer group can perform further updates until undo space is freed from the pool.

When no `UNDO_POOL` directive is explicitly defined, users are allowed unlimited undo space.

See Also: Chapter 25, "Managing Resource Allocation with Oracle Database Resource Manager"

Managing Space Threshold Alerts for the Undo Tablespace

Oracle Database also provides proactive help in managing tablespace disk space use by alerting you when tablespaces run low on available space. Please refer to "Managing Tablespace Alerts" on page 17-1 for information on how to set alert thresholds for the undo tablespace.

In addition to the proactive undo space alerts, Oracle Database also provides alerts if your system has long-running queries that cause `SNAPSHOT TOO OLD` errors. To prevent excessive alerts, the long query alert is issued at most once every 24 hours. When the alert is generated, you can check the Undo Advisor Page of Enterprise Manager to get more information about the undo tablespace.

Migrating to Automatic Undo Management

If you are currently using rollback segments to manage undo space, Oracle strongly recommends that you migrate your database to automatic undo management.

For instructions, see *Oracle Database Upgrade Guide*.

Undo Space Data Dictionary Views

This section lists views that are useful for viewing information about undo space in the automatic undo management mode and provides some examples. In addition to views listed here, you can obtain information from the views available for viewing tablespace and datafile information. Please refer to "Datafiles Data Dictionary Views" on page 13-25 for information on getting information about those views.

The following dynamic performance views are useful for obtaining space information about the undo tablespace:

View	Description
`V$UNDOSTAT`	Contains statistics for monitoring and tuning undo space. Use this view to help estimate the amount of undo space required for the current workload. The database also uses this information to help tune undo usage in the system. This view is meaningful only in automatic undo management mode.

View	Description
V$ROLLSTAT	For automatic undo management mode, information reflects behavior of the undo segments in the undo tablespace
V$TRANSACTION	Contains undo segment information
DBA_UNDO_EXTENTS	Shows the status and size of each extent in the undo tablespace.
DBA_HIST_UNDOSTAT	Contains statistical snapshots of V$UNDOSTAT information. Please refer to *Oracle Database 2 Day DBA* for more information.

See Also: *Oracle Database Reference* for complete descriptions of the views used in automatic undo management mode

The V$UNDOSTAT view is useful for monitoring the effects of transaction execution on undo space in the current instance. Statistics are available for undo space consumption, transaction concurrency, the tuning of undo retention, and the length and SQL ID of long-running queries in the instance.

Each row in the view contains statistics collected in the instance for a ten-minute interval. The rows are in descending order by the BEGIN_TIME column value. Each row belongs to the time interval marked by (BEGIN_TIME, END_TIME). Each column represents the data collected for the particular statistic in that time interval. The first row of the view contains statistics for the (partial) current time period. The view contains a total of 576 rows, spanning a 4 day cycle.

The following example shows the results of a query on the V$UNDOSTAT view.

```
SELECT TO_CHAR(BEGIN_TIME, 'MM/DD/YYYY HH24:MI:SS') BEGIN_TIME,
       TO_CHAR(END_TIME, 'MM/DD/YYYY HH24:MI:SS') END_TIME,
       UNDOTSN, UNDOBLKS, TXNCOUNT, MAXCONCURRENCY AS "MAXCON"
       FROM v$UNDOSTAT WHERE rownum <= 144;

BEGIN_TIME          END_TIME               UNDOTSN   UNDOBLKS   TXNCOUNT     MAXCON
------------------- ------------------- ---------- ---------- ---------- ----------
10/28/2004 14:25:12 10/28/2004 14:32:17          8         74   12071108          3
10/28/2004 14:15:12 10/28/2004 14:25:12          8         49   12070698          2
10/28/2004 14:05:12 10/28/2004 14:15:12          8        125   12070220          1
10/28/2004 13:55:12 10/28/2004 14:05:12          8         99   12066511          3
...
10/27/2004 14:45:12 10/27/2004 14:55:12          8         15   11831676          1
10/27/2004 14:35:12 10/27/2004 14:45:12          8        154   11831165          2

144 rows selected.
```

The preceding example shows how undo space is consumed in the system for the previous 24 hours from the time 14:35:12 on 10/27/2004.

15 Using Oracle-Managed Files

This chapter discusses the use of the Oracle-managed files and contains the following topics:

What Are Oracle-Managed Files?

Using Oracle-managed files simplifies the administration of an Oracle Database. Oracle-managed files eliminate the need for you, the DBA, to directly manage the operating system files that make up an Oracle Database. With Oracle-managed files, you specify file system directories in which the database automatically creates, names, and manages files at the database object level. For example, you need only specify that you want to create a tablespace; you do not need to specify the name and path of the tablespace's datafile with the `DATAFILE` clause. This feature works well with a logical volume manager (LVM).

The database internally uses standard file system interfaces to create and delete files as needed for the following database structures:

- Tablespaces
- Redo log files
- Control files
- Archived logs
- Block change tracking files
- Flashback logs
- RMAN backups

Through initialization parameters, you specify the file system directory to be used for a particular type of file. The database then ensures that a unique file, an Oracle-managed file, is created and deleted when no longer needed.

This feature does not affect the creation or naming of administrative files such as trace files, audit files, alert logs, and core files.

See Also: *Oracle Database Storage Administrator's Guide* for information about Automatic Storage Management (ASM), the Oracle Database integrated file system and volume manager that extends the power of Oracle-managed files. With Oracle-managed files, files are created and managed automatically for you, but with ASM, you get the additional benefits of features such as striping, software mirroring, and dynamic storage configuration, without the need to purchase a third-party logical volume manager.

Who Can Use Oracle-Managed Files?

Oracle-managed files are most useful for the following types of databases:

- Databases that are supported by the following:
  - A logical volume manager that supports striping/RAID and dynamically extensible logical volumes
  - A file system that provides large, extensible files
- Low end or test databases

The Oracle-managed files feature is not intended to ease administration of systems that use raw disks. This feature provides better integration with operating system functionality for disk space allocation. Since there is no operating system support for allocation of raw disks (it is done manually), this feature cannot help. On the other hand, because Oracle-managed files require that you use the operating system file system (unlike raw disks), you lose control over how files are laid out on the disks and thus, you lose some I/O tuning ability.

What Is a Logical Volume Manager?

A logical volume manager (LVM) is a software package available with most operating systems. Sometimes it is called a logical disk manager (LDM). It allows pieces of multiple physical disks to be combined into a single contiguous address space that appears as one disk to higher layers of software. An LVM can make the logical volume have better capacity, performance, reliability, and availability characteristics than any of the underlying physical disks. It uses techniques such as mirroring, striping, concatenation, and RAID 5 to implement these characteristics.

Some LVMs allow the characteristics of a logical volume to be changed after it is created, even while it is in use. The volume may be resized or mirrored, or it may be relocated to different physical disks.

What Is a File System?

A file system is a data structure built inside a contiguous disk address space. A file manager (FM) is a software package that manipulates file systems, but it is sometimes called the file system. All operating systems have file managers. The primary task of a file manager is to allocate and deallocate disk space into files within a file system.

A file system allows the disk space to be allocated to a large number of files. Each file is made to appear as a contiguous address space to applications such as Oracle Database. The files may not actually be contiguous within the disk space of the file system. Files can be created, read, written, resized, and deleted. Each file has a name associated with it that is used to refer to the file.

A file system is commonly built on top of a logical volume constructed by an LVM. Thus all the files in a particular file system have the same performance, reliability, and availability characteristics inherited from the underlying logical volume. A file system is a single pool of storage that is shared by all the files in the file system. If a file system is out of space, then none of the files in that file system can grow. Space available in one file system does not affect space in another file system. However some LVM/FM combinations allow space to be added or removed from a file system.

An operating system can support multiple file systems. Multiple file systems are constructed to give different storage characteristics to different files as well as to divide the available disk space into pools that do not affect each other.

Benefits of Using Oracle-Managed Files

Consider the following benefits of using Oracle-managed files:

- They make the administration of the database easier.

  There is no need to invent filenames and define specific storage requirements. A consistent set of rules is used to name all relevant files. The file system defines the characteristics of the storage and the pool where it is allocated.

- They reduce corruption caused by administrators specifying the wrong file.

  Each Oracle-managed file and filename is unique. Using the same file in two different databases is a common mistake that can cause very large down times and loss of committed transactions. Using two different names that refer to the same file is another mistake that causes major corruptions.

- They reduce wasted disk space consumed by obsolete files.

  Oracle Database automatically removes old Oracle-managed files when they are no longer needed. Much disk space is wasted in large systems simply because no one is sure if a particular file is still required. This also simplifies the administrative task of removing files that are no longer required on disk and prevents the mistake of deleting the wrong file.

- They simplify creation of test and development databases.

  You can minimize the time spent making decisions regarding file structure and naming, and you have fewer file management tasks. You can focus better on meeting the actual requirements of your test or development database.

- Oracle-managed files make development of portable third-party tools easier.

  Oracle-managed files eliminate the need to put operating system specific file names in SQL scripts.

Oracle-Managed Files and Existing Functionality

Using Oracle-managed files does not eliminate any existing functionality. Existing databases are able to operate as they always have. New files can be created as managed files while old ones are administered in the old way. Thus, a database can have a mixture of Oracle-managed and unmanaged files.

Enabling the Creation and Use of Oracle-Managed Files

The following initialization parameters allow the database server to use the Oracle-managed files feature:

Initialization Parameter	Description
`DB_CREATE_FILE_DEST`	Defines the location of the default file system directory where the database creates datafiles or tempfiles when no file specification is given in the creation operation. Also used as the default file system directory for redo log and control files if `DB_CREATE_ONLINE_LOG_DEST_n` is not specified.
`DB_CREATE_ONLINE_LOG_DEST_n`	Defines the location of the default file system directory for redo log files and control file creation when no file specification is given in the creation operation. You can use this initialization parameter multiple times, where *n* specifies a multiplexed copy of the redo log or control file. You can specify up to five multiplexed copies.
`DB_RECOVERY_FILE_DEST`	Defines the location of the flash recovery area, which is the default file system directory where the database creates RMAN backups when no format option is used, archived logs when no other local destination is configured, and flashback logs. Also used as the default file system directory for redo log and control files if `DB_CREATE_ONLINE_LOG_DEST_n` is not specified.

The file system directory specified by either of these parameters must already exist: the database does not create it. The directory must also have permissions to allow the database to create the files in it.

The default location is used whenever a location is not explicitly specified for the operation creating the file. The database creates the filename, and a file thus created is an Oracle-managed file.

Both of these initialization parameters are dynamic, and can be set using the `ALTER SYSTEM` or `ALTER SESSION` statement.

See Also:

- *Oracle Database Reference* for additional information about initialization parameters
- "How Oracle-Managed Files Are Named" on page 15-6

Setting the DB_CREATE_FILE_DEST Initialization Parameter

Include the `DB_CREATE_FILE_DEST` initialization parameter in your initialization parameter file to identify the default location for the database server to create:

- Datafiles
- Tempfiles
- Redo log files
- Control files
- Block change tracking files

You specify the name of a file system directory that becomes the default location for the creation of the operating system files for these entities. The following example sets `/u01/oradata` as the default directory to use when creating Oracle-managed files:

```
DB_CREATE_FILE_DEST = '/u01/oradata'
```

Setting the DB_RECOVERY_FILE_DEST Parameter

Include the `DB_RECOVERY_FILE_DEST` and `DB_RECOVERY_FILE_DEST_SIZE` parameters in your initialization parameter file to identify the default location in which Oracle Database should create:

- Redo log files
- Control files
- RMAN backups (datafile copies, control file copies, backup pieces, control file autobackups)
- Archived logs
- Flashback logs

You specify the name of file system directory that becomes the default location for creation of the operating system files for these entities. For example:

```
DB_RECOVERY_FILE_DEST      = '/u01/oradata'
DB_RECOVERY_FILE_DEST_SIZE = 20G
```

Setting the DB_CREATE_ONLINE_LOG_DEST_n Initialization Parameter

Include the `DB_CREATE_ONLINE_LOG_DEST_`*n* initialization parameter in your initialization parameter file to identify the default location for the database server to create:

- Redo log files
- Control files

You specify the name of a file system directory that becomes the default location for the creation of the operating system files for these entities. You can specify up to five multiplexed locations.

For the creation of redo log files and control files only, this parameter overrides any default location specified in the `DB_CREATE_FILE_DEST` and `DB_RECOVERY_FILE_DEST` initialization parameters. If you do not specify a `DB_CREATE_FILE_DEST` parameter, but you do specify the `DB_CREATE_ONLINE_LOG_DEST_`*n* parameter, then only redo log files and control files can be created as Oracle-managed files.

It is recommended that you specify at least two parameters. For example:

```
DB_CREATE_ONLINE_LOG_DEST_1 = '/u02/oradata'
DB_CREATE_ONLINE_LOG_DEST_2 = '/u03/oradata'
```

This allows multiplexing, which provides greater fault-tolerance for the redo log and control file if one of the destinations fails.

Creating Oracle-Managed Files

If you have met any of the following conditions, then Oracle Database creates Oracle-managed files for you, as appropriate, when no file specification is given in the creation operation:

- You have included any of the `DB_CREATE_FILE_DEST`, `DB_REDOVERY_FILE_DEST`, or `DB_CREATE_ONLINE_LOG_DEST_`*n* initialization parameters in your initialization parameter file.

- You have issued the `ALTER SYSTEM` statement to dynamically set any of `DB_RECOVERY_FILE_DEST`, `DB_CREATE_FILE_DEST`, or `DB_CREATE_ONLINE_LOG_DEST_`*n* initialization parameters
- You have issued the `ALTER SESSION` statement to dynamically set any of the `DB_CREATE_FILE_DEST`, `DB_RECOVERY_FILE_DEST`, or `DB_CREATE_ONLINE_LOG_DEST_`*n* initialization parameters.

If a statement that creates an Oracle-managed file finds an error or does not complete due to some failure, then any Oracle-managed files created by the statement are automatically deleted as part of the recovery of the error or failure. However, because of the large number of potential errors that can occur with file systems and storage subsystems, there can be situations where you must manually remove the files using operating system commands. When an Oracle-managed file is created, its filename is written to the alert log. This information can be used to find the file if it is necessary to manually remove the file.

The following topics are discussed in this section:

- How Oracle-Managed Files Are Named
- Creating Oracle-Managed Files at Database Creation
- Creating Datafiles for Tablespaces Using Oracle-Managed Files
- Creating Tempfiles for Temporary Tablespaces Using Oracle-Managed Files
- Creating Control Files Using Oracle-Managed Files
- Creating Redo Log Files Using Oracle-Managed Files
- Creating Archived Logs Using Oracle-Managed Files

How Oracle-Managed Files Are Named

The filenames of Oracle-managed files comply with the Optimal Flexible Architecture (OFA) standard for file naming. The assigned names are intended to meet the following requirements:

- Database files are easily distinguishable from all other files.
- Files of one database type are easily distinguishable from other database types.
- Files are clearly associated with important attributes specific to the file type. For example, a datafile name may include the tablespace name to allow for easy association of datafile to tablespace, or an archived log name may include the thread, sequence, and creation date.

No two Oracle-managed files are given the same name. The name that is used for creation of an Oracle-managed file is constructed from three sources:

- The default creation location
- A file name template that is chosen based on the type of the file. The template also depends on the operating system platform and whether or not automatic storage management is used.
- A unique string created by the Oracle Database server or the operating system. This ensures that file creation does not damage an existing file and that the file cannot be mistaken for some other file.

As a specific example, filenames for Oracle-managed files have the following format on a Solaris file system:

```
<destination_prefix>/o1_mf_%t_%u_.dbf
```

where:

- <*destination_prefix*> is <*destination_location*>/<*db_unique_name*>/<*datafile*>

  where:

  – <*destination_location*> is the location specified in `DB_CREATE_FILE_DEST`

  – <*db_unique_name*> is the globally unique name (`DB_UNIQUE_NAME` initialization parameter) of the target database. If there is no `DB_UNIQUE_NAME` parameter, then the `DB_NAME` initialization parameter value is used.

- %t is the tablespace name.
- %u is an eight-character string that guarantees uniqueness

For example, assume the following parameter settings:

```
DB_CREATE_FILE_DEST   = /u01/oradata
DB_UNIQUE_NAME = PAYROLL
```

Then an example datafile name would be:

```
/u01/oradata/PAYROLL/datafile/o1_mf_tbs1_2ixh90q_.dbf
```

Names for other file types are similar. Names on other platforms are also similar, subject to the constraints of the naming rules of the platform.

The examples on the following pages use Oracle-managed file names as they might appear with a Solaris file system as an OMF destination.

Caution: Do not rename an Oracle-managed file. The database identifies an Oracle-managed file based on its name. If you rename the file, the database is no longer able to recognize it as an Oracle-managed file and will not manage the file accordingly.

Creating Oracle-Managed Files at Database Creation

The behavior of the `CREATE DATABASE` statement for creating database structures when using Oracle-managed files is discussed in this section.

See Also: *Oracle Database SQL Language Reference* for a description of the `CREATE DATABASE` statement

Specifying Control Files at Database Creation

At database creation, the control file is created in the files specified by the `CONTROL_FILES` initialization parameter. If the `CONTROL_FILES` parameter is not set and at least one of the initialization parameters required for the creation of Oracle-managed files is set, then an Oracle-managed control file is created in the default control file destinations. In order of precedence, the default destination is defined as follows:

- One or more control files as specified in the `DB_CREATE_ONLINE_LOG_DEST_`*n* initialization parameter. The file in the first directory is the primary control file. When `DB_CREATE_ONLINE_LOG_DEST_`*n* is specified, the database does not create a control file in DB_CREATE_FILE_DEST or in DB_RECOVERY_FILE_DEST (the flash recovery area).

- If no value is specified for DB_CREATE_ONLINE_LOG_DEST_*n*, but values are set for both the DB_CREATE_FILE_DEST and DB_RECOVERY_FILE_DEST, then the database creates one control file in each location. The location specified in DB_CREATE_FILE_DEST is the primary control file.
- If a value is specified only for DB_CREATE_FILE_DEST, then the database creates one control file in that location.
- If a value is specified only for DB_RECOVERY_FILE_DEST, then the database creates one control file in that location.

If the CONTROL_FILES parameter is not set and none of these initialization parameters are set, then the Oracle Database default behavior is operating system dependent. At least one copy of a control file is created in an operating system dependent default location. Any copies of control files created in this fashion are not Oracle-managed files, and you must add a CONTROL_FILES initialization parameter to any initialization parameter file.

If the database creates an Oracle-managed control file, and if there is a server parameter file, then the database creates a CONTROL_FILES initialization parameter entry in the server parameter file. If there is no server parameter file, then you must manually include a CONTROL_FILES initialization parameter entry in the text initialization parameter file.

See Also: Chapter 9, "Managing Control Files"

Specifying Redo Log Files at Database Creation

The LOGFILE clause is not required in the CREATE DATABASE statement, and omitting it provides a simple means of creating Oracle-managed redo log files. If the LOGFILE clause is omitted, then redo log files are created in the default redo log file destinations. In order of precedence, the default destination is defined as follows:

- If either the DB_CREATE_ONLINE_LOG_DEST_*n* is set, then the database creates a log file member in each directory specified, up to the value of the MAXLOGMEMBERS initialization parameter.
- If the DB_CREATE_ONLINE_LOG_DEST_*n* parameter is not set, but both the DB_CREATE_FILE_DEST and DB_RECOVERY_FILE_DEST initialization parameters are set, then the database creates one Oracle-managed log file member in each of those locations. The log file in the DB_CREATE_FILE_DEST destination is the first member.
- If only the DB_CREATE_FILE_DEST initialization parameter is specified, then the database creates a log file member in that location.
- If only the DB_RECOVERY_FILE_DEST initialization parameter is specified, then the database creates a log file member in that location.

The default size of an Oracle-managed redo log file is 100 MB.

Optionally, you can create Oracle-managed redo log files, and override default attributes, by including the LOGFILE clause but omitting a filename. Redo log files are created the same way, except for the following: If no filename is provided in the LOGFILE clause of CREATE DATABASE, and none of the initialization parameters required for creating Oracle-managed files are provided, then the CREATE DATABASE statement fails.

See Also: Chapter 10, "Managing the Redo Log"

Specifying the SYSTEM and SYSAUX Tablespace Datafiles at Database Creation

The DATAFILE or SYSAUX DATAFILE clause is not required in the CREATE DATABASE statement, and omitting it provides a simple means of creating Oracle-managed datafiles for the SYSTEM and SYSAUX tablespaces. If the DATAFILE clause is omitted, then one of the following actions occurs:

- If DB_CREATE_FILE_DEST is set, then one Oracle-managed datafile for the SYSTEM tablespace and another for the SYSAUX tablespace are created in the DB_CREATE_FILE_DEST directory.
- If DB_CREATE_FILE_DEST is not set, then the database creates one SYSTEM, and one SYSAUX, tablespace datafile whose name and size are operating system dependent. Any SYSTEM or SYSAUX tablespace datafile created in this manner is not an Oracle-managed file.

The default size for an Oracle-managed datafile is 100 MB and the file is autoextensible. When autoextension is required, the database extends the datafile by its existing size or 100 MB, whichever is smaller. You can also explicitly specify the autoextensible unit using the NEXT parameter of the STORAGE clause when you specify the datafile (in a CREATE or ALTER TABLESPACE operation).

Optionally, you can create an Oracle-managed datafile for the SYSTEM or SYSAUX tablespace and override default attributes. This is done by including the DATAFILE clause, omitting a filename, but specifying overriding attributes. When a filename is not supplied and the DB_CREATE_FILE_DEST parameter is set, an Oracle-managed datafile for the SYSTEM or SYSAUX tablespace is created in the DB_CREATE_FILE_DEST directory with the specified attributes being overridden. However, if a filename is not supplied and the DB_CREATE_FILE_DEST parameter is not set, then the CREATE DATABASE statement fails.

When overriding the default attributes of an Oracle-managed file, if a SIZE value is specified but no AUTOEXTEND clause is specified, then the datafile is *not* autoextensible.

Specifying the Undo Tablespace Datafile at Database Creation

The DATAFILE subclause of the UNDO TABLESPACE clause is optional and a filename is not required in the file specification. If a filename is not supplied and the DB_CREATE_FILE_DEST parameter is set, then an Oracle-managed datafile is created in the DB_CREATE_FILE_DEST directory. If DB_CREATE_FILE_DEST is not set, then the statement fails with a syntax error.

The UNDO TABLESPACE clause itself is optional in the CREATE DATABASE statement. If it is not supplied, and automatic undo management mode is enabled, then a default undo tablespace named SYS_UNDOTBS is created and a 10 MB datafile that is autoextensible is allocated as follows:

- If DB_CREATE_FILE_DEST is set, then an Oracle-managed datafile is created in the indicated directory.
- If DB_CREATE_FILE_DEST is not set, then the datafile location is operating system specific.

See Also: Chapter 14, "Managing Undo"

Specifying the Default Temporary Tablespace Tempfile at Database Creation

The `TEMPFILE` subclause is optional for the `DEFAULT TEMPORARY TABLESPACE` clause and a filename is not required in the file specification. If a filename is not supplied and the `DB_CREATE_FILE_DEST` parameter set, then an Oracle-managed tempfile is created in the `DB_CREATE_FILE_DEST` directory. If `DB_CREATE_FILE_DEST` is not set, then the `CREATE DATABASE` statement fails with a syntax error.

The `DEFAULT TEMPORARY TABLESPACE` clause itself is optional. If it is not specified, then no default temporary tablespace is created.

The default size for an Oracle-managed tempfile is 100 MB and the file is autoextensible with an unlimited maximum size.

CREATE DATABASE Statement Using Oracle-Managed Files: Examples

This section contains examples of the `CREATE DATABASE` statement when using the Oracle-managed files feature.

CREATE DATABASE: Example 1 This example creates a database with the following Oracle-managed files:

- A `SYSTEM` tablespace datafile in directory `/u01/oradata` that is 100 MB and autoextensible up to an unlimited size.
- A `SYSAUX` tablespace datafile in directory `/u01/oradata` that is 100 MB and autoextensible up to an unlimited size. The tablespace is locally managed with automatic segment-space management.
- Two online log groups with two members of 100 MB each, one each in `/u02/oradata` and `/u03/oradata.`
- If automatic undo management mode is enabled, then an undo tablespace datafile in directory `/u01/oradata` that is 10 MB and autoextensible up to an unlimited size. An undo tablespace named `SYS_UNDOTBS` is created.
- If no `CONTROL_FILES` initialization parameter is specified, then two control files, one each in `/u02/oradata` and `/u03/oradata`. The control file in `/u02/oradata` is the primary control file.

The following parameter settings relating to Oracle-managed files, are included in the initialization parameter file:

```
DB_CREATE_FILE_DEST = '/u01/oradata'
DB_CREATE_ONLINE_LOG_DEST_1 = '/u02/oradata'
DB_CREATE_ONLINE_LOG_DEST_2 = '/u03/oradata'
```

The following statement is issued at the SQL prompt:

```
SQL> CREATE DATABASE sample;
```

CREATE DATABASE: Example 2 This example creates a database with the following Oracle-managed files:

- A 100 MB `SYSTEM` tablespace datafile in directory `/u01/oradata` that is autoextensible up to an unlimited size.
- A `SYSAUX` tablespace datafile in directory `/u01/oradata` that is 100 MB and autoextensible up to an unlimited size. The tablespace is locally managed with automatic segment-space management.

- Two redo log files of 100 MB each in directory `/u01/oradata`. They are not multiplexed.
- An undo tablespace datafile in directory `/u01/oradata` that is 10 MB and autoextensible up to an unlimited size. An undo tablespace named `SYS_UNDOTBS` is created.
- A control file in `/u01/oradata`.

In this example, it is assumed that:

- No `DB_CREATE_ONLINE_LOG_DEST_`*n* initialization parameters are specified in the initialization parameter file.
- No `CONTROL_FILES` initialization parameter was specified in the initialization parameter file.
- Automatic undo management mode is enabled.

The following statements are issued at the SQL prompt:

```
SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/u01/oradata';
SQL> CREATE DATABASE sample2;
```

This database configuration is not recommended for a production database. The example illustrates how a very low-end database or simple test database can easily be created. To better protect this database from failures, at least one more control file should be created and the redo log should be multiplexed.

CREATE DATABASE: Example 3 In this example, the file size for the Oracle-managed files for the default temporary tablespace and undo tablespace are specified. A database with the following Oracle-managed files is created:

- A 400 MB `SYSTEM` tablespace datafile in directory `/u01/oradata`. Because `SIZE` is specified, the file in not autoextensible.
- A 200 MB `SYSAUX` tablespace datafile in directory `/u01/oradata`. Because `SIZE` is specified, the file in not autoextensible. The tablespace is locally managed with automatic segment-space management.
- Two redo log groups with two members of 100 MB each, one each in directories `/u02/oradata` and `/u03/oradata`.
- For the default temporary tablespace `dflt_ts`, a 10 MB tempfile in directory `/u01/oradata`. Because `SIZE` is specified, the file in not autoextensible.
- For the undo tablespace `undo_ts`, a 10 MB datafile in directory `/u01/oradata`. Because `SIZE` is specified, the file in not autoextensible.
- If no `CONTROL_FILES` initialization parameter was specified, then two control files, one each in directories `/u02/oradata` and `/u03/oradata`. The control file in `/u02/oradata` is the primary control file.

The following parameter settings are included in the initialization parameter file:

```
DB_CREATE_FILE_DEST = '/u01/oradata'
DB_CREATE_ONLINE_LOG_DEST_1 = '/u02/oradata'
DB_CREATE_ONLINE_LOG_DEST_2 = '/u03/oradata'
```

The following statement is issued at the SQL prompt:

```
SQL> CREATE DATABASE sample3 DATAFILE SIZE 400M
2>   SYSAUX DATAFILE SIZE 200M
3>   DEFAULT TEMPORARY TABLESPACE dflt_ts TEMPFILE SIZE 10M
4>   UNDO TABLESPACE undo_ts DATAFILE SIZE 10M;
```

Creating Datafiles for Tablespaces Using Oracle-Managed Files

The following statements that can create datafiles are relevant to the discussion in this section:

- `CREATE TABLESPACE`
- `CREATE UNDO TABLESPACE`
- `ALTER TABLESPACE ... ADD DATAFILE`

When creating a tablespace, either a regular tablespace or an undo tablespace, the `DATAFILE` clause is optional. When you include the `DATAFILE` clause the filename is optional. If the `DATAFILE` clause or filename is not provided, then the following rules apply:

- If the `DB_CREATE_FILE_DEST` initialization parameter is specified, then an Oracle-managed datafile is created in the location specified by the parameter.
- If the `DB_CREATE_FILE_DEST` initialization parameter is not specified, then the statement creating the datafile fails.

When you add a datafile to a tablespace with the `ALTER TABLESPACE...ADD DATAFILE` statement the filename is optional. If the filename is not specified, then the same rules apply as discussed in the previous paragraph.

By default, an Oracle-managed datafile for a regular tablespace is 100 MB and is autoextensible with an unlimited maximum size. However, if in your `DATAFILE` clause you override these defaults by specifying a `SIZE` value (and no `AUTOEXTEND` clause), then the datafile is *not* autoextensible.

See Also:

- "Specifying the SYSTEM and SYSAUX Tablespace Datafiles at Database Creation" on page 15-9
- "Specifying the Undo Tablespace Datafile at Database Creation" on page 15-9
- Chapter 12, "Managing Tablespaces"

CREATE TABLESPACE: Examples

The following are some examples of creating tablespaces with Oracle-managed files.

See Also: *Oracle Database SQL Language Reference* for a description of the `CREATE TABLESPACE` statement

CREATE TABLESPACE: Example 1 The following example sets the default location for datafile creations to `/u01/oradata` and then creates a tablespace `tbs_1` with a datafile in that location. The datafile is 100 MB and is autoextensible with an unlimited maximum size.

```
SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/u01/oradata';
SQL> CREATE TABLESPACE tbs_1;
```

CREATE TABLESPACE: Example 2 This example creates a tablespace named `tbs_2` with a datafile in the directory `/u01/oradata`. The datafile initial size is 400 MB, and because the SIZE clause is specified, the datafile is not autoextensible.

The following parameter setting is included in the initialization parameter file:

```
DB_CREATE_FILE_DEST = '/u01/oradata'
```

The following statement is issued at the SQL prompt:

```
SQL> CREATE TABLESPACE tbs_2 DATAFILE SIZE 400M;
```

CREATE TABLESPACE: Example 3 This example creates a tablespace named `tbs_3` with an autoextensible datafile in the directory `/u01/oradata` with a maximum size of 800 MB and an initial size of 100 MB:

The following parameter setting is included in the initialization parameter file:

```
DB_CREATE_FILE_DEST = '/u01/oradata'
```

The following statement is issued at the SQL prompt:

```
SQL> CREATE TABLESPACE tbs_3 DATAFILE AUTOEXTEND ON MAXSIZE 800M;
```

CREATE TABLESPACE: Example 4 The following example sets the default location for datafile creations to `/u01/oradata` and then creates a tablespace named `tbs_4` in that directory with two datafiles. Both datafiles have an initial size of 200 MB, and because a `SIZE` value is specified, they are not autoextensible

```
SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/u01/oradata';
SQL> CREATE TABLESPACE tbs_4 DATAFILE SIZE 200M SIZE 200M;
```

CREATE UNDO TABLESPACE: Example

The following example creates an undo tablespace named `undotbs_1` with a datafile in the directory `/u01/oradata`. The datafile for the undo tablespace is 100 MB and is autoextensible with an unlimited maximum size.

The following parameter setting is included in the initialization parameter file:

```
DB_CREATE_FILE_DEST = '/u01/oradata'
```

The following statement is issued at the SQL prompt:

```
SQL> CREATE UNDO TABLESPACE undotbs_1;
```

> **See Also:** *Oracle Database SQL Language Reference* for a description of the `CREATE UNDO TABLESPACE` statement

ALTER TABLESPACE: Example

This example adds an Oracle-managed autoextensible datafile to the `tbs_1` tablespace. The datafile has an initial size of 100 MB and a maximum size of 800 MB.

The following parameter setting is included in the initialization parameter file:

```
DB_CREATE_FILE_DEST = '/u01/oradata'
```

The following statement is entered at the SQL prompt:

```
SQL> ALTER TABLESPACE tbs_1 ADD DATAFILE AUTOEXTEND ON MAXSIZE 800M;
```

> **See Also:** *Oracle Database SQL Language Reference* for a description of the `ALTER TABLESPACE` statement

Creating Tempfiles for Temporary Tablespaces Using Oracle-Managed Files

The following statements that create tempfiles are relevant to the discussion in this section:

- `CREATE TEMPORARY TABLESPACE`

- ALTER TABLESPACE ... ADD TEMPFILE

When creating a temporary tablespace the `TEMPFILE` clause is optional. If you include the `TEMPFILE` clause, then the filename is optional. If the `TEMPFILE` clause or filename is not provided, then the following rules apply:

- If the `DB_CREATE_FILE_DEST` initialization parameter is specified, then an Oracle-managed tempfile is created in the location specified by the parameter.
- If the `DB_CREATE_FILE_DEST` initialization parameter is not specified, then the statement creating the tempfile fails.

When you add a tempfile to a tablespace with the `ALTER TABLESPACE...ADD TEMPFILE` statement the filename is optional. If the filename is not specified, then the same rules apply as discussed in the previous paragraph.

When overriding the default attributes of an Oracle-managed file, if a `SIZE` value is specified but no `AUTOEXTEND` clause is specified, then the datafile is *not* autoextensible.

> **See Also:** "Specifying the Default Temporary Tablespace Tempfile at Database Creation" on page 15-10

CREATE TEMPORARY TABLESPACE: Example

The following example sets the default location for datafile creations to `/u01/oradata` and then creates a tablespace named `temptbs_1` with a tempfile in that location. The tempfile is 100 MB and is autoextensible with an unlimited maximum size.

```
SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/u01/oradata';
SQL> CREATE TEMPORARY TABLESPACE temptbs_1;
```

> **See Also:** *Oracle Database SQL Language Reference* for a description of the `CREATE TABLESPACE` statement

ALTER TABLESPACE... ADD TEMPFILE: Example

The following example sets the default location for datafile creations to `/u03/oradata` and then adds a tempfile in the default location to a tablespace named `temptbs_1`. The tempfile initial size is 100 MB. It is autoextensible with an unlimited maximum size.

```
SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/u03/oradata';
SQL> ALTER TABLESPACE TBS_1 ADD TEMPFILE;
```

> **See Also:** *Oracle Database SQL Language Reference* for a description of the `ALTER TABLESPACE` statement

Creating Control Files Using Oracle-Managed Files

When you issue the `CREATE CONTROLFILE` statement, a control file is created (or reused, if `REUSE` is specified) in the files specified by the `CONTROL_FILES` initialization parameter. If the `CONTROL_FILES` parameter is not set, then the control file is created in the default control file destinations. The default destination is determined according to the precedence documented in "Specifying Control Files at Database Creation" on page 15-7.

If Oracle Database creates an Oracle-managed control file, and there is a server parameter file, then the database creates a `CONTROL_FILES` initialization parameter for the server parameter file. If there is no server parameter file, then you must create a

CONTROL_FILES initialization parameter manually and include it in the initialization parameter file.

If the datafiles in the database are Oracle-managed files, then the database-generated filenames for the files must be supplied in the DATAFILE clause of the statement.

If the redo log files are Oracle-managed files, then the NORESETLOGS or RESETLOGS keyword determines what can be supplied in the LOGFILE clause:

- If the NORESETLOGS keyword is used, then the database-generated filenames for the Oracle-managed redo log files must be supplied in the LOGFILE clause.
- If the RESETLOGS keyword is used, then the redo log file names can be supplied as with the CREATE DATABASE statement. See "Specifying Redo Log Files at Database Creation" on page 15-8.

The sections that follow contain examples of using the CREATE CONTROLFILE statement with Oracle-managed files.

See Also:

- *Oracle Database SQL Language Reference* for a description of the CREATE CONTROLFILE statement
- "Specifying Control Files at Database Creation" on page 15-7

CREATE CONTROLFILE Using NORESETLOGS Keyword: Example

The following CREATE CONTROLFILE statement is generated by an ALTER DATABASE BACKUP CONTROLFILE TO TRACE statement for a database with Oracle-managed datafiles and redo log files:

```
CREATE CONTROLFILE
     DATABASE sample
     LOGFILE
       GROUP 1 ('/u01/oradata/SAMPLE/onlinelog/o1_mf_1_o220rtt9_.log',
                '/u02/oradata/SAMPLE/onlinelog/o1_mf_1_v2o0b2i3_.log')
                 SIZE 100M,
       GROUP 2 ('/u01/oradata/SAMPLE/onlinelog/o1_mf_2_p22056iw_.log',
                '/u02/oradata/SAMPLE/onlinelog/o1_mf_2_p02rcyg3_.log')
                 SIZE 100M
     NORESETLOGS
     DATAFILE '/u01/oradata/SAMPLE/datafile/o1_mf_system_xu34ybm2_.dbf'
              SIZE 100M,
              '/u01/oradata/SAMPLE/datafile/o1_mf_sysaux_aawbmz51_.dbf'
              SIZE 100M,
              '/u01/oradata/SAMPLE/datafile/o1_mf_sys_undotbs_apqbmz51_.dbf'
              SIZE 100M
     MAXLOGFILES 5
     MAXLOGHISTORY 100
     MAXDATAFILES 10
     MAXINSTANCES 2
     ARCHIVELOG;
```

CREATE CONTROLFILE Using RESETLOGS Keyword: Example

The following is an example of a CREATE CONTROLFILE statement with the RESETLOGS option. Some combination of DB_CREATE_FILE_DEST, DB_RECOVERY_FILE_DEST, and DB_CREATE_ONLINE_LOG_DEST_*n* or must be set.

```
CREATE CONTROLFILE
     DATABASE sample
     RESETLOGS
```

```
DATAFILE '/u01/oradata/SAMPLE/datafile/o1_mf_system_aawbmz51_.dbf',
         '/u01/oradata/SAMPLE/datafile/o1_mf_sysaux_axybmz51_.dbf',
         '/u01/oradata/SAMPLE/datafile/o1_mf_sys_undotbs_azzbmz51_.dbf'
SIZE 100M
MAXLOGFILES 5
MAXLOGHISTORY 100
MAXDATAFILES 10
MAXINSTANCES 2
ARCHIVELOG;
```

Later, you must issue the `ALTER DATABASE OPEN RESETLOGS` statement to re-create the redo log files. This is discussed in "Using the ALTER DATABASE OPEN RESETLOGS Statement" on page 15-17. If the previous log files are Oracle-managed files, then they are not deleted.

Creating Redo Log Files Using Oracle-Managed Files

Redo log files are created at database creation time. They can also be created when you issue either of the following statements:

- `ALTER DATABASE ADD LOGFILE`
- `ALTER DATABASE OPEN RESETLOGS`

See Also: *Oracle Database SQL Language Reference* for a description of the `ALTER DATABASE` statement

Using the ALTER DATABASE ADD LOGFILE Statement

The `ALTER DATABASE ADD LOGFILE` statement lets you later add a new group to your current redo log. The filename in the `ADD LOGFILE` clause is optional if you are using Oracle-managed files. If a filename is not provided, then a redo log file is created in the default log file destination. The default destination is determined according to the precedence documented in "Specifying Redo Log Files at Database Creation" on page 15-8.

If a filename is not provided and you have not provided one of the initialization parameters required for creating Oracle-managed files, then the statement returns an error.

The default size for an Oracle-managed log file is 100 MB.

You continue to add and drop redo log file members by specifying complete filenames.

See Also:

- "Specifying Redo Log Files at Database Creation" on page 15-8
- "Creating Control Files Using Oracle-Managed Files" on page 15-14

Adding New Redo Log Files: Example The following example creates a log group with a member in `/u01/oradata` and another member in `/u02/oradata`. The size of each log file is 100 MB.

The following parameter settings are included in the initialization parameter file:

```
DB_CREATE_ONLINE_LOG_DEST_1 = '/u01/oradata'
DB_CREATE_ONLINE_LOG_DEST_2 = '/u02/oradata'
```

The following statement is issued at the SQL prompt:

```
SQL> ALTER DATABASE ADD LOGFILE;
```

Using the ALTER DATABASE OPEN RESETLOGS Statement

If you previously created a control file specifying RESETLOGS and either did not specify filenames or specified nonexistent filenames, then the database creates redo log files for you when you issue the ALTER DATABASE OPEN RESETLOGS statement. The rules for determining the directories in which to store redo log files, when none are specified in the control file, are the same as those discussed in "Specifying Redo Log Files at Database Creation" on page 15-8.

Creating Archived Logs Using Oracle-Managed Files

Archived logs are created in the DB_RECOVERY_FILE_DEST location when:

- The ARC or LGWR background process archives an online redo log or
- An ALTER SYSTEM ARHIVE LOG CURRENT statement is issued.

For example, assume that the following parameter settings are included in the initialization parameter file:

```
DB_RECOVERY_FILE_DEST_SIZE = 20G
DB_RECOVERY_FILE_DEST      = '/u01/oradata'
LOG_ARCHIVE_DEST_1         = 'LOCATION=USE_DB_RECOVERY_FILE_DEST'
```

Behavior of Oracle-Managed Files

The filenames of Oracle-managed files are accepted in SQL statements wherever a filename is used to identify an existing file. These filenames, like other filenames, are stored in the control file and, if using Recovery Manager (RMAN) for backup and recovery, in the RMAN catalog. They are visible in all of the usual fixed and dynamic performance views that are available for monitoring datafiles and tempfiles (for example, V$DATAFILE or DBA_DATA_FILES).

The following are some examples of statements using database-generated filenames:

```
SQL> ALTER DATABASE
  2> RENAME FILE '/u01/oradata/mydb/datafile/o1_mf_tbs01_ziw3bopb_.dbf'
  3> TO '/u01/oradata/mydb/tbs0101.dbf';

SQL> ALTER DATABASE
  2> DROP LOGFILE '/u01/oradata/mydb/onlinelog/o1_mf_1_wo94n2xi_.log';

SQL> ALTER TABLE emp
  2> ALLOCATE EXTENT
  3> (DATAFILE '/u01/oradata/mydb/datafile/o1_mf_tbs1_2ixfh90q_.dbf');
```

You can backup and restore Oracle-managed datafiles, tempfiles, and control files as you would corresponding non Oracle-managed files. Using database-generated filenames does not impact the use of logical backup files such as export files. This is particularly important for tablespace point-in-time recovery (TSPITR) and transportable tablespace export files.

There are some cases where Oracle-managed files behave differently. These are discussed in the sections that follow.

Dropping Datafiles and Tempfiles

Unlike files that are not managed by the database, when an Oracle-managed datafile or tempfile is dropped, the filename is removed from the control file and the file is automatically deleted from the file system. The statements that delete Oracle-managed files when they are dropped are:

- `DROP TABLESPACE`
- `ALTER DATABASE TEMPFILE ... DROP`

You can also use these statements, which always delete files, Oracle-managed or not:

- `ALTER TABLESPACE ... DROP DATAFILE`
- `ALTER TABLESPACE ... DROP TEMPFILE`

Dropping Redo Log Files

When an Oracle-managed redo log file is dropped its Oracle-managed files are deleted. You specify the group or members to be dropped. The following statements drop and delete redo log files:

- `ALTER DATABASE DROP LOGFILE`
- `ALTER DATABASE DROP LOGFILE MEMBER`

Renaming Files

The following statements are used to rename files:

- `ALTER DATABASE RENAME FILE`
- `ALTER TABLESPACE ... RENAME DATAFILE`

These statements do not actually rename the files on the operating system, but rather, the names in the control file are changed. If the old file is an Oracle-managed file and it exists, then it is deleted. You must specify each filename using the conventions for filenames on your operating system when you issue this statement.

Managing Standby Databases

The datafiles, control files, and redo log files in a standby database can be managed by the database. This is independent of whether Oracle-managed files are used on the primary database.

When recovery of a standby database encounters redo for the creation of a datafile, if the datafile is an Oracle-managed file, then the recovery process creates an empty file in the local default file system location. This allows the redo for the new file to be applied immediately without any human intervention.

When recovery of a standby database encounters redo for the deletion of a tablespace, it deletes any Oracle-managed datafiles in the local file system. Note that this is independent of the `INCLUDING DATAFILES` option issued at the primary database.

Scenarios for Using Oracle-Managed Files

This section further demonstrates the use of Oracle-managed files by presenting scenarios of their use.

Scenario 1: Create and Manage a Database with Multiplexed Redo Logs

In this scenario, a DBA creates a database where the datafiles and redo log files are created in separate directories. The redo log files and control files are multiplexed. The database uses an undo tablespace, and has a default temporary tablespace. The following are tasks involved with creating and maintaining this database.

1. Setting the initialization parameters

   The DBA includes three generic file creation defaults in the initialization parameter file before creating the database. Automatic undo management mode is also specified.

   ```
   DB_CREATE_FILE_DEST = '/u01/oradata'
   DB_CREATE_ONLINE_LOG_DEST_1 = '/u02/oradata'
   DB_CREATE_ONLINE_LOG_DEST_2 = '/u03/oradata'
   UNDO_MANAGEMENT = AUTO
   ```

   The `DB_CREATE_FILE_DEST` parameter sets the default file system directory for the datafiles and tempfiles.

   The `DB_CREATE_ONLINE_LOG_DEST_1` and `DB_CREATE_ONLINE_LOG_DEST_2` parameters set the default file system directories for redo log file and control file creation. Each redo log file and control file is multiplexed across the two directories.

2. Creating a database

   Once the initialization parameters are set, the database can be created by using this statement:

   ```
   SQL> CREATE DATABASE sample
   2>   DEFAULT TEMPORARY TABLESPACE dflttmp;
   ```

   Because a `DATAFILE` clause is not present and the `DB_CREATE_FILE_DEST` initialization parameter is set, the `SYSTEM` tablespace datafile is created in the default file system (`/u01/oradata` in this scenario). The filename is uniquely generated by the database. The file is autoextensible with an initial size of 100 MB and an unlimited maximum size. The file is an Oracle-managed file. A similar datafile is created for the `SYSAUX` tablespace.

   Because a `LOGFILE` clause is not present, two redo log groups are created. Each log group has two members, with one member in the `DB_CREATE_ONLINE_LOG_DEST_1` location and the other member in the `DB_CREATE_ONLINE_LOG_DEST_2` location. The filenames are uniquely generated by the database. The log files are created with a size of 100 MB. The log file members are Oracle-managed files.

   Similarly, because the `CONTROL_FILES` initialization parameter is not present, and two `DB_CREATE_ONLINE_LOG_DEST_`*n* initialization parameters are specified, two control files are created. The control file located in the `DB_CREATE_ONLINE_LOG_DEST_1` location is the primary control file; the control file located in the `DB_CREATE_ONLINE_LOG_DEST_2` location is a multiplexed copy. The filenames are uniquely generated by the database. They are Oracle-managed files. Assuming there is a server parameter file, a `CONTROL_FILES` initialization parameter is generated.

   Automatic undo management mode is specified, but because an undo tablespace is not specified and the `DB_CREATE_FILE_DEST` initialization parameter is set, a default undo tablespace named `SYS_UNDOTBS` is created in the directory specified by `DB_CREATE_FILE_DEST`. The datafile is a 10 MB datafile that is autoextensible. It is an Oracle-managed file.

Lastly, a default temporary tablespace named `dflttmp` is specified. Because `DB_CREATE_FILE_DEST` is included in the parameter file, the tempfile for `dflttmp` is created in the directory specified by that parameter. The tempfile is 100 MB and is autoextensible with an unlimited maximum size. It is an Oracle-managed file.

The resultant file tree, with generated filenames, is as follows:

```
/u01
     /oradata
          /SAMPLE
               /datafile
                    /o1_mf_system_cmr7t30p_.dbf
                    /o1_mf_sysaux_cmr7t88p_.dbf
                    /o1_mf_sys_undotbs_2ixfh90q_.dbf
                    /o1_mf_dflttmp_157se6ff_.tmp
/u02
     /oradata
          /SAMPLE
               /onlinelog
                    /o1_mf_1_0orrm31z_.log
                    /o1_mf_2_2xyz16am_.log
               /controlfile
                    /o1_mf_cmr7t30p_.ctl
/u03
     /oradata
          /SAMPLE
               /onlinelog
                    /o1_mf_1_ixfvm8w9_.log
                    /o1_mf_2_q89tmp28_.log
               /controlfile
                    /o1_mf_x1sr8t36_.ctl
```

The internally generated filenames can be seen when selecting from the usual views. For example:

```
SQL> SELECT NAME FROM V$DATAFILE;

NAME
----------------------------------------------------
/u01/oradata/SAMPLE/datafile/o1_mf_system_cmr7t30p_.dbf
/u01/oradata/SAMPLE/datafile/o1_mf_sysaux_cmr7t88p_.dbf
/u01/oradata/SAMPLE/datafile/o1_mf_sys_undotbs_2ixfh90q_.dbf

3 rows selected
```

The name is also printed to the alert log when the file is created.

3. Managing control files

   The control file was created when generating the database, and a `CONTROL_FILES` initialization parameter was added to the parameter file. If needed, then the DBA can re-create the control file or build a new one for the database using the `CREATE CONTROLFILE` statement.

   The correct Oracle-managed filenames must be used in the `DATAFILE` and `LOGFILE` clauses. The `ALTER DATABASE BACKUP CONTROLFILE TO TRACE` statement generates a script with the correct filenames. Alternatively, the filenames can be found by selecting from the `V$DATAFILE`, `V$TEMPFILE`, and `V$LOGFILE` views. The following example re-creates the control file for the sample database:

```
CREATE CONTROLFILE REUSE
  DATABASE sample
  LOGFILE
    GROUP 1('/u02/oradata/SAMPLE/onlinelog/o1_mf_1_0orrm31z_.log',
            '/u03/oradata/SAMPLE/onlinelog/o1_mf_1_ixfvm8w9_.log'),
    GROUP 2('/u02/oradata/SAMPLE/onlinelog/o1_mf_2_2xyz16am_.log',
            '/u03/oradata/SAMPLE/onlinelog/o1_mf_2_q89tmp28_.log')
  NORESETLOGS
  DATAFILE '/u01/oradata/SAMPLE/datafile/o1_mf_system_cmr7t30p_.dbf',
           '/u01/oradata/SAMPLE/datafile/o1_mf_sysaux_cmr7t88p_.dbf',
           '/u01/oradata/SAMPLE/datafile/o1_mf_sys_undotbs_2ixfh90q_.dbf',
           '/u01/oradata/SAMPLE/datafile/o1_mf_dflttmp_157se6ff_.tmp'
  MAXLOGFILES 5
  MAXLOGHISTORY 100
  MAXDATAFILES 10
  MAXINSTANCES 2
  ARCHIVELOG;
```

The control file created by this statement is located as specified by the `CONTROL_FILES` initialization parameter that was generated when the database was created. The `REUSE` clause causes any existing files to be overwritten.

4. Managing the redo log

   To create a new group of redo log files, the DBA can use the `ALTER DATABASE ADD LOGFILE` statement. The following statement adds a log file with a member in the `DB_CREATE_ONLINE_LOG_DEST_1` location and a member in the `DB_CREATE_ONLINE_LOG_DEST_2` location. These files are Oracle-managed files.

```
SQL> ALTER DATABASE ADD LOGFILE;
```

   Log file members continue to be added and dropped by specifying complete filenames.

   The `GROUP` clause can be used to drop a log group. In the following example the operating system file associated with each Oracle-managed log file member is automatically deleted.

```
SQL> ALTER DATABASE DROP LOGFILE GROUP 3;
```

5. Managing tablespaces

   The default storage for all datafiles for future tablespace creations in the `sample` database is the location specified by the `DB_CREATE_FILE_DEST` initialization parameter (`/u01/oradata` in this scenario). Any datafiles for which no filename is specified, are created in the file system specified by the initialization parameter `DB_CREATE_FILE_DEST`. For example:

```
SQL> CREATE TABLESPACE tbs_1;
```

   The preceding statement creates a tablespace whose storage is in `/u01/oradata`. A datafile is created with an initial of 100 MB and it is autoextensible with an unlimited maximum size. The datafile is an Oracle-managed file.

   When the tablespace is dropped, the Oracle-managed files for the tablespace are automatically removed. The following statement drops the tablespace and all the Oracle-managed files used for its storage:

```
SQL> DROP TABLESPACE tbs_1;
```

Once the first datafile is full, the database does not automatically create a new datafile. More space can be added to the tablespace by adding another Oracle-managed datafile. The following statement adds another datafile in the location specified by `DB_CREATE_FILE_DEST`:

```
SQL> ALTER TABLESPACE tbs_1 ADD DATAFILE;
```

The default file system can be changed by changing the initialization parameter. This does not change any existing datafiles. It only affects future creations. This can be done dynamically using the following statement:

```
SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST='/u04/oradata';
```

6. Archiving redo information

   Archiving of redo log files is no different for Oracle-managed files, than it is for unmanaged files. A file system location for the archived log files can be specified using the `LOG_ARCHIVE_DEST_`*n* initialization parameters. The filenames are formed based on the `LOG_ARCHIVE_FORMAT` parameter or its default. The archived logs are not Oracle-managed files

7. Backup, restore, and recover

   Since an Oracle-managed file is compatible with standard operating system files, you can use operating system utilities to backup or restore Oracle-managed files. All existing methods for backing up, restoring, and recovering the database work for Oracle-managed files.

Scenario 2: Create and Manage a Database with Database and Flash Recovery Areas

In this scenario, a DBA creates a database where the control files and redo log files are multiplexed. Archived logs and RMAN backups are created in the flash recovery area. The following tasks are involved in creating and maintaining this database:

1. Setting the initialization parameters

   The DBA includes the following generic file creation defaults:

```
DB_CREATE_FILE_DEST = '/u01/oradata'
DB_RECOVERY_FILE_DEST_SIZE = 10G
DB_RECOVERY_FILE_DEST = '/u02/oradata'
LOG_ARCHIVE_DEST_1 = 'LOCATION = USE_DB_RECOVERY_FILE_DEST'
```

   The `DB_CREATE_FILE_DEST` parameter sets the default file system directory for datafiles, tempfiles, control files, and redo logs.

   The `DB_RECOVERY_FILE_DEST` parameter sets the default file system directory for control files, redo logs, and RMAN backups.

   The `LOG_ARCHIVE_DEST_1` configuration '`LOCATION=USE_DB_RECOVERY_FILE_DEST`' redirects archived logs to the `DB_RECOVERY_FILE_DEST` location.

   The `DB_CREATE_FILE_DEST` and `DB_RECOVERY_FILE_DEST` parameters set the default directory for log file and control file creation. Each redo log and control file is multiplexed across the two directories.

2. Creating a database
3. Managing control files

4. Managing the redo log
5. Managing tablespaces

   Tasks 2, 3, 4, and 5 are the same as in Scenario 1, except that the control files and redo logs are multiplexed across the `DB_CREATE_FILE_DEST` and `DB_RECOVERY_FILE_DEST` locations.
6. Archiving redo log information

   Archiving online logs is no different for Oracle-managed files than it is for unmanaged files. The archived logs are created in `DB_RECOVERY_FILE_DEST` and are Oracle-managed files.
7. Backup, restore, and recover

   An Oracle-managed file is compatible with standard operating system files, so you can use operating system utilities to backup or restore Oracle-managed files. All existing methods for backing up, restoring, and recovering the database work for Oracle-managed files. When no format option is specified, all disk backups by RMAN are created in the `DB_RECOVERY_FILE_DEST` location. The backups are Oracle-managed files.

Scenario 3: Adding Oracle-Managed Files to an Existing Database

Assume in this case that an existing database does not have any Oracle-managed files, but the DBA would like to create new tablespaces with Oracle-managed files and locate them in directory `/u03/oradata`.

1. Setting the initialization parameters

   To allow automatic datafile creation, set the `DB_CREATE_FILE_DEST` initialization parameter to the file system directory in which to create the datafiles. This can be done dynamically as follows:

   ```
   SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/u03/oradata';
   ```
2. Creating tablespaces

   Once `DB_CREATE_FILE_DEST` is set, the `DATAFILE` clause can be omitted from a `CREATE TABLESPACE` statement. The datafile is created in the location specified by `DB_CREATE_FILE_DEST` by default. For example:

   ```
   SQL> CREATE TABLESPACE tbs_2;
   ```

   When the `tbs_2` tablespace is dropped, its datafiles are automatically deleted.

Part III

Schema Objects

Part IV describes the creation and maintenance of schema objects in the Oracle Database. It includes the following chapters:

16

Managing Schema Objects

This chapter describes schema object management issues that are common across multiple types of schema objects. The following topics are presented:

Creating Multiple Tables and Views in a Single Operation

You can create several tables and views and grant privileges in one operation using the `CREATE SCHEMA` statement. The `CREATE SCHEMA` statement is useful if you want to guarantee the creation of several tables, views, and grants in one operation. If an individual table, view or grant fails, the entire statement is rolled back. None of the objects are created, nor are the privileges granted.

Specifically, the `CREATE SCHEMA` statement can include *only* `CREATE TABLE`, `CREATE VIEW`, and `GRANT` statements. You must have the privileges necessary to issue the included statements. You are not actually creating a schema, that is done when the user is created with a `CREATE USER` statement. Rather, you are populating the schema.

The following statement creates two tables and a view that joins data from the two tables:

```
CREATE SCHEMA AUTHORIZATION scott
    CREATE TABLE dept (
        deptno NUMBER(3,0) PRIMARY KEY,
        dname VARCHAR2(15),
        loc VARCHAR2(25))
    CREATE TABLE emp (
        empno NUMBER(5,0) PRIMARY KEY,
        ename VARCHAR2(15) NOT NULL,
        job VARCHAR2(10),
        mgr NUMBER(5,0),
        hiredate DATE DEFAULT (sysdate),
        sal NUMBER(7,2),
        comm NUMBER(7,2),
        deptno NUMBER(3,0) NOT NULL
        CONSTRAINT dept_fkey REFERENCES dept)
   CREATE VIEW sales_staff AS
        SELECT empno, ename, sal, comm
        FROM emp
        WHERE deptno = 30
        WITH CHECK OPTION CONSTRAINT sales_staff_cnst
        GRANT SELECT ON sales_staff TO human_resources;
```

The CREATE SCHEMA statement does not support Oracle Database extensions to the ANSI CREATE TABLE and CREATE VIEW statements, including the STORAGE clause.

See Also: *Oracle Database SQL Language Reference* for syntax and other information about the CREATE SCHEMA statement

Analyzing Tables, Indexes, and Clusters

You analyze a schema object (table, index, or cluster) to:

- Collect and manage statistics for it
- Verify the validity of its storage format
- Identify migrated and chained rows of a table or cluster

Note: Do not use the COMPUTE and ESTIMATE clauses of ANALYZE to collect optimizer statistics. These clauses are supported for backward compatibility. Instead, use the DBMS_STATS package, which lets you collect statistics in parallel, collect global statistics for partitioned objects, and fine tune your statistics collection in other ways. The cost-based optimizer, which depends upon statistics, will eventually use only statistics that have been collected by DBMS_STATS. See *Oracle Database PL/SQL Packages and Types Reference* for more information on the DBMS_STATS package.

You must use the ANALYZE statement (rather than DBMS_STATS) for statistics collection not related to the cost-based optimizer, such as:

- To use the VALIDATE or LIST CHAINED ROWS clauses
- To collect information on freelist blocks

The following topics are discussed in this section:

- Using DBMS_STATS to Collect Table and Index Statistics
- Validating Tables, Indexes, Clusters, and Materialized Views
- Listing Chained Rows of Tables and Clusters

Using DBMS_STATS to Collect Table and Index Statistics

You can use the DBMS_STATS package or the ANALYZE statement to gather statistics about the physical storage characteristics of a table, index, or cluster. These statistics are stored in the data dictionary and can be used by the optimizer to choose the most efficient execution plan for SQL statements accessing analyzed objects.

Oracle recommends using the more versatile `DBMS_STATS` package for gathering optimizer statistics, but you must use the `ANALYZE` statement to collect statistics unrelated to the optimizer, such as empty blocks, average space, and so forth.

The `DBMS_STATS` package allows both the gathering of statistics, including utilizing parallel execution, and the external manipulation of statistics. Statistics can be stored in tables outside of the data dictionary, where they can be manipulated without affecting the optimizer. Statistics can be copied between databases or backup copies can be made.

The following `DBMS_STATS` procedures enable the gathering of optimizer statistics:

- `GATHER_INDEX_STATS`
- `GATHER_TABLE_STATS`
- `GATHER_SCHEMA_STATS`
- `GATHER_DATABASE_STATS`

See Also:

- *Oracle Database Performance Tuning Guide* for information about using `DBMS_STATS` to gather statistics for the optimizer
- *Oracle Database PL/SQL Packages and Types Reference* for a description of the `DBMS_STATS` package

Validating Tables, Indexes, Clusters, and Materialized Views

To verify the integrity of the structure of a table, index, cluster, or materialized view, use the `ANALYZE` statement with the `VALIDATE STRUCTURE` option. If the structure is valid, no error is returned. However, if the structure is corrupt, you receive an error message.

For example, in rare cases such as hardware or other system failures, an index can become corrupted and not perform correctly. When validating the index, you can confirm that every entry in the index points to the correct row of the associated table. If the index is corrupt, you can drop and re-create it.

If a table, index, or cluster is corrupt, you should drop it and re-create it. If a materialized view is corrupt, perform a complete refresh and ensure that you have remedied the problem. If the problem is not corrected, drop and re-create the materialized view.

The following statement analyzes the `emp` table:

```
ANALYZE TABLE emp VALIDATE STRUCTURE;
```

You can validate an object and all dependent objects (for example, indexes) by including the `CASCADE` option. The following statement validates the `emp` table and all associated indexes:

```
ANALYZE TABLE emp VALIDATE STRUCTURE CASCADE;
```

By default the `CASCADE` option performs a complete validation. Because this operation can be resource intensive, you can perform a faster version of the validation by using the `FAST` clause. This version checks for the existence of corruptions using an optimized check algorithm, but does not report details about the corruption. If the `FAST` check finds a corruption, you can then use the `CASCADE` option without the

FAST clause to locate it. The following statement performs a fast validation on the emp table and all associated indexes:

```
ANALYZE TABLE emp VALIDATE STRUCTURE CASCADE FAST;
```

You can specify that you want to perform structure validation online while DML is occurring against the object being validated. There can be a slight performance impact when validating with ongoing DML affecting the object, but this is offset by the flexibility of being able to perform ANALYZE online. The following statement validates the emp table and all associated indexes online:

```
ANALYZE TABLE emp VALIDATE STRUCTURE CASCADE ONLINE;
```

See Also: *Oracle Database SQL Language Reference* for more information on the ANALYZE statement

Listing Chained Rows of Tables and Clusters

You can look at the chained and migrated rows of a table or cluster using the ANALYZE statement with the LIST CHAINED ROWS clause. The results of this statement are stored in a specified table created explicitly to accept the information returned by the LIST CHAINED ROWS clause. These results are useful in determining whether you have enough room for updates to rows.

Creating a CHAINED_ROWS Table

To create the table to accept data returned by an ANALYZE...LIST CHAINED ROWS statement, execute the UTLCHAIN.SQL or UTLCHN1.SQL script. These scripts are provided by the database. They create a table named CHAINED_ROWS in the schema of the user submitting the script.

Note: Your choice of script to execute for creating the CHAINED_ROWS table is dependent upon the compatibility level of your database and the type of table you are analyzing. See the *Oracle Database SQL Language Reference* for more information.

After a CHAINED_ROWS table is created, you specify it in the INTO clause of the ANALYZE statement. For example, the following statement inserts rows containing information about the chained rows in the emp_dept cluster into the CHAINED_ROWS table:

```
ANALYZE CLUSTER emp_dept LIST CHAINED ROWS INTO CHAINED_ROWS;
```

See Also:

- *Oracle Database Reference* for a description of the CHAINED_ROWS table
- "Using the Segment Advisor" on page 17-16 for information on how the Segment Advisor reports tables with excess row chaining.

Eliminating Migrated or Chained Rows in a Table

You can use the information in the CHAINED_ROWS table to reduce or eliminate migrated and chained rows in an existing table. Use the following procedure.

1. Use the ANALYZE statement to collect information about migrated and chained rows.

```
ANALYZE TABLE order_hist LIST CHAINED ROWS;
```

2. Query the output table:

```
SELECT *
FROM CHAINED_ROWS
WHERE TABLE_NAME = 'ORDER_HIST';

OWNER_NAME  TABLE_NAME  CLUST... HEAD_ROWID          TIMESTAMP
----------  ----------  -----... ------------------  ---------
SCOTT       ORDER_HIST       ... AAAAluAAHAAAAA1AAA  04-MAR-96
SCOTT       ORDER_HIST       ... AAAAluAAHAAAAA1AAB  04-MAR-96
SCOTT       ORDER_HIST       ... AAAAluAAHAAAAA1AAC  04-MAR-96
```

The output lists all rows that are either migrated or chained.

3. If the output table shows that you have many migrated or chained rows, then you can eliminate migrated rows by continuing through the following steps:

4. Create an intermediate table with the same columns as the existing table to hold the migrated and chained rows:

```
CREATE TABLE int_order_hist
   AS SELECT *
      FROM order_hist
      WHERE ROWID IN
         (SELECT HEAD_ROWID
            FROM CHAINED_ROWS
            WHERE TABLE_NAME = 'ORDER_HIST');
```

5. Delete the migrated and chained rows from the existing table:

```
DELETE FROM order_hist
   WHERE ROWID IN
      (SELECT HEAD_ROWID
         FROM CHAINED_ROWS
         WHERE TABLE_NAME = 'ORDER_HIST');
```

6. Insert the rows of the intermediate table into the existing table:

```
INSERT INTO order_hist
   SELECT *
   FROM int_order_hist;
```

7. Drop the intermediate table:

```
DROP TABLE int_order_history;
```

8. Delete the information collected in step 1 from the output table:

```
DELETE FROM CHAINED_ROWS
   WHERE TABLE_NAME = 'ORDER_HIST';
```

9. Use the `ANALYZE` statement again, and query the output table.

Any rows that appear in the output table are chained. You can eliminate chained rows only by increasing your data block size. It might not be possible to avoid chaining in all situations. Chaining is often unavoidable with tables that have a `LONG` column or large `CHAR` or `VARCHAR2` columns.

Truncating Tables and Clusters

You can delete all rows of a table or all rows in a group of clustered tables so that the table (or cluster) still exists, but is completely empty. For example, consider a table that contains monthly data, and at the end of each month, you need to empty it (delete all rows) after archiving its data.

To delete all rows from a table, you have the following options:

- Use the `DELETE` statement.
- Use the `DROP` and `CREATE` statements.
- Use the `TRUNCATE` statement.

These options are discussed in the following sections

Using DELETE

You can delete the rows of a table using the `DELETE` statement. For example, the following statement deletes all rows from the `emp` table:

```
DELETE FROM emp;
```

If there are many rows present in a table or cluster when using the `DELETE` statement, significant system resources are consumed as the rows are deleted. For example, CPU time, redo log space, and undo segment space from the table and any associated indexes require resources. Also, as each row is deleted, triggers can be fired. The space previously allocated to the resulting empty table or cluster remains associated with that object. With `DELETE` you can choose which rows to delete, whereas `TRUNCATE` and `DROP` affect the entire object.

> **See Also:** *Oracle Database SQL Language Reference* for syntax and other information about the `DELETE` statement

Using DROP and CREATE

You can drop a table and then re-create the table. For example, the following statements drop and then re-create the `emp` table:

```
DROP TABLE emp;
CREATE TABLE emp ( ... );
```

When dropping and re-creating a table or cluster, all associated indexes, integrity constraints, and triggers are also dropped, and all objects that depend on the dropped table or clustered table are invalidated. Also, all grants for the dropped table or clustered table are dropped.

Using TRUNCATE

You can delete all rows of the table using the `TRUNCATE` statement. For example, the following statement truncates the `emp` table:

```
TRUNCATE TABLE emp;
```

Using the `TRUNCATE` statement provides a fast, efficient method for deleting all rows from a table or cluster. A `TRUNCATE` statement does not generate any undo information and it commits immediately. It is a DDL statement and cannot be rolled back. A `TRUNCATE` statement does not affect any structures associated with the table being truncated (constraints and triggers) or authorizations. A `TRUNCATE` statement also specifies whether space currently allocated for the table is returned to the containing tablespace after truncation.

You can truncate any table or cluster in your own schema. Any user who has the DROP ANY TABLE system privilege can truncate a table or cluster in any schema.

Before truncating a table or clustered table containing a parent key, all referencing foreign keys in different tables must be disabled. A self-referential constraint does not have to be disabled.

As a TRUNCATE statement deletes rows from a table, triggers associated with the table are not fired. Also, a TRUNCATE statement does not generate any audit information corresponding to DELETE statements if auditing is enabled. Instead, a single audit record is generated for the TRUNCATE statement being issued. See the *Oracle Database Security Guide* for information about auditing.

A hash cluster cannot be truncated, nor can tables within a hash or index cluster be individually truncated. Truncation of an index cluster deletes all rows from all tables in the cluster. If all the rows must be deleted from an individual clustered table, use the DELETE statement or drop and re-create the table.

The REUSE STORAGE or DROP STORAGE options of the TRUNCATE statement control whether space currently allocated for a table or cluster is returned to the containing tablespace after truncation. The default option, DROP STORAGE, reduces the number of extents allocated to the resulting table to the original setting for MINEXTENTS. Freed extents are then returned to the system and can be used by other objects.

Alternatively, the REUSE STORAGE option specifies that all space currently allocated for the table or cluster remains allocated to it. For example, the following statement truncates the emp_dept cluster, leaving all extents previously allocated for the cluster available for subsequent inserts and deletes:

```
TRUNCATE CLUSTER emp_dept REUSE STORAGE;
```

The REUSE or DROP STORAGE option also applies to any associated indexes. When a table or cluster is truncated, all associated indexes are also truncated. The storage parameters for a truncated table, cluster, or associated indexes are not changed as a result of the truncation.

> **See Also:** *Oracle Database SQL Language Reference* for syntax and other information about the TRUNCATE TABLE and TRUNCATE CLUSTER statements

Enabling and Disabling Triggers

Database triggers are procedures that are stored in the database and activated ("fired") when specific conditions occur, such as adding a row to a table. You can use triggers to supplement the standard capabilities of the database to provide a highly customized database management system. For example, you can create a trigger to restrict DML operations against a table, allowing only statements issued during regular business hours.

Database triggers can be associated with a table, schema, or database. They are implicitly fired when:

- DML statements are executed (INSERT, UPDATE, DELETE) against an associated table
- Certain DDL statements are executed (for example: ALTER, CREATE, DROP) on objects within a database or schema

- A specified database event occurs (for example: `STARTUP`, `SHUTDOWN`, `SERVERERROR`)

This is not a complete list. See the *Oracle Database SQL Language Reference* for a full list of statements and database events that cause triggers to fire

Create triggers with the `CREATE TRIGGER` statement. They can be defined as firing `BEFORE` or `AFTER` the triggering event, or `INSTEAD OF` it. The following statement creates a trigger `scott.emp_permit_changes` on table `scott.emp`. The trigger fires before any of the specified statements are executed.

```
CREATE TRIGGER scott.emp_permit_changes
     BEFORE
     DELETE OR INSERT OR UPDATE
     ON scott.emp
     .
     .
     .
pl/sql block
     .
     .
     .
```

You can later remove a trigger from the database by issuing the `DROP TRIGGER` statement.

A trigger can be in either of two distinct modes:

- Enabled

  An enabled trigger executes its trigger body if a triggering statement is issued and the trigger restriction, if any, evaluates to true. By default, triggers are enabled when first created.

- Disabled

  A disabled trigger does not execute its trigger body, even if a triggering statement is issued and the trigger restriction (if any) evaluates to true.

To enable or disable triggers using the `ALTER TABLE` statement, you must own the table, have the `ALTER` object privilege for the table, or have the `ALTER ANY TABLE` system privilege. To enable or disable an individual trigger using the `ALTER TRIGGER` statement, you must own the trigger or have the `ALTER ANY TRIGGER` system privilege.

See Also:

- *Oracle Database Concepts* for a more detailed description of triggers
- *Oracle Database SQL Language Reference* for syntax of the `CREATE TRIGGER` statement
- *Oracle Database PL/SQL Language Reference* for information about creating and using triggers

Enabling Triggers

You enable a disabled trigger using the `ALTER TRIGGER` statement with the `ENABLE` option. To enable the disabled trigger named `reorder` on the `inventory` table, enter the following statement:

```
ALTER TRIGGER reorder ENABLE;
```

To enable all triggers defined for a specific table, use the `ALTER TABLE` statement with the `ENABLE ALL TRIGGERS` option. To enable all triggers defined for the `INVENTORY` table, enter the following statement:

```
ALTER TABLE inventory
    ENABLE ALL TRIGGERS;
```

See Also: *Oracle Database SQL Language Reference* for syntax and other information about the `ALTER TRIGGER` statement

Disabling Triggers

Consider temporarily disabling a trigger if one of the following conditions is true:

- An object that the trigger references is not available.
- You must perform a large data load and want it to proceed quickly without firing triggers.
- You are loading data into the table to which the trigger applies.

You disable a trigger using the `ALTER TRIGGER` statement with the `DISABLE` option. To disable the trigger `reorder` on the `inventory` table, enter the following statement:

```
ALTER TRIGGER reorder DISABLE;
```

You can disable all triggers associated with a table at the same time using the `ALTER TABLE` statement with the `DISABLE ALL TRIGGERS` option. For example, to disable all triggers defined for the `inventory` table, enter the following statement:

```
ALTER TABLE inventory
    DISABLE ALL TRIGGERS;
```

Managing Integrity Constraints

Integrity constraints are rules that restrict the values for one or more columns in a table. Constraint clauses can appear in either `CREATE TABLE` or `ALTER TABLE` statements, and identify the column or columns affected by the constraint and identify the conditions of the constraint.

This section discusses the concepts of constraints and identifies the SQL statements used to define and manage integrity constraints. The following topics are contained in this section:

See Also:

- *Oracle Database Concepts* for a more thorough discussion of integrity constraints
- *Oracle Database Advanced Application Developer's Guide* for detailed information and examples of using integrity constraints in applications

Integrity Constraint States

You can specify that a constraint is enabled (`ENABLE`) or disabled (`DISABLE`). If a constraint is enabled, data is checked as it is entered or updated in the database, and data that does not conform to the constraint is prevented from being entered. If a constraint is disabled, then data that does not conform can be allowed to enter the database.

Additionally, you can specify that existing data in the table must conform to the constraint (`VALIDATE`). Conversely, if you specify `NOVALIDATE`, you are not ensured that existing data conforms.

An integrity constraint defined on a table can be in one of the following states:

- `ENABLE`, `VALIDATE`
- `ENABLE`, `NOVALIDATE`
- `DISABLE`, `VALIDATE`
- `DISABLE`, `NOVALIDATE`

For details about the meaning of these states and an understanding of their consequences, see the *Oracle Database SQL Language Reference.* Some of these consequences are discussed here.

Disabling Constraints

To enforce the rules defined by integrity constraints, the constraints should always be enabled. However, consider temporarily disabling the integrity constraints of a table for the following performance reasons:

- When loading large amounts of data into a table
- When performing batch operations that make massive changes to a table (for example, changing every employee's number by adding 1000 to the existing number)
- When importing or exporting one table at a time

In all three cases, temporarily disabling integrity constraints can improve the performance of the operation, especially in data warehouse configurations.

It is possible to enter data that violates a constraint while that constraint is disabled. Thus, you should always enable the constraint after completing any of the operations listed in the preceding bullet list.

Enabling Constraints

While a constraint is enabled, no row violating the constraint can be inserted into the table. However, while the constraint is disabled such a row can be inserted. This row is known as an exception to the constraint. If the constraint is in the enable novalidated state, violations resulting from data entered while the constraint was disabled remain.

The rows that violate the constraint must be either updated or deleted in order for the constraint to be put in the validated state.

You can identify exceptions to a specific integrity constraint while attempting to enable the constraint. See "Reporting Constraint Exceptions" on page 16-14. All rows violating constraints are noted in an `EXCEPTIONS` table, which you can examine.

Enable Novalidate Constraint State

When a constraint is in the enable novalidate state, all subsequent statements are checked for conformity to the constraint. However, any existing data in the table is not checked. A table with enable novalidated constraints can contain invalid data, but it is not possible to add new invalid data to it. Enabling constraints in the novalidated state is most useful in data warehouse configurations that are uploading valid OLTP data.

Enabling a constraint does not require validation. Enabling a constraint novalidate is much faster than enabling and validating a constraint. Also, validating a constraint that is already enabled does not require any DML locks during validation (unlike validating a previously disabled constraint). Enforcement guarantees that no violations are introduced during the validation. Hence, enabling without validating enables you to reduce the downtime typically associated with enabling a constraint.

Efficient Use of Integrity Constraints: A Procedure

Using integrity constraint states in the following order can ensure the best benefits:

1. Disable state.
2. Perform the operation (load, export, import).
3. Enable novalidate state.
4. Enable state.

Some benefits of using constraints in this order are:

- No locks are held.
- All constraints can go to enable state concurrently.
- Constraint enabling is done in parallel.
- Concurrent activity on table is permitted.

Setting Integrity Constraints Upon Definition

When an integrity constraint is defined in a `CREATE TABLE` or `ALTER TABLE` statement, it can be enabled, disabled, or validated or not validated as determined by your specification of the `ENABLE/DISABLE` clause. If the `ENABLE/DISABLE` clause is not specified in a constraint definition, the database automatically enables and validates the constraint.

Disabling Constraints Upon Definition

The following `CREATE TABLE` and `ALTER TABLE` statements both define and disable integrity constraints:

```
CREATE TABLE emp (
    empno NUMBER(5) PRIMARY KEY DISABLE,   . . . ;

ALTER TABLE emp
   ADD PRIMARY KEY (empno) DISABLE;
```

An ALTER TABLE statement that defines and disables an integrity constraint never fails because of rows in the table that violate the integrity constraint. The definition of the constraint is allowed because its rule is not enforced.

Enabling Constraints Upon Definition

The following CREATE TABLE and ALTER TABLE statements both define and enable integrity constraints:

```
CREATE TABLE emp (
    empno NUMBER(5) CONSTRAINT emp.pk PRIMARY KEY,   . . . ;

ALTER TABLE emp
    ADD CONSTRAINT emp.pk PRIMARY KEY (empno);
```

An ALTER TABLE statement that defines and attempts to enable an integrity constraint can fail because rows of the table violate the integrity constraint. If this case, the statement is rolled back and the constraint definition is not stored and not enabled.

When you enable a UNIQUE or PRIMARY KEY constraint an associated index is created.

Note: An efficient procedure for enabling a constraint that can make use of parallelism is described in "Efficient Use of Integrity Constraints: A Procedure" on page 16-11.

See Also: "Creating an Index Associated with a Constraint" on page 19-8

Modifying, Renaming, or Dropping Existing Integrity Constraints

You can use the ALTER TABLE statement to enable, disable, modify, or drop a constraint. When the database is using a UNIQUE or PRIMARY KEY index to enforce a constraint, and constraints associated with that index are dropped or disabled, the index is dropped, unless you specify otherwise.

While enabled foreign keys reference a PRIMARY or UNIQUE key, you cannot disable or drop the PRIMARY or UNIQUE key constraint or the index.

Disabling Enabled Constraints

The following statements disable integrity constraints. The second statement specifies that the associated indexes are to be kept.

```
ALTER TABLE dept
    DISABLE CONSTRAINT dname_ukey;

ALTER TABLE dept
    DISABLE PRIMARY KEY KEEP INDEX,
    DISABLE UNIQUE (dname, loc) KEEP INDEX;
```

The following statements enable novalidate disabled integrity constraints:

```
ALTER TABLE dept
    ENABLE NOVALIDATE CONSTRAINT dname_ukey;

ALTER TABLE dept
    ENABLE NOVALIDATE PRIMARY KEY,
    ENABLE NOVALIDATE UNIQUE (dname, loc);
```

The following statements enable or validate disabled integrity constraints:

```
ALTER TABLE dept
    MODIFY CONSTRAINT dname_key VALIDATE;

ALTER TABLE dept
    MODIFY PRIMARY KEY ENABLE NOVALIDATE;
```

The following statements enable disabled integrity constraints:

```
ALTER TABLE dept
    ENABLE CONSTRAINT dname_ukey;

ALTER TABLE dept
    ENABLE PRIMARY KEY,
    ENABLE UNIQUE (dname, loc);
```

To disable or drop a `UNIQUE` key or `PRIMARY KEY` constraint and all dependent `FOREIGN KEY` constraints in a single step, use the `CASCADE` option of the `DISABLE` or `DROP` clauses. For example, the following statement disables a `PRIMARY KEY` constraint and any `FOREIGN KEY` constraints that depend on it:

```
ALTER TABLE dept
    DISABLE PRIMARY KEY CASCADE;
```

Renaming Constraints

The `ALTER TABLE...RENAME CONSTRAINT` statement enables you to rename any currently existing constraint for a table. The new constraint name must not conflict with any existing constraint names for a user.

The following statement renames the `dname_ukey` constraint for table `dept`:

```
ALTER TABLE dept
    RENAME CONSTRAINT dname_ukey TO dname_unikey;
```

When you rename a constraint, all dependencies on the base table remain valid.

The `RENAME CONSTRAINT` clause provides a means of renaming system generated constraint names.

Dropping Constraints

You can drop an integrity constraint if the rule that it enforces is no longer true, or if the constraint is no longer needed. You can drop the constraint using the `ALTER TABLE` statement with one of the following clauses:

- `DROP PRIMARY KEY`
- `DROP UNIQUE`
- `DROP CONSTRAINT`

The following two statements drop integrity constraints. The second statement keeps the index associated with the `PRIMARY KEY` constraint:

```
ALTER TABLE dept
    DROP UNIQUE (dname, loc);

ALTER TABLE emp
    DROP PRIMARY KEY KEEP INDEX,
    DROP CONSTRAINT dept_fkey;
```

If FOREIGN KEYs reference a UNIQUE or PRIMARY KEY, you must include the CASCADE CONSTRAINTS clause in the DROP statement, or you cannot drop the constraint.

Deferring Constraint Checks

When the database checks a constraint, it signals an error if the constraint is not satisfied. You can defer checking the validity of constraints until the end of a transaction.

When you issue the SET CONSTRAINTS statement, the SET CONSTRAINTS mode lasts for the duration of the transaction, or until another SET CONSTRAINTS statement resets the mode.

Notes:

- You cannot issue a SET CONSTRAINT statement inside a trigger.
- Deferrable unique and primary keys must use nonunique indexes.

Set All Constraints Deferred

Within the application being used to manipulate the data, you must set all constraints deferred before you actually begin processing any data. Use the following DML statement to set all deferrable constraints deferred:

```
SET CONSTRAINTS ALL DEFERRED;
```

Note: The SET CONSTRAINTS statement applies only to the current transaction. The defaults specified when you create a constraint remain as long as the constraint exists. The ALTER SESSION SET CONSTRAINTS statement applies for the current session only.

Check the Commit (Optional)

You can check for constraint violations before committing by issuing the SET CONSTRAINTS ALL IMMEDIATE statement just before issuing the COMMIT. If there are any problems with a constraint, this statement fails and the constraint causing the error is identified. If you commit while constraints are violated, the transaction is rolled back and you receive an error message.

Reporting Constraint Exceptions

If exceptions exist when a constraint is validated, an error is returned and the integrity constraint remains novalidated. When a statement is not successfully executed because integrity constraint exceptions exist, the statement is rolled back. If exceptions exist, you cannot validate the constraint until all exceptions to the constraint are either updated or deleted.

To determine which rows violate the integrity constraint, issue the ALTER TABLE statement with the EXCEPTIONS option in the ENABLE clause. The EXCEPTIONS option places the rowid, table owner, table name, and constraint name of all exception rows into a specified table.

You must create an appropriate exceptions report table to accept information from the `EXCEPTIONS` option of the `ENABLE` clause before enabling the constraint. You can create an exception table by executing the `UTLEXCPT.SQL` script or the `UTLEXPT1.SQL` script.

> **Note:** Your choice of script to execute for creating the `EXCEPTIONS` table is dependent upon the compatibility level of your database and the type of table you are analyzing. See the *Oracle Database SQL Language Reference* for more information.

Both of these scripts create a table named `EXCEPTIONS`. You can create additional exceptions tables with different names by modifying and resubmitting the script.

The following statement attempts to validate the `PRIMARY KEY` of the `dept` table, and if exceptions exist, information is inserted into a table named `EXCEPTIONS`:

```
ALTER TABLE dept ENABLE PRIMARY KEY EXCEPTIONS INTO EXCEPTIONS;
```

If duplicate primary key values exist in the `dept` table and the name of the `PRIMARY KEY` constraint on `dept` is `sys_c00610`, then the following query will display those exceptions:

```
SELECT * FROM EXCEPTIONS;
```

The following exceptions are shown:

```
fROWID               OWNER      TABLE_NAME      CONSTRAINT
------------------  ---------  --------------  -----------
AAAAZ9AABAAABvqAAB  SCOTT      DEPT            SYS_C00610
AAAAZ9AABAAABvqAAG  SCOTT      DEPT            SYS_C00610
```

A more informative query would be to join the rows in an exception report table and the master table to list the actual rows that violate a specific constraint, as shown in the following statement and results:

```
SELECT deptno, dname, loc FROM dept, EXCEPTIONS
    WHERE EXCEPTIONS.constraint = 'SYS_C00610'
    AND dept.rowid = EXCEPTIONS.row_id;

DEPTNO     DNAME            LOC
---------- --------------    -----------
10         ACCOUNTING        NEW YORK
10         RESEARCH          DALLAS
```

All rows that violate a constraint must be either updated or deleted from the table containing the constraint. When updating exceptions, you must change the value violating the constraint to a value consistent with the constraint or to a null. After the row in the master table is updated or deleted, the corresponding rows for the exception in the exception report table should be deleted to avoid confusion with later exception reports. The statements that update the master table and the exception report table should be in the same transaction to ensure transaction consistency.

To correct the exceptions in the previous examples, you might issue the following transaction:

```
UPDATE dept SET deptno = 20 WHERE dname = 'RESEARCH';
DELETE FROM EXCEPTIONS WHERE constraint = 'SYS_C00610';
COMMIT;
```

When managing exceptions, the goal is to eliminate all exceptions in your exception report table.

Note: While you are correcting current exceptions for a table with the constraint disabled, it is possible for other users to issue statements creating new exceptions. You can avoid this by marking the constraint `ENABLE NOVALIDATE` before you start eliminating exceptions.

See Also: *Oracle Database Reference* for a description of the `EXCEPTIONS` table

Viewing Constraint Information

Oracle Database provides the following views that enable you to see constraint definitions on tables and to identify columns that are specified in constraints:

View	Description

`DBA_CONSTRAINTS`
`ALL_CONSTRAINTS`
`USER_CONSTRAINTS`
	`DBA` view describes all constraint definitions in the database. `ALL` view describes constraint definitions accessible to current user. `USER` view describes constraint definitions owned by the current user.

`DBA_CONS_COLUMNS`
`ALL_CONS_COLUMNS`
`USER_CONS_COLUMNS`
	`DBA` view describes all columns in the database that are specified in constraints. `ALL` view describes only those columns accessible to current user that are specified in constraints. `USER` view describes only those columns owned by the current user that are specified in constraints.

See Also: *Oracle Database Reference* contains descriptions of the columns in these views

Renaming Schema Objects

To rename an object, it must be in your schema. You can rename schema objects in either of the following ways:

- Drop and re-create the object
- Rename the object using the `RENAME` statement

If you drop and re-create an object, all privileges granted for that object are lost. Privileges must be regranted when the object is re-created.

Alternatively, a table, view, sequence, or a private synonym of a table, view, or sequence can be renamed using the `RENAME` statement. When using the `RENAME` statement, integrity constraints, indexes, and grants made for the object are carried forward for the new name. For example, the following statement renames the `sales_staff` view:

```
RENAME sales_staff TO dept_30;
```

Note: You cannot use `RENAME` for a stored PL/SQL program unit, public synonym, index, or cluster. To rename such an object, you must drop and re-create it.

Before renaming a schema object, consider the following effects:

- All views and PL/SQL program units dependent on a renamed object become invalid, and must be recompiled before next use.
- All synonyms for a renamed object return an error when used.

See Also: *Oracle Database SQL Language Reference* for syntax of the `RENAME` statement

Managing Object Dependencies

This section provides background information about object dependencies and object invalidation, and explains how invalid objects can be revalidated. The following topics are included:

- About Object Dependencies and Object Invalidation
- Manually Recompiling Invalid Objects with DDL
- Manually Recompiling Invalid Objects with PL/SQL Package Procedures

About Object Dependencies and Object Invalidation

Some types of schema objects reference other objects. For example, a view contains a query that references tables or other views, and a PL/SQL subprogram might invoke other subprograms and might use static SQL to reference tables or views. An object that references another object is called a **dependent object**, and an object being referenced is a **referenced object**. These references are established at compile time, and if the compiler cannot resolve them, the dependent object being compiled is marked *invalid*.

Oracle Database provides an automatic mechanism to ensure that a dependent object is always up to date with respect to its referenced objects. When a dependent object is created, the database tracks dependencies between the dependent object and its referenced objects. When a referenced object is changed in a way that might affect a dependent object, the dependent object is marked invalid. An invalid dependent object must be recompiled against the new definition of a referenced object before the dependent object can be used. Recompilation occurs automatically when the invalid dependent object is referenced.

It is important to be aware of changes that can invalidate schema objects, because invalidation affects applications running on the database. This section describes how objects become invalid, how you can identify invalid objects, and how you can validate invalid objects.

Object Invalidation

In a typical running application, you would not expect to see views or stored procedures become invalid, because applications typically do not change table structures or change view or stored procedure definitions during normal execution. Changes to tables, views, or PL/SQL units typically occur when an application is patched or upgraded using a patch script or ad-hoc DDL statements. Dependent objects might be left invalid after a patch has been applied to change a set of referenced objects.

Use the following query to display the set of invalid objects in the database:

```
SELECT object_name, object_type FROM dba_objects
WHERE status = 'INVALID';
```

The Database Home page in Enterprise Manager displays an alert when schema objects become invalid.

Object invalidation affects applications in two ways. First, an invalid object must be revalidated before it can be used by an application. Revalidation adds latency to application execution. If the number of invalid objects is large, the added latency on the first execution can be significant. Second, invalidation of a procedure, function or package can cause exceptions in other sessions concurrently executing the procedure, function or package. If a patch is applied when the application is in use in a different session, the session executing the application notices that an object in use has been invalidated and raises one of the following 4 exceptions: ORA-4061, ORA-4064, ORA-4065 or ORA-4068. These exceptions must be remedied by restarting application sessions following a patch.

You can force the database to recompile a schema object using the appropriate SQL statement with the `COMPILE` clause. See "Manually Recompiling Invalid Objects with DDL" on page 16-18 for more information.

If you know that there are a large number of invalid objects, use the `UTL_RECOMP` PL/SQL package to perform a mass recompilation. See "Manually Recompiling Invalid Objects with PL/SQL Package Procedures" on page 16-18 for details.

The following are some general rules for the invalidation of schema objects:

- Between a referenced object and each of its dependent objects, the database tracks the elements of the referenced object that are involved in the dependency. For example, if a single-table view selects only a subset of columns in a table, only those columns are involved in the dependency. For each dependent of an object, if a change is made to the definition of any element involved in the dependency (including dropping the element), the dependent object is invalidated. Conversely, if changes are made only to definitions of elements that are not involved in the dependency, the dependent object remains valid.

  In many cases, therefore, developers can avoid invalidation of dependent objects and unnecessary extra work for the database if they exercise care when changing schema objects.
- Dependent objects are *cascade invalidated*. If any object becomes invalid for any reason, all of that object's dependent objects are immediately invalidated.
- If you revoke any object privileges on a schema object, dependent objects are cascade invalidated.

See Also: *Oracle Database Concepts* for more detailed information about schema object dependencies

Manually Recompiling Invalid Objects with DDL

You can use an `ALTER` statement to manually recompile a single schema object. For example, to recompile package body `Pkg1`, you would execute the following DDL statement:

```
ALTER PACKAGE pkg1 COMPILE REUSE SETTINGS;
```

See Also: *Oracle Database SQL Language Reference* for syntax and other information about the various `ALTER` statements

Manually Recompiling Invalid Objects with PL/SQL Package Procedures

Following an application upgrade or patch, it is good practice to revalidate invalid objects to avoid application latencies that result from on-demand object revalidation.

Oracle provides the `UTL_RECOMP` package to assist in object revalidation. The `RECOMP_SERIAL` procedure recompiles all invalid objects in a specified schema, or all invalid objects in the database if you do not supply the schema name argument. The `RECOMP_PARALLEL` procedure does the same, but in parallel, employing multiple CPUs.

Examples

Execute the following PL/SQL block to revalidate all invalid objects in the database, in parallel and in dependency order:

```
begin
   utl_recomp.recomp_parallel();
end;
```

You can also revalidate individual invalid objects using the package `DBMS_UTILITY`. The following PL/SQL block revalidates the procedure `UPDATE_SALARY` in schema `HR`:

```
begin
   dbms_utility.validate('HR', 'UPDATE_SALARY', namespace=>1);
end;
```

The following PL/SQL block revalidates the package body `HR.ACCT_MGMT`:

```
begin
   dbms_utility.validate('HR', 'ACCT_MGMT', namespace=>2);
end;
```

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for more information on the `UTL_RECOMP` and `DBMS_UTILITY` packages.

Managing Object Name Resolution

Object names referenced in SQL statements can consist of several pieces, separated by periods. The following describes how the database resolves an object name.

1. Oracle Database attempts to qualify the first piece of the name referenced in the SQL statement. For example, in `scott.emp`, `scott` is the first piece. If there is only one piece, the one piece is considered the first piece.

   a. In the current schema, the database searches for an object whose name matches the first piece of the object name. If it does not find such an object, it continues with step b.

   b. The database searches for a public synonym that matches the first piece of the name. If it does not find one, it continues with step c.

   c. The database searches for a schema whose name matches the first piece of the object name. If it finds one, it returns to step b, now using the second piece of the name as the object to find in the qualified schema. If the second piece does not correspond to an object in the previously qualified schema or there is not a second piece, the database returns an error.

   If no schema is found in step c, the object cannot be qualified and the database returns an error.

2. A schema object has been qualified. Any remaining pieces of the name must match a valid part of the found object. For example, if `scott.emp.deptno` is the name, `scott` is qualified as a schema, `emp` is qualified as a table, and `deptno` must correspond to a column (because `emp` is a table). If `emp` is qualified as a package,

deptno must correspond to a public constant, variable, procedure, or function of that package.

When global object names are used in a distributed database, either explicitly or indirectly within a synonym, the local database resolves the reference locally. For example, it resolves a synonym to global object name of a remote table. The partially resolved statement is shipped to the remote database, and the remote database completes the resolution of the object as described here.

Because of how the database resolves references, it is possible for an object to depend on the nonexistence of other objects. This situation occurs when the dependent object uses a reference that would be interpreted differently were another object present. For example, assume the following:

- At the current point in time, the company schema contains a table named emp.
- A PUBLIC synonym named emp is created for company.emp and the SELECT privilege for company.emp is granted to the PUBLIC role.
- The jward schema does not contain a table or private synonym named emp.
- The user jward creates a view in his schema with the following statement:

```
CREATE VIEW dept_salaries AS
     SELECT deptno, MIN(sal), AVG(sal), MAX(sal) FROM emp
     GROUP BY deptno
     ORDER BY deptno;
```

When jward creates the dept_salaries view, the reference to emp is resolved by first looking for jward.emp as a table, view, or private synonym, none of which is found, and then as a public synonym named emp, which is found. As a result, the database notes that jward.dept_salaries depends on the nonexistence of jward.emp and on the existence of public.emp.

Now assume that jward decides to create a new view named emp in his schema using the following statement:

```
CREATE VIEW emp AS
     SELECT empno, ename, mgr, deptno
     FROM company.emp;
```

Notice that jward.emp does not have the same structure as company.emp.

As it attempts to resolve references in object definitions, the database internally makes note of dependencies that the new dependent object has on "nonexistent" objects--schema objects that, if they existed, would change the interpretation of the object's definition. Such dependencies must be noted in case a nonexistent object is later created. If a nonexistent object is created, all dependent objects must be invalidated so that dependent objects can be recompiled and verified and all dependent function-based indexes must be marked unusable.

Therefore, in the previous example, as jward.emp is created, jward.dept_salaries is invalidated because it depends on jward.emp. Then when jward.dept_salaries is used, the database attempts to recompile the view. As the database resolves the reference to emp, it finds jward.emp (public.emp is no longer the referenced object). Because jward.emp does not have a sal column, the database finds errors when replacing the view, leaving it invalid.

In summary, you must manage dependencies on nonexistent objects checked during object resolution in case the nonexistent object is later created.

> **See Also:** "Schema Objects and Database Links" on page 29-14 for information about name resolution in a distributed database

Switching to a Different Schema

The following statement sets the schema of the current session to the schema name specified in the statement.

```
ALTER SESSION SET CURRENT_SCHEMA = <schema name>
```

In subsequent SQL statements, Oracle Database uses this schema name as the schema qualifier when the qualifier is omitted. In addition, the database uses the temporary tablespace of the specified schema for sorts, joins, and storage of temporary database objects. The session retains its original privileges and does not acquire any extra privileges by the preceding `ALTER SESSION` statement.

For example:

```
CONNECT scott/tiger
ALTER SESSION SET CURRENT_SCHEMA = joe;
SELECT * FROM emp;
```

Because `emp` is not schema-qualified, the table name is resolved under schema `joe`. But if `scott` does not have select privilege on table `joe.emp`, then `scott` cannot execute the `SELECT` statement.

Displaying Information About Schema Objects

Oracle Database provides a PL/SQL package that enables you to determine the DDL that created an object and data dictionary views that you can use to display information about schema objects. Packages and views that are unique to specific types of schema objects are described in the associated chapters. This section describes views and packages that are generic in nature and apply to multiple schema objects.

Using a PL/SQL Package to Display Information About Schema Objects

The Oracle-supplied PL/SQL package `DBMS_METADATA.GET_DDL` lets you obtain metadata (in the form of DDL used to create the object) about a schema object.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for a description of PL/SQL packages

Example: Using the DBMS_METADATA Package

The `DBMS_METADATA` package is a powerful tool for obtaining the complete definition of a schema object. It enables you to obtain all of the attributes of an object in one pass. The object is described as DDL that can be used to (re)create it.

In the following statements the `GET_DDL` function is used to fetch the DDL for all tables in the current schema, filtering out nested tables and overflow segments. The `SET_TRANSFORM_PARAM` (with the handle value equal to `DBMS_METADATA.SESSION_TRANSFORM` meaning "for the current session") is used to specify that storage clauses are not to be returned in the SQL DDL. Afterwards, the session-level transform parameters are reset to their defaults. Once set, transform parameter values remain in effect until specifically reset to their defaults.

```
EXECUTE DBMS_METADATA.SET_TRANSFORM_PARAM(
     DBMS_METADATA.SESSION_TRANSFORM,'STORAGE',false);
SELECT DBMS_METADATA.GET_DDL('TABLE',u.table_name)
```

```
     FROM USER_ALL_TABLES u
     WHERE u.nested='NO'
     AND (u.iot_type is null or u.iot_type='IOT');
EXECUTE DBMS_METADATA.SET_TRANSFORM_PARAM(
     DBMS_METADATA.SESSION_TRANSFORM,'DEFAULT');
```

The output from `DBMS_METADATA.GET_DDL` is a `LONG` datatype. When using SQL*Plus, your output may be truncated by default. Issue the following SQL*Plus command before issuing the `DBMS_METADATA.GET_DDL` statement to ensure that your output is not truncated:

```
SQL> SET LONG 9999
```

See Also: *Oracle XML Developer's Kit Programmer's Guide* for detailed information and further examples relating to the use of the `DBMS_METADATA` package

Schema Objects Data Dictionary Views

These views display general information about schema objects:

View	Description

`DBA_OBJECTS`
`ALL_OBJECTS`
`USER_OBJECTS`
	`DBA` view describes all schema objects in the database. `ALL` view describes objects accessible to current user. `USER` view describes objects owned by the current user.

`DBA_CATALOG`
`ALL_CATALOG`
`USER_CATALOG`
	List the name, type, and owner (`USER` view does not display owner) for all tables, views, synonyms, and sequences in the database.

`DBA_DEPENDENCIES`
`ALL_DEPENDENCIES`
`USER_DEPENDENCIES`
	List all dependencies between procedures, packages, functions, package bodies, and triggers, including dependencies on views without any database links.

See Also: *Oracle Database Reference* for a complete description of data dictionary views

The following are examples of using some of these views:

- Example 1: Displaying Schema Objects By Type
- Example 2: Displaying Dependencies of Views and Synonyms

Example 1: Displaying Schema Objects By Type

The following query lists all of the objects owned by the user issuing the query:

```
SELECT OBJECT_NAME, OBJECT_TYPE
    FROM USER_OBJECTS;
```

The following is the query output:

```
OBJECT_NAME                  OBJECT_TYPE
-------------------------    -------------------
EMP_DEPT                     CLUSTER
EMP                          TABLE
DEPT                         TABLE
EMP_DEPT_INDEX               INDEX
```

```
PUBLIC_EMP                 SYNONYM
EMP_MGR                    VIEW
```

Example 2: Displaying Dependencies of Views and Synonyms

When you create a view or a synonym, the view or synonym is based on its underlying base object. The `ALL_DEPENDENCIES`, `USER_DEPENDENCIES`, and `DBA_DEPENDENCIES` data dictionary views can be used to reveal the dependencies for a view. The `ALL_SYNONYMS`, `USER_SYNONYMS`, and `DBA_SYNONYMS` data dictionary views can be used to list the base object of a synonym. For example, the following query lists the base objects for the synonyms created by user `jward`:

```
SELECT TABLE_OWNER, TABLE_NAME, SYNONYM_NAME
    FROM DBA_SYNONYMS
    WHERE OWNER = 'JWARD';
```

The following is the query output:

```
TABLE_OWNER             TABLE_NAME   SYNONYM_NAME
----------------------  -----------  -----------------
SCOTT                   DEPT         DEPT
SCOTT                   EMP          EMP
```

17 Managing Space for Schema Objects

This chapter offers guidelines for managing space for schema objects. You should familiarize yourself with the concepts in this chapter before attempting to manage specific schema objects as described in later chapters.

This chapter contains the following topics:

Managing Tablespace Alerts

Oracle Database provides proactive help in managing disk space for tablespaces by alerting you when available space is running low. Two alert thresholds are defined by default: **warning** and **critical**. The warning threshold is the limit at which space is beginning to run low. The critical threshold is a serious limit that warrants your immediate attention. The database issues alerts at both thresholds.

There are two ways to specify alert thresholds for both locally managed and dictionary managed tablespaces:

- By percent full

  For both warning and critical thresholds, when space used becomes greater than or equal to a percent of total space, an alert is issued.

- By free space remaining (in kilobytes (KB))

  For both warning and critical thresholds, when remaining space falls below an amount in KB, an alert is issued. Free-space-remaining thresholds are more useful for very large tablespaces.

Alerts for locally managed tablespaces are server-generated. For dictionary managed tablespaces, Enterprise Manager provides this functionality. See "Monitoring with Server-Generated Alerts" on page 7-4 for more information.

New tablespaces are assigned alert thresholds as follows:

- **Locally managed tablespace—**When you create a new locally managed tablespace, it is assigned the default threshold values defined for the database. A newly created database has a default of 85% full for the warning threshold and 97% full for the critical threshold. Defaults for free space remaining thresholds for a new database are both zero (disabled). You can change these database defaults, as described later in this section.
- **Dictionary managed tablespace—**When you create a new dictionary managed tablespace, it is assigned the threshold values that Enterprise Manager lists for "All others" in the metrics categories "Tablespace Free Space (MB) (dictionary managed)" and "Tablespace Space Used (%) (dictionary managed)." You change these values on the Metric and Policy Settings page.

Note: In a database that is upgraded from version 9.x or earlier to 10.x, database defaults for all locally managed tablespace alert thresholds are set to zero. This setting effectively disables the alert mechanism to avoid excessive alerts in a newly migrated database.

Setting Alert Thresholds

For each tablespace, you can set just percent-full thresholds, just free-space-remaining thresholds, or both types of thresholds simultaneously. Setting either type of threshold to zero disables it.

The ideal setting for the warning threshold is one that issues an alert early enough for you to resolve the problem before it becomes critical. The critical threshold should be one that issues an alert still early enough so that you can take immediate action to avoid loss of service.

To set alert threshold values:

- For locally managed tablespaces, use Enterprise Manager (see *Oracle Database 2 Day DBA* for instructions) or the `DBMS_SERVER_ALERT.SET_THRESHOLD` package procedure (see *Oracle Database PL/SQL Packages and Types Reference* for usage details).
- For dictionary managed tablespaces, use Enterprise Manager. See *Oracle Database 2 Day DBA* for instructions.

Example—Locally Managed Tablespace

The following example sets the free-space-remaining thresholds in the `USERS` tablespace to 10 MB (warning) and 2 MB (critical), and disables the percent-full thresholds.

```
BEGIN
DBMS_SERVER_ALERT.SET_THRESHOLD(
   metrics_id              => DBMS_SERVER_ALERT.TABLESPACE_BYT_FREE,
   warning_operator        => DBMS_SERVER_ALERT.OPERATOR_LE,
   warning_value           => '10240',
   critical_operator       => DBMS_SERVER_ALERT.OPERATOR_LE,
   critical_value          => '2048',
   observation_period      => 1,
   consecutive_occurrences => 1,
   instance_name           => NULL,
   object_type             => DBMS_SERVER_ALERT.OBJECT_TYPE_TABLESPACE,
   object_name             => 'USERS');

DBMS_SERVER_ALERT.SET_THRESHOLD(
   metrics_id              => DBMS_SERVER_ALERT.TABLESPACE_PCT_FULL,
   warning_operator        => DBMS_SERVER_ALERT.OPERATOR_GT,
   warning_value           => '0',
   critical_operator       => DBMS_SERVER_ALERT.OPERATOR_GT,
   critical_value          => '0',
   observation_period      => 1,
   consecutive_occurrences => 1,
   instance_name           => NULL,
   object_type             => DBMS_SERVER_ALERT.OBJECT_TYPE_TABLESPACE,
   object_name             => 'USERS');
END;
/
```

Note: When setting non-zero values for percent-full thresholds, use the greater-than-or-equal-to operator, `OPERATOR_GE`.

Restoring a Tablespace to Database Default Thresholds

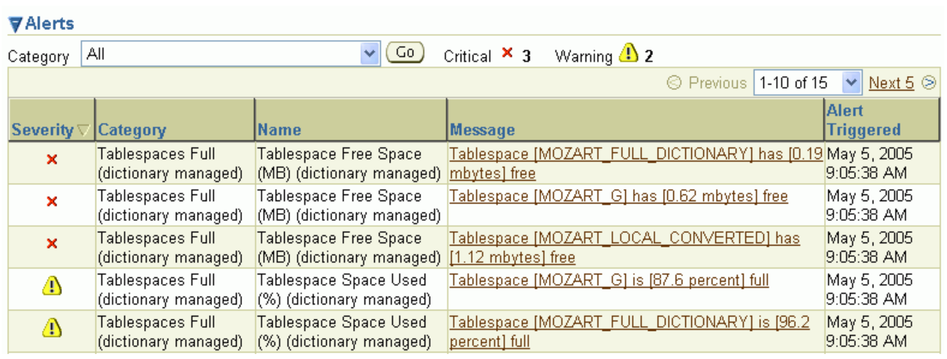
After explicitly setting values for locally managed tablespace alert thresholds, you can cause the values to revert to the database defaults by setting them to `NULL` with `DBMS_SERVER_ALERT.SET_THRESHOLD`.

Modifying Database Default Thresholds

To modify database default thresholds for locally managed tablespaces, invoke `DBMS_SERVER_ALERT.SET_THRESHOLD` as shown in the previous example, but set `object_name` to `NULL`. All tablespaces that use the database default are then switched to the new default.

Viewing Alerts

You view alerts by accessing the home page of Enterprise Manager Database Control.



Severity	Category	Name	Message	Alert Triggered
✗	Tablespaces Full (dictionary managed)	Tablespace Free Space (MB) (dictionary managed)	Tablespace [MOZART_FULL_DICTIONARY] has [0.19 mbytes] free	May 5, 2005 9:05:38 AM
✗	Tablespaces Full (dictionary managed)	Tablespace Free Space (MB) (dictionary managed)	Tablespace [MOZART_G] has [0.62 mbytes] free	May 5, 2005 9:05:38 AM
✗	Tablespaces Full (dictionary managed)	Tablespace Free Space (MB) (dictionary managed)	Tablespace [MOZART_LOCAL_CONVERTED] has [1.12 mbytes] free	May 5, 2005 9:05:38 AM
⚠	Tablespaces Full (dictionary managed)	Tablespace Space Used (%) (dictionary managed)	Tablespace [MOZART_G] is [87.6 percent] full	May 5, 2005 9:05:38 AM
⚠	Tablespaces Full (dictionary managed)	Tablespace Space Used (%) (dictionary managed)	Tablespace [MOZART_FULL_DICTIONARY] is [96.2 percent] full	May 5, 2005 9:05:38 AM

You can also view alerts for locally managed tablespaces with the `DBA_OUTSTANDING_ALERTS` view. See "Server-Generated Alerts Data Dictionary Views" on page 7-6 for more information.

Limitations

Threshold-based alerts have the following limitations:

- Alerts are not issued for locally managed tablespaces that are offline or in read-only mode. However, the database reactivates the alert system for such tablespaces after they become read/write or available.

- When you take a tablespace offline or put it in read-only mode, you should disable the alerts for the tablespace by setting the thresholds to zero. You can then reenable the alerts by resetting the thresholds when the tablespace is once again online and in read/write mode.

See Also:

- "Monitoring with Server-Generated Alerts" on page 7-4 for additional information on server-generated alerts in general
- *Oracle Database PL/SQL Packages and Types Reference* for information on the procedures of the `DBMS_SERVER_ALERT` package and how to use them
- *Oracle Database Performance Tuning Guide* for information on using the Automatic Workload Repository to gather statistics on space usage
- "Reclaiming Wasted Space" on page 17-15 for various ways to reclaim space that is no longer being used in the tablespace
- "Purging Objects in the Recycle Bin" on page 18-45 for information on reclaiming recycle bin space

Managing Space in Data Blocks

The following topics are contained in this section:

- Specifying the INITRANS Parameter

See Also:

- *Oracle Database Concepts* for more information on data blocks
- *Oracle Database SQL Language Reference* for syntax and other details of the `INITRANS` physical attributes parameters

Specifying the INITRANS Parameter

`INITRANS` specifies the number of update transaction entries for which space is initially reserved in the data block header. Space is reserved in the headers of all data blocks in the associated segment.

As multiple transactions concurrently access the rows of the same data block, space is allocated for each update transaction entry in the block. Once the space reserved by `INITRANS` is depleted, space for additional transaction entries is allocated out of the free space in a block, if available. Once allocated, this space effectively becomes a permanent part of the block header.

Note: In earlier releases of Oracle Database, the `MAXTRANS` parameter limited the number of transaction entries that could concurrently use data in a data block. This parameter has been deprecated. Oracle Database now automatically allows up to 255 concurrent update transactions for any data block, depending on the available space in the block.

The database ignores `MAXTRANS` when specified by users only for new objects created when the `COMPATIBLE` initialization parameter is set to 10.0.0 or greater.

You should consider the following when setting the INITRANS parameter for a schema object:

- The space you would like to reserve for transaction entries compared to the space you would reserve for database data
- The number of concurrent transactions that are likely to touch the same data blocks at any given time

For example, if a table is very large and only a small number of users simultaneously access the table, the chances of multiple concurrent transactions requiring access to the same data block is low. Therefore, INITRANS can be set low, especially if space is at a premium in the database.

Alternatively, assume that a table is usually accessed by many users at the same time. In this case, you might consider preallocating transaction entry space by using a high INITRANS. This eliminates the overhead of having to allocate transaction entry space, as required when the object is in use.

In general, Oracle recommends that you not change the value of INITRANS from its default.

Managing Storage Parameters

This section describes the storage parameters that you can specify for schema object segments to tell the database how to store the object in the database. Schema objects include tables, indexes, partitions, clusters, materialized views, and materialized view logs

The following topics are contained in this section:

- Identifying the Storage Parameters
- Specifying Storage Parameters at Object Creation
- Setting Storage Parameters for Clusters
- Setting Storage Parameters for Partitioned Tables
- Setting Storage Parameters for Index Segments
- Setting Storage Parameters for LOBs, Varrays, and Nested Tables
- Changing Values of Storage Parameters
- Understanding Precedence in Storage Parameters

Identifying the Storage Parameters

Storage parameters determine space allocation for objects when their segments are created in a tablespace. Not all storage parameters can be specified for every type of database object, and not all storage parameters can be specified in both the CREATE and ALTER statements. Storage parameters for objects in locally managed tablespaces are supported mainly for backward compatibility.

The Oracle Database server manages extents for locally managed tablespaces. If you specified the UNIFORM clause when the tablespace was created, then the database creates all extents of a uniform size that you specified (or a default size) for any objects created in the tablespace. If you specified the AUTOALLOCATE clause, then the database determines the extent sizing policy for the tablespace. So, for example, if you specific the INITIAL clause when you create an object in a locally managed tablespace you are telling the database to preallocate at least that much space. The database then determines the appropriate number of extents needed to allocate that much space.

Table 17–1 contains a brief description of each storage parameter. For a complete description of these parameters, including their default, minimum, and maximum settings, see the *Oracle Database SQL Language Reference*.

Table 17–1 Object Storage Parameters

Parameter	Description
`INITIAL`	In a tablespace that is specified as `EXTENT MANAGEMENT LOCAL`, the database uses the value of `INITIAL` with the extent size for the tablespace to determine the initial amount of space to reserve for the object. For example, in a uniform locally managed tablespace with 5M extents, if you specify an `INITIAL` value of 1M, then the database must allocate one 5M extent. If the extent size of the tablespace is smaller than the value of `INITIAL`, then the initial amount of space allocated will in fact be more than one extent.
`MINEXTENTS`	In a tablespace that is specified as `EXTENT MANAGEMENT LOCAL`, `MINEXTENTS` is used to compute the initial amount of space that is allocated. The initial amount of space that is allocated is equal to `INITIAL` * `MINEXTENTS`. Thereafter it is set to 1 (as seen in the `DBA_SEGMENTS` view).
`BUFFER POOL`	Defines a default buffer pool (cache) for a schema object. For information on the use of this parameter, see *Oracle Database Performance Tuning Guide*.

Specifying Storage Parameters at Object Creation

At object creation, you can specify storage parameters for each individual schema object. These parameter settings override any default storage settings. Use the `STORAGE` clause of the `CREATE` or `ALTER` statement for specifying storage parameters for the individual object.

Setting Storage Parameters for Clusters

Use the `STORAGE` clause of the `CREATE TABLE` or `ALTER TABLE` statement to set the storage parameters for non-clustered tables.

In contrast, set the storage parameters for the data segments of a cluster using the `STORAGE` clause of the `CREATE CLUSTER` or `ALTER CLUSTER` statement, rather than the individual `CREATE` or `ALTER` statements that put tables into the cluster. Storage parameters specified when creating or altering a clustered table are ignored. The storage parameters set for the cluster override the table storage parameters.

Setting Storage Parameters for Partitioned Tables

With partitioned tables, you can set default storage parameters at the table level. When creating a new partition of the table, the default storage parameters are inherited from the table level (unless you specify them for the individual partition). If no storage parameters are specified at the table level, then they are inherited from the tablespace.

Setting Storage Parameters for Index Segments

Storage parameters for an index segment created for a table index can be set using the `STORAGE` clause of the `CREATE INDEX` or `ALTER INDEX` statement.

Storage parameters of an index segment created for the index used to enforce a primary key or unique key constraint can be set in either of the following ways:

- In the `ENABLE` ... `USING INDEX` clause of the `CREATE TABLE` or `ALTER TABLE` statement
- In the `STORAGE` clause of the `ALTER INDEX` statement

Setting Storage Parameters for LOBs, Varrays, and Nested Tables

A table or materialized view can contain `LOB`, varray, or nested table column types. These entities can be stored in their own segments. `LOB`s and varrays are stored in `LOB` segments, while a nested table is stored in a storage table. You can specify a `STORAGE` clause for these segments that will override storage parameters specified at the table level.

See Also:

- *Oracle Database SecureFiles and Large Objects Developer's Guide* for more information about LOBs
- *Oracle Database Object-Relational Developer's Guide* for more information about varrays and nested tables

Changing Values of Storage Parameters

You can alter default storage parameters for tablespaces and specific storage parameters for individual objects if you so choose. Default storage parameters can be reset for a tablespace; however, changes affect only new objects created in the tablespace or new extents allocated for a segment. As discussed previously, you cannot specify default storage parameters for locally managed tablespaces, so this discussion does not apply.

The `INITIAL` and `MINEXTENTS` storage parameters cannot be altered for an existing table, cluster, index. If only `NEXT` is altered for a segment, the next incremental extent is the size of the new `NEXT`, and subsequent extents can grow by `PCTINCREASE` as usual.

If both `NEXT` and `PCTINCREASE` are altered for a segment, the next extent is the new value of `NEXT`, and from that point forward, `NEXT` is calculated using `PCTINCREASE` as usual.

Understanding Precedence in Storage Parameters

Starting with default values, the storage parameters in effect for a database object at a given time are determined by the following, listed in order of precedence (where higher numbers take precedence over lower numbers):

1. Oracle Database default values
2. `DEFAULT STORAGE` clause of `CREATE TABLESPACE` statement
3. `DEFAULT STORAGE` clause of `ALTER TABLESPACE` statement
4. `STORAGE` clause of `CREATE [TABLE | CLUSTER | MATERIALIZED VIEW | MATERIALIZED VIEW LOG | INDEX]` statement
5. `STORAGE` clause of `ALTER [TABLE | CLUSTER | MATERIALIZED VIEW | MATERIALIZED VIEW LOG | INDEX]` statement

Any storage parameter specified at the object level overrides the corresponding option set at the tablespace level. When storage parameters are not explicitly set at the object level, they default to those at the tablespace level. When storage parameters are not set at the tablespace level, Oracle Database system defaults apply. If storage parameters are altered, the new options apply only to the extents not yet allocated.

Note: The storage parameters for temporary segments always use the default storage parameters set for the associated tablespace.

Managing Resumable Space Allocation

Oracle Database provides a means for suspending, and later resuming, the execution of large database operations in the event of space allocation failures. This enables you to take corrective action instead of the Oracle Database server returning an error to the user. After the error condition is corrected, the suspended operation automatically resumes. This feature is called **resumable space allocation**. The statements that are affected are called resumable statements.

This section contains the following topics:

- Resumable Space Allocation Overview
- Enabling and Disabling Resumable Space Allocation
- Detecting Suspended Statements
- Operation-Suspended Alert
- Resumable Space Allocation Example: Registering an AFTER SUSPEND Trigger

Resumable Space Allocation Overview

This section provides an overview of resumable space allocation. It describes how resumable space allocation works, and specifically defines qualifying statements and error conditions.

How Resumable Space Allocation Works

The following is an overview of how resumable space allocation works. Details are contained in later sections.

1. A statement executes in a resumable mode only if its session has been enabled for resumable space allocation by one of the following actions:
   - The `RESUMABLE_TIMEOUT` initialization parameter is set to a nonzero value.
   - The `ALTER SESSION ENABLE RESUMABLE` statement is issued.
2. A resumable statement is suspended when one of the following conditions occur (these conditions result in corresponding errors being signalled for non-resumable statements):
   - Out of space condition
   - Maximum extents reached condition
   - Space quota exceeded condition.
3. When the execution of a resumable statement is suspended, there are mechanisms to perform user supplied operations, log errors, and to query the status of the statement execution. When a resumable statement is suspended the following actions are taken:
   - The error is reported in the alert log.

- The system issues the Resumable Session Suspended alert.
- If the user registered a trigger on the `AFTER SUSPEND` system event, the user trigger is executed. A user supplied PL/SQL procedure can access the error message data using the `DBMS_RESUMABLE` package and the `DBA_` or `USER_RESUMABLE` view.

4. Suspending a statement automatically results in suspending the transaction. Thus all transactional resources are held through a statement suspend and resume.
5. When the error condition is resolved (for example, as a result of user intervention or perhaps sort space released by other queries), the suspended statement automatically resumes execution and the Resumable Session Suspended alert is cleared.
6. A suspended statement can be forced to throw the exception using the `DBMS_RESUMABLE.ABORT()` procedure. This procedure can be called by a DBA, or by the user who issued the statement.
7. A suspension time out interval is associated with resumable statements. A resumable statement that is suspended for the timeout interval (the default is two hours) wakes up and returns the exception to the user.
8. A resumable statement can be suspended and resumed multiple times during execution.

What Operations are Resumable?

The following operations are resumable:

- Queries

  `SELECT` statements that run out of temporary space (for sort areas) are candidates for resumable execution. When using OCI, the calls `OCIStmtExecute()` and `OCIStmtFetch()` are candidates.

- DML

  `INSERT`, `UPDATE`, and `DELETE` statements are candidates. The interface used to execute them does not matter; it can be OCI, SQLJ, PL/SQL, or another interface. Also, `INSERT INTO...SELECT` from external tables can be resumable.

- Import/Export

  As for SQL*Loader, a command line parameter controls whether statements are resumable after recoverable errors.

- DDL

  The following statements are candidates for resumable execution:

  – `CREATE TABLE ... AS SELECT`

  – `CREATE INDEX`

  – `ALTER INDEX ... REBUILD`

  – `ALTER TABLE ... MOVE PARTITION`

  – `ALTER TABLE ... SPLIT PARTITION`

  – `ALTER INDEX ... REBUILD PARTITION`

  – `ALTER INDEX ... SPLIT PARTITION`

  – `CREATE MATERIALIZED VIEW`

– `CREATE MATERIALIZED VIEW LOG`

What Errors are Correctable?

There are three classes of correctable errors:

- Out of space condition

  The operation cannot acquire any more extents for a table/index/temporary segment/undo segment/cluster/LOB/table partition/index partition in a tablespace. For example, the following errors fall in this category:

  ```
  ORA-1653 unable to extend table ... in tablespace ...
  ORA-1654 unable to extend index ... in tablespace ...
  ```

- Maximum extents reached condition

  The number of extents in a table/index/temporary segment/undo segment/cluster/LOB/table partition/index partition equals the maximum extents defined on the object. For example, the following errors fall in this category:

  ```
  ORA-1631 max # extents ... reached in table ...
  ORA-1654 max # extents ... reached in index ...
  ```

- Space quota exceeded condition

  The user has exceeded his assigned space quota in the tablespace. Specifically, this is noted by the following error:

  ```
  ORA-1536 space quote exceeded for tablespace string
  ```

Resumable Space Allocation and Distributed Operations

In a distributed environment, if a user enables or disables resumable space allocation, or if you, as a DBA, alter the `RESUMABLE_TIMEOUT` initialization parameter, only the local instance is affected. In a distributed transaction, sessions or remote instances are suspended only if `RESUMABLE` has been enabled in the remote instance.

Parallel Execution and Resumable Space Allocation

In parallel execution, if one of the parallel execution server processes encounters a correctable error, that server process suspends its execution. Other parallel execution server processes will continue executing their respective tasks, until either they encounter an error or are blocked (directly or indirectly) by the suspended server process. When the correctable error is resolved, the suspended process resumes execution and the parallel operation continues execution. If the suspended operation is terminated, the parallel operation aborts, throwing the error to the user.

Different parallel execution server processes may encounter one or more correctable errors. This may result in firing an `AFTER SUSPEND` trigger multiple times, in parallel. Also, if a parallel execution server process encounters a non-correctable error while another parallel execution server process is suspended, the suspended statement is immediately aborted.

For parallel execution, every parallel execution coordinator and server process has its own entry in the `DBA_` or `USER_RESUMABLE` view.

Enabling and Disabling Resumable Space Allocation

Resumable space allocation is only possible when statements are executed within a session that has resumable mode enabled. There are two means of enabling and disabling resumable space allocation. You can control it at the system level with the RESUMABLE_TIMEOUT initialization parameter, or users can enable it at the session level using clauses of the ALTER SESSION statement.

Note: Because suspended statements can hold up some system resources, users must be granted the RESUMABLE system privilege before they are allowed to enable resumable space allocation and execute resumable statements.

Setting the RESUMABLE_TIMEOUT Initialization Parameter

You can enable resumable space allocation system wide and specify a timeout interval by setting the RESUMABLE_TIMEOUT initialization parameter. For example, the following setting of the RESUMABLE_TIMEOUT parameter in the initialization parameter file causes all sessions to initially be enabled for resumable space allocation and sets the timeout period to 1 hour:

```
RESUMABLE_TIMEOUT  = 3600
```

If this parameter is set to 0, then resumable space allocation is disabled initially for all sessions. This is the default.

You can use the ALTER SYSTEM SET statement to change the value of this parameter at the system level. For example, the following statement will disable resumable space allocation for all sessions:

```
ALTER SYSTEM SET RESUMABLE_TIMEOUT=0;
```

Within a session, a user can issue the ALTER SESSION SET statement to set the RESUMABLE_TIMEOUT initialization parameter and enable resumable space allocation, change a timeout value, or to disable resumable mode.

Using ALTER SESSION to Enable and Disable Resumable Space Allocation

A user can enable resumable mode for a session, using the following SQL statement:

```
ALTER SESSION ENABLE RESUMABLE;
```

To disable resumable mode, a user issues the following statement:

```
ALTER SESSION DISABLE RESUMABLE;
```

The default for a new session is resumable mode disabled, unless the RESUMABLE_TIMEOUT initialization parameter is set to a nonzero value.

The user can also specify a timeout interval, and can provide a name used to identify a resumable statement. These are discussed separately in following sections.

See Also: "Using a LOGON Trigger to Set Default Resumable Mode" on page 17-12

Specifying a Timeout Interval A timeout period, after which a suspended statement will error if no intervention has taken place, can be specified when resumable mode is enabled. The following statement specifies that resumable transactions will time out and error after 3600 seconds:

```
ALTER SESSION ENABLE RESUMABLE TIMEOUT 3600;
```

The value of TIMEOUT remains in effect until it is changed by another ALTER SESSION ENABLE RESUMABLE statement, it is changed by another means, or the session ends. The default timeout interval when using the ENABLE RESUMABLE TIMEOUT clause to enable resumable mode is 7200 seconds.

> **See Also:** "Setting the RESUMABLE_TIMEOUT Initialization Parameter" on page 17-11 for other methods of changing the timeout interval for resumable space allocation

Naming Resumable Statements Resumable statements can be identified by name. The following statement assigns a name to resumable statements:

```
ALTER SESSION ENABLE RESUMABLE TIMEOUT 3600 NAME 'insert into table';
```

The NAME value remains in effect until it is changed by another ALTER SESSION ENABLE RESUMABLE statement, or the session ends. The default value for NAME is 'User *username*(*userid*), Session *sessionid*, Instance *instanceid*'.

The name of the statement is used to identify the resumable statement in the DBA_RESUMABLE and USER_RESUMABLE views.

Using a LOGON Trigger to Set Default Resumable Mode

Another method of setting default resumable mode, other than setting the RESUMABLE_TIMEOUT initialization parameter, is that you can register a database level LOGON trigger to alter a user's session to enable resumable and set a timeout interval.

> **Note:** If there are multiple triggers registered that change default mode and timeout for resumable statements, the result will be unspecified because Oracle Database does not guarantee the order of trigger invocation.

Detecting Suspended Statements

When a resumable statement is suspended, the error is not raised to the client. In order for corrective action to be taken, Oracle Database provides alternative methods for notifying users of the error and for providing information about the circumstances.

Notifying Users: The AFTER SUSPEND System Event and Trigger

When a resumable statement encounter a correctable error, the system internally generates the AFTER SUSPEND system event. Users can register triggers for this event at both the database and schema level. If a user registers a trigger to handle this system event, the trigger is executed after a SQL statement has been suspended.

SQL statements executed within a AFTER SUSPEND trigger are always non-resumable and are always autonomous. Transactions started within the trigger use the SYSTEM rollback segment. These conditions are imposed to overcome deadlocks and reduce the chance of the trigger experiencing the same error condition as the statement.

Users can use the USER_RESUMABLE or DBA_RESUMABLE views, or the DBMS_RESUMABLE.SPACE_ERROR_INFO function, within triggers to get information about the resumable statements.

Triggers can also call the DBMS_RESUMABLE package to terminate suspended statements and modify resumable timeout values. In the following example, the default system timeout is changed by creating a system wide AFTER SUSPEND trigger that calls DBMS_RESUMABLE to set the timeout to 3 hours:

```
CREATE OR REPLACE TRIGGER resumable_default_timeout
AFTER SUSPEND
ON DATABASE
BEGIN
   DBMS_RESUMABLE.SET_TIMEOUT(10800);
END;
```

See Also: *Oracle Database PL/SQL Language Reference* for information about triggers and system events

Using Views to Obtain Information About Suspended Statements

The following views can be queried to obtain information about the status of resumable statements:

View	Description
DBA_RESUMABLE USER_RESUMABLE	These views contain rows for all currently executing or suspended resumable statements. They can be used by a DBA, AFTER SUSPEND trigger, or another session to monitor the progress of, or obtain specific information about, resumable statements.
V$SESSION_WAIT	When a statement is suspended the session invoking the statement is put into a wait state. A row is inserted into this view for the session with the EVENT column containing "statement suspended, wait error to be cleared".

See Also: *Oracle Database Reference* for specific information about the columns contained in these views

Using the DBMS_RESUMABLE Package

The DBMS_RESUMABLE package helps control resumable space allocation. The following procedures can be invoked:

Procedure	Description
ABORT(sessionID)	This procedure aborts a suspended resumable statement. The parameter sessionID is the session ID in which the statement is executing. For parallel DML/DDL, sessionID is any session ID which participates in the parallel DML/DDL. Oracle Database guarantees that the ABORT operation always succeeds. It may be called either inside or outside of the AFTER SUSPEND trigger. The caller of ABORT must be the owner of the session with sessionID, have ALTER SYSTEM privilege, or have DBA privileges.
GET_SESSION_TIMEOUT(sessionID)	This function returns the current timeout value of resumable space allocation for the session with sessionID. This returned timeout is in seconds. If the session does not exist, this function returns -1.
SET_SESSION_TIMEOUT(sessionID, timeout)	This procedure sets the timeout interval of resumable space allocation for the session with sessionID. The parameter timeout is in seconds. The new timeout setting will applies to the session immediately. If the session does not exist, no action is taken.
GET_TIMEOUT()	This function returns the current timeout value of resumable space allocation for the current session. The returned value is in seconds.

Procedure	Description
`SET_TIMEOUT(timeout)`	This procedure sets a `timeout` value for resumable space allocation for the current session. The parameter `timeout` is in seconds. The new timeout setting applies to the session immediately.

See Also: *Oracle Database PL/SQL Packages and Types Reference*

Operation-Suspended Alert

When a resumable session is suspended, an operation-suspended alert is issued on the object that needs allocation of resource for the operation to complete. Once the resource is allocated and the operation completes, the operation-suspended alert is cleared. Please refer to "Managing Tablespace Alerts" on page 17-1 for more information on system-generated alerts.

Resumable Space Allocation Example: Registering an AFTER SUSPEND Trigger

In the following example, a system wide `AFTER SUSPEND` trigger is created and registered as user `SYS` at the database level. Whenever a resumable statement is suspended in any session, this trigger can have either of two effects:

- If an undo segment has reached its space limit, then a message is sent to the DBA and the statement is aborted.
- If any other recoverable error has occurred, the timeout interval is reset to 8 hours.

Here are the statements for this example:

```
CREATE OR REPLACE TRIGGER resumable_default
AFTER SUSPEND
ON DATABASE
DECLARE
   /* declare transaction in this trigger is autonomous */
   /* this is not required because transactions within a trigger
      are always autonomous */
   PRAGMA AUTONOMOUS_TRANSACTION;
   cur_sid           NUMBER;
   cur_inst          NUMBER;
   errno             NUMBER;
   err_type          VARCHAR2;
   object_owner      VARCHAR2;
   object_type       VARCHAR2;
   table_space_name  VARCHAR2;
   object_name       VARCHAR2;
   sub_object_name   VARCHAR2;
   error_txt         VARCHAR2;
   msg_body          VARCHAR2;
   ret_value         BOOLEAN;
   mail_conn         UTL_SMTP.CONNECTION;
BEGIN
   -- Get session ID
   SELECT DISTINCT(SID) INTO cur_SID FROM V$MYSTAT;

   -- Get instance number
   cur_inst := userenv('instance');

   -- Get space error information
   ret_value :=
   DBMS_RESUMABLE.SPACE_ERROR_INFO(err_type,object_type,object_owner,
        table_space_name,object_name, sub_object_name);
   /*
   -- If the error is related to undo segments, log error, send email
   -- to DBA, and abort the statement. Otherwise, set timeout to 8 hours.
   --
   -- sys.rbs_error is a table which is to be
   -- created by a DBA manually and defined as
   -- (sql_text VARCHAR2(1000), error_msg VARCHAR2(4000),
   -- suspend_time DATE)
   */

   IF OBJECT_TYPE = 'UNDO SEGMENT' THEN
       /* LOG ERROR */
       INSERT INTO sys.rbs_error (
           SELECT SQL_TEXT, ERROR_MSG, SUSPEND_TIME
           FROM DBMS_RESUMABLE
           WHERE SESSION_ID = cur_sid AND INSTANCE_ID = cur_inst
        );
       SELECT ERROR_MSG INTO error_txt FROM DBMS_RESUMABLE
           WHERE SESSION_ID = cur_sid and INSTANCE_ID = cur_inst;

        -- Send email to receipient via UTL_SMTP package
        msg_body:='Subject: Space Error Occurred

                   Space limit reached for undo segment ' || object_name ||
                   on ' || TO_CHAR(SYSDATE, 'Month dd, YYYY, HH:MIam') ||
                   '. Error message was ' || error_txt;

        mail_conn := UTL_SMTP.OPEN_CONNECTION('localhost', 25);
        UTL_SMTP.HELO(mail_conn, 'localhost');
        UTL_SMTP.MAIL(mail_conn, 'sender@localhost');
        UTL_SMTP.RCPT(mail_conn, 'recipient@localhost');
        UTL_SMTP.DATA(mail_conn, msg_body);
        UTL_SMTP.QUIT(mail_conn);

        -- Abort the statement
        DBMS_RESUMABLE.ABORT(cur_sid);
    ELSE
        -- Set timeout to 8 hours
        DBMS_RESUMABLE.SET_TIMEOUT(28800);
    END IF;

    /* commit autonomous transaction */
    COMMIT;
END;
/
```

Reclaiming Wasted Space

This section explains how to reclaim wasted space, and also introduces the Segment Advisor, which is the Oracle Database component that identifies segments that have space available for reclamation. The following topics are covered:

- Understanding Reclaimable Unused Space
- Using the Segment Advisor
- Shrinking Database Segments Online
- Deallocating Unused Space

Understanding Reclaimable Unused Space

Over time, updates and deletes on objects within a tablespace can create pockets of empty space that individually are not large enough to be reused for new data. This type of empty space is referred to as fragmented free space.

Objects with fragmented free space can result in much wasted space, and can impact database performance. The preferred way to defragment and reclaim this space is to perform an **online segment shrink**. This process consolidates fragmented free space below the high water mark and compacts the segment. After compaction, the high water mark is moved, resulting in new free space above the high water mark. That space above the high water mark is then deallocated. The segment remains available for queries and DML during most of the operation, and no extra disk space need be allocated.

You use the **Segment Advisor** to identify segments that would benefit from online segment shrink. Only segments in locally managed tablespaces with automatic segment space management (ASSM) are eligible. Other restrictions on segment type exist. For more information, see "Shrinking Database Segments Online" on page 17-28.

If a table with reclaimable space is not eligible for online segment shrink, or if you want to make changes to logical or physical attributes of the table while reclaiming space, you can use **online table redefinition** as an alternative to segment shrink. Online redefinition is also referred to as **reorganization**. Unlike online segment shrink, it requires extra disk space to be allocated. See "Redefining Tables Online" on page 18-26 for more information.

Using the Segment Advisor

The Segment Advisor identifies segments that have space available for reclamation. It performs its analysis by examining usage and growth statistics in the Automatic Workload Repository (AWR), and by sampling the data in the segment. It is configured to run during maintenance windows as an automated maintenance task, and you can also run it on demand (manually). The Segment Advisor automated maintenance task is known as the Automatic Segment Advisor.

The Segment Advisor generates the following types of advice:

- If the Segment Advisor determines that an object has a significant amount of free space, it recommends online segment shrink. If the object is a table that is not eligible for shrinking, as in the case of a table in a tablespace without automatic segment space management, the Segment Advisor recommends online table redefinition.
- If the Segment Advisor encounters a table with row chaining above a certain threshold, it records that fact that the table has an excess of chained rows.

Note: The Segment Advisor flags only the type of row chaining that results from updates that increase row length.

If you receive a space management alert, or if you decide that you want to reclaim space, you should start with the Segment Advisor.

To use the Segment Advisor:

1. Check the results of the Automatic Segment Advisor.

To understand the Automatic Segment Advisor, see "Automatic Segment Advisor", later in this section. For details on how to view results, see "Viewing Segment Advisor Results" on page 17-21.

2. (Optional) Obtain updated results on individual segments by rerunning the Segment Advisor manually.

   See "Running the Segment Advisor Manually", later in this section.

Automatic Segment Advisor

The Automatic Segment Advisor is an automated maintenance task that is configured to run during all maintenance windows.

The Automatic Segment Advisor does not analyze every database object. Instead, it examines database statistics, samples segment data, and then selects the following objects to analyze:

- Tablespaces that have exceeded a critical or warning space threshold
- Segments that have the most activity
- Segments that have the highest growth rate

If an object is selected for analysis but the maintenance window expires before the Segment Advisor can process the object, the object is included in the next Automatic Segment Advisor run.

You cannot change the set of tablespaces and segments that the Automatic Segment Advisor selects for analysis. You can, however, enable or disable the Automatic Segment Advisor task, change the times during which the Automatic Segment Advisor is scheduled to run, or adjust automated maintenance task system resource utilization. See "Configuring the Automatic Segment Advisor" on page 17-27 for more information.

See Also:

- "Viewing Segment Advisor Results" on page 17-21
- Chapter 24, "Managing Automated Database Maintenance Tasks"

Running the Segment Advisor Manually

You can manually run the Segment Advisor at any time with Enterprise Manager or with PL/SQL package procedure calls. Reasons to manually run the Segment Advisor include the following:

- You want to analyze a tablespace or segment that was not selected by the Automatic Segment Advisor.
- You want to repeat the analysis of an individual tablespace or segment to get more up-to-date recommendations.

You can request advice from the Segment Advisor at three levels:

- **Segment level**—Advice is generated for a single segment, such as an unpartitioned table, a partition or subpartition of a partitioned table, an index, or a LOB column.
- **Object level**—Advice is generated for an entire object, such as a table or index. If the object is partitioned, advice is generated on all the partitions of the object. In addition, if you run Segment Advisor manually from Enterprise Manager, you can request advice on the object's dependent objects, such as indexes and LOB segments for a table.

- **Tablespace level**—Advice is generated for every segment in a tablespace.

The OBJECT_TYPE column of Table 17–3 on page 17-20 shows the types of objects for which you can request advice.

Running the Segment Advisor Manually with Enterprise Manager You must have the OEM_ADVISOR role to run the Segment Advisor manually with Enterprise Manager. There are two ways to run the Segment Advisor:

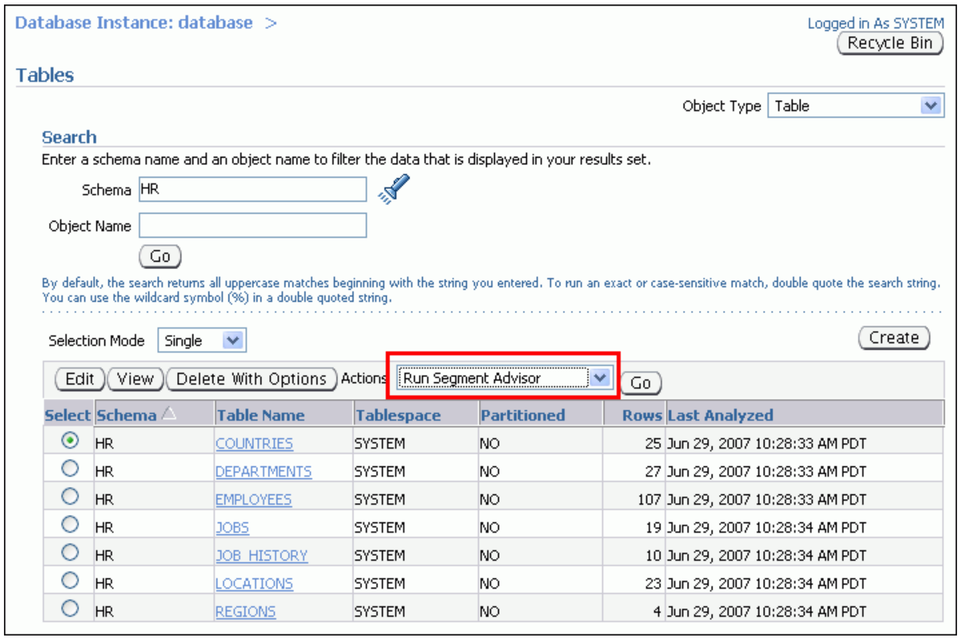
- Using the Segment Advisor Wizard

  This method enables you to request advice at the tablespace level or object level. At the object level, you can request advice on tables, indexes, table partitions, and index partitions. Dependent objects such as LOB segments cannot be included in the analysis.

- Using the Run Segment Advisor command on a schema object page.

  For example, if you display a list of tables on the Tables page (accessible from the Schema page), you can select a table and then select the **Run Segment Advisor** command from the Actions menu.

Figure 17–1 Tables page



Object Type: Table

Enter a schema name and an object name to filter the data that is displayed in your results set.

Schema: HR

Object Name:

By default, the search returns all uppercase matches beginning with the string you entered. To run an exact or case-sensitive match, double quote the search string. You can use the wildcard symbol (%) in a double quoted string.

Selection Mode: Single

Actions: Run Segment Advisor

Select	Schema	Table Name	Tablespace	Partitioned	Rows	Last Analyzed
●	HR	COUNTRIES	SYSTEM	NO	25	Jun 29, 2007 10:28:33 AM PDT
○	HR	DEPARTMENTS	SYSTEM	NO	27	Jun 29, 2007 10:28:33 AM PDT
○	HR	EMPLOYEES	SYSTEM	NO	107	Jun 29, 2007 10:28:33 AM PDT
○	HR	JOBS	SYSTEM	NO	19	Jun 29, 2007 10:28:34 AM PDT
○	HR	JOB_HISTORY	SYSTEM	NO	10	Jun 29, 2007 10:28:34 AM PDT
○	HR	LOCATIONS	SYSTEM	NO	23	Jun 29, 2007 10:28:34 AM PDT
○	HR	REGIONS	SYSTEM	NO	4	Jun 29, 2007 10:28:34 AM PDT

This method enables you to include the schema object's dependent objects in the Segment Advisor run. For example, if you select a table and select the **Run Segment Advisor** command, Enterprise Manager displays the table's dependent objects, such as partitions, index segments, LOB segments, and so on. You can then select dependent objects to include in the run.

In both cases, Enterprise Manager creates the Segment Advisor task as an Oracle Database Scheduler job. You can schedule the job to run immediately, or can take advantage of advanced scheduling features offered by the Scheduler.

To run the Segment Advisor manually with the Segment Advisor Wizard:

1. From the database Home page, under Related Links, click **Advisor Central**.

   The Advisor Central page appears. (See Figure 17–2.)

2. Under Advisors, click **Segment Advisor**.

   The first page of the Segment Advisor wizard appears.

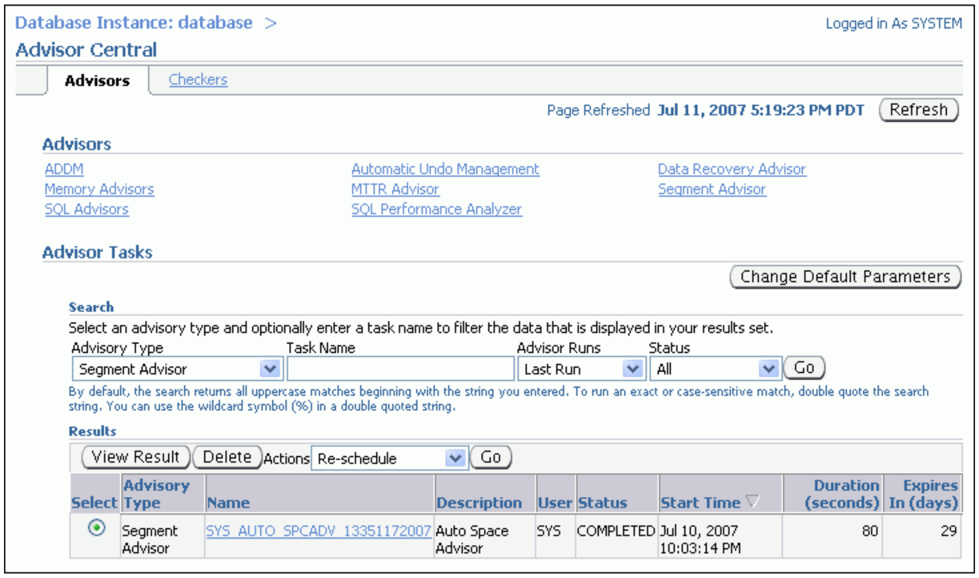
3. Follow the wizard steps to schedule the Segment Advisor job, and then click **Submit** on the final wizard page.

   The Advisor Central page reappears, with the new Segment Advisor job at the top of the list under the Results heading. The job status is `SCHEDULED` or `RUNNING`. (If you do not see your job, use the search fields above the list to display it.)

4. Check the status of the job. If it is not `COMPLETED`, click the **Refresh** button at the top of the page repeatedly. (Do not use your browser's Refresh icon.)

   When the job status changes to `COMPLETED`, select the job by clicking in the **Select** column, and then click **View Result**.

Figure 17–2 Advisor Central page



Database Instance: database >

Logged in As SYSTEM

Advisor Central

Advisors | Checkers

Page Refreshed **Jul 11, 2007 5:19:23 PM PDT** Refresh

Advisors

ADDM | Automatic Undo Management | Data Recovery Advisor
Memory Advisors | MTTR Advisor | Segment Advisor
SQL Advisors | SQL Performance Analyzer

Advisor Tasks

Change Default Parameters

Search

Select an advisory type and optionally enter a task name to filter the data that is displayed in your results set.

Advisory Type: Segment Advisor | Task Name: | Advisor Runs: Last Run | Status: All | Go

By default, the search returns all uppercase matches beginning with the string you entered. To run an exact or case-sensitive match, double quote the search string. You can use the wildcard symbol (%) in a double quoted string.

Results

View Result | Delete | Actions: Re-schedule | Go

Select	Advisory Type	Name	Description	User	Status	Start Time	Duration (seconds)	Expires In (days)
●	Segment Advisor	SYS_AUTO_SPCADV_13351172007	Auto Space Advisor	SYS	COMPLETED	Jul 10, 2007 10:03:14 PM	80	29

> **See Also:** Chapter 27, "Scheduling Jobs with Oracle Scheduler" for more information about the advanced scheduling features of the Scheduler.

Running the Segment Advisor Manually with PL/SQL You can also run the Segment Advisor with the `DBMS_ADVISOR` package. You use package procedures to create a Segment Advisor task, set task arguments, and then execute the task. You must have the `ADVISOR` privilege. Table 17–2 shows the procedures that are relevant for the Segment Advisor. Please refer to *Oracle Database PL/SQL Packages and Types Reference* for more details on these procedures.

Table 17–2 DBMS_ADVISOR package procedures relevant to the Segment Advisor

Package Procedure Name	Description
CREATE_TASK	Use this procedure to create the Segment Advisor task. Specify 'Segment Advisor' as the value of the ADVISOR_NAME parameter.
CREATE_OBJECT	Use this procedure to identify the target object for segment space advice. The parameter values of this procedure depend upon the object type. Table 17–3 lists the parameter values for each type of object. Note: To request advice on an IOT overflow segment, use an object type of TABLE, TABLE PARTITION, or TABLE SUBPARTITION. Use the following query to find the overflow segment for an IOT and to determine the overflow segment table name to use with CREATE_OBJECT: `select table_name, iot_name, iot_type from dba_tables;`
SET_TASK_PARAMETER	Use this procedure to describe the segment advice that you need. Table 17–4 shows the relevant input parameters of this procedure. Parameters not listed here are not used by the Segment Advisor.
EXECUTE_TASK	Use this procedure to execute the Segment Advisor task.

Table 17–3 Input for DBMS_ADVISOR.CREATE_OBJECT

Input Parameter				
OBJECT_TYPE	**ATTR1**	**ATTR2**	**ATTR3**	**ATTR4**
TABLESPACE	*tablespace name*	NULL	NULL	Unused. Specify NULL.
TABLE	*schema name*	*table name*	NULL	Unused. Specify NULL.
INDEX	*schema name*	*index name*	NULL	Unused. Specify NULL.
TABLE PARTITION	*schema name*	*table name*	*table partition name*	Unused. Specify NULL.
INDEX PARTITION	*schema name*	*index name*	*index partition name*	Unused. Specify NULL.
TABLE SUBPARTITION	*schema name*	*table name*	*table subpartition name*	Unused. Specify NULL.
INDEX SUBPARTITION	*schema name*	*index name*	*index subpartition name*	Unused. Specify NULL.
LOB	*schema name*	*segment name*	NULL	Unused. Specify NULL.
LOB PARTITION	*schema name*	*segment name*	*lob partition name*	Unused. Specify NULL.
LOB SUBPARTITION	*schema name*	*segment name*	*lob subpartition name*	Unused. Specify NULL.

Table 17–4 Input for DBMS_ADVISOR.SET_TASK_PARAMETER

Input Parameter	Description	Possible Values	Default Value
time_limit	The time limit for the Segment Advisor run, specified in seconds.	Any number of seconds	UNLIMITED
recommend_all	Whether the Segment Advisor should generate findings for all segments.	TRUE: Findings are generated on all segments specified, whether or not space reclamation is recommended. FALSE: Findings are generated only for those objects that generate recommendations for space reclamation.	TRUE

Example The example that follows shows how to use the DBMS_ADVISOR procedures to run the Segment Advisor for the sample table hr.employees. The user executing these package procedures must have the EXECUTE object privilege on the package or the ADVISOR system privilege.

Note that passing an object type of TABLE to DBMS_ADVISOR.CREATE_OBJECT amounts to an object level request. If the table is not partitioned, the table segment is analyzed (without any dependent segments like index or LOB segments). If the table is partitioned, the Segment Advisor analyzes all table partitions and generates separate findings and recommendations for each.

```
variable id number;
begin
  declare
  name varchar2(100);
  descr varchar2(500);
  obj_id number;
  begin
  name:='Manual_Employees';
  descr:='Segment Advisor Example';

  dbms_advisor.create_task (
    advisor_name     => 'Segment Advisor',
    task_id          => :id,
    task_name        => name,
    task_desc        => descr);

  dbms_advisor.create_object (
    task_name        => name,
    object_type      => 'TABLE',
    attr1            => 'HR',
    attr2            => 'EMPLOYEES',
    attr3            => NULL,
    attr4            => NULL,
    attr5            => NULL,
    object_id        => obj_id);

  dbms_advisor.set_task_parameter(
    task_name        => name,
    parameter        => 'recommend_all',
    value            => 'TRUE');

  dbms_advisor.execute_task(name);
  end;
end;
/
```

Viewing Segment Advisor Results

The Segment Advisor creates several types of results: recommendations, findings, actions, and objects. You can view results in the following ways:

- With Enterprise Manager
- By querying the DBA_ADVISOR_* views
- By calling the DBMS_SPACE.ASA_RECOMMENDATIONS procedure

Table Table 17–5 describes the various result types and their associated DBA_ADVISOR_* views.

Table 17–5 Segment Advisor Result Types

Result Type	Associated View	Description
Recommendations	`DBA_ADVISOR_RECOMMENDATIONS`	If a segment would benefit from a segment shrink or reorganization, the Segment Advisor generates a recommendation for the segment. Table 17–6 shows examples of generated findings and recommendations.
Findings	`DBA_ADVISOR_FINDINGS`	Findings are a report of what the Segment Advisor observed in analyzed segments. Findings include space used and free space statistics for each analyzed segment. Not all findings result in a recommendation. (There may be only a few recommendations, but there could be many findings.) When running the Segment Advisor manually with PL/SQL, if you specify `'TRUE'` for `recommend_all` in the `SET_TASK_PARAMETER` procedure, then the Segment Advisor generates a finding for each segment that qualifies for analysis, whether or not a recommendation is made for that segment. For row chaining advice, the Automatic Segment Advisor generates findings only, and not recommendations. If the Automatic Segment Advisor has no space reclamation recommendations to make, it does not generate findings.
Actions	`DBA_ADVISOR_ACTIONS`	Every recommendation is associated with a suggested action to perform: either segment shrink or online redefinition (reorganization). The `DBA_ADVISOR_ACTIONS` view provides either the SQL that you need to perform a segment shrink, or a suggestion to reorganize the object.
Objects	`DBA_ADVISOR_OBJECTS`	All findings, recommendations, and actions are associated with an object. If the Segment Advisor analyzes more than one segment, as with a tablespace or partitioned table, then one entry is created in the `DBA_ADVISOR_OBJECTS` view for each analyzed segment. Table 17–3 defines the columns in this view to query for information on the analyzed segments. You can correlate the objects in this view with the objects in the findings, recommendations, and actions views.

See Also:

- *Oracle Database Reference* for details on the `DBA_ADVISOR_*` views.
- *Oracle Database PL/SQL Packages and Types Reference* for details on the `DBMS_SPACE.ASA_RECOMMENDATIONS` function.

Viewing Segment Advisor Results with Enterprise Manager

With Enterprise Manager (EM), you can view Segment Advisor results for both Automatic Segment Advisor runs and manual Segment Advisor runs. You can view the following types of results:

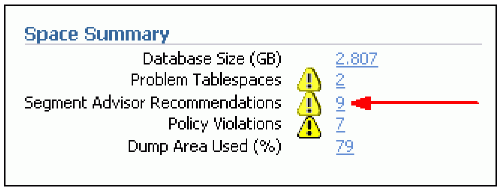
- All recommendations (multiple automatic and manual Segment Advisor runs)
- Recommendations from the last Automatic Segment Advisor run
- Recommendations from a specific run

- Row chaining findings

You can also view a list of the segments that were analyzed by the last Automatic Segment Advisor run.

To view Segment Advisor results with EM—All runs:

1. On the database Home page, under the Space Summary heading, click the numeric link next to the title **Segment Advisor Recommendations**.

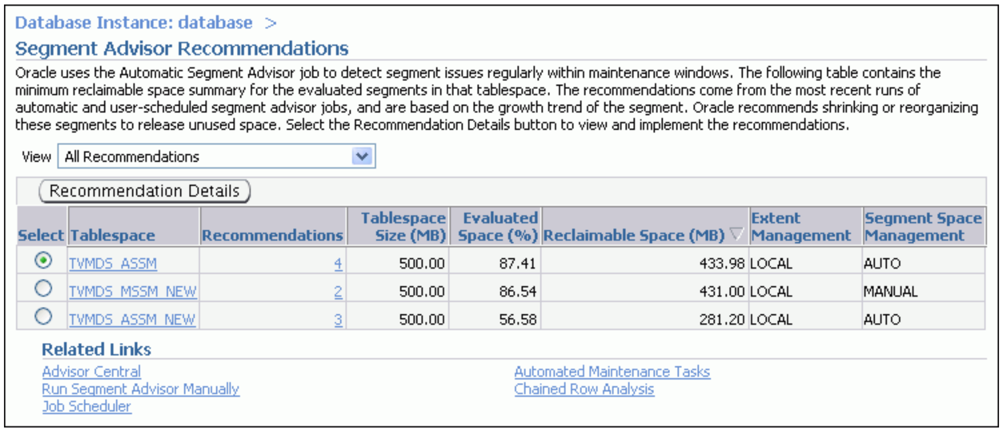


Space Summary

Database Size (GB)	2.807
Problem Tablespaces	⚠ 2
Segment Advisor Recommendations	⚠ 9
Policy Violations	⚠ 7
Dump Area Used (%)	79

The Segment Advisor Recommendations page appears. Recommendations are organized by tablespace.

Figure 17–3 Segment Advisor Recommendations page



Database Instance: database >

Segment Advisor Recommendations

Oracle uses the Automatic Segment Advisor job to detect segment issues regularly within maintenance windows. The following table contains the minimum reclaimable space summary for the evaluated segments in that tablespace. The recommendations come from the most recent runs of automatic and user-scheduled segment advisor jobs, and are based on the growth trend of the segment. Oracle recommends shrinking or reorganizing these segments to release unused space. Select the Recommendation Details button to view and implement the recommendations.

View: All Recommendations

Select	Tablespace	Recommendations	Tablespace Size (MB)	Evaluated Space (%)	Reclaimable Space (MB)	Extent Management	Segment Space Management
●	TVMDS_ASSM	4	500.00	87.41	433.98	LOCAL	AUTO
○	TVMDS_MSSM_NEW	2	500.00	86.54	431.00	LOCAL	MANUAL
○	TVMDS_ASSM_NEW	3	500.00	56.58	281.20	LOCAL	AUTO

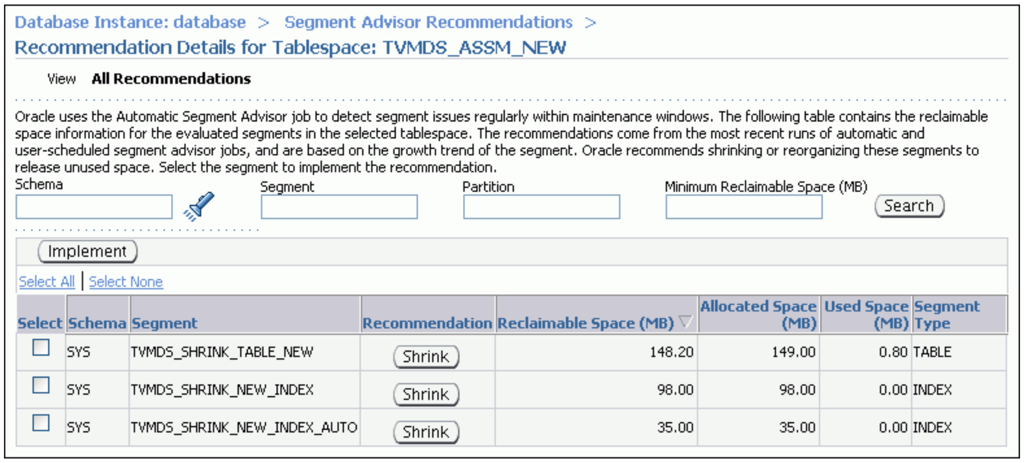
Related Links

Advisor Central
Run Segment Advisor Manually
Job Scheduler
Automated Maintenance Tasks
Chained Row Analysis

2. If any recommendations are present, select a tablespace, and then click **Recommendation Details**.

   The Recommendation Details page appears. You can initiate the recommended activity from this page (shrink or reorganize).

Figure 17–4 Recommendation Details page



Database Instance: database > Segment Advisor Recommendations >

Recommendation Details for Tablespace: TVMDS_ASSM_NEW

View **All Recommendations**

Oracle uses the Automatic Segment Advisor job to detect segment issues regularly within maintenance windows. The following table contains the reclaimable space information for the evaluated segments in the selected tablespace. The recommendations come from the most recent runs of automatic and user-scheduled segment advisor jobs, and are based on the growth trend of the segment. Oracle recommends shrinking or reorganizing these segments to release unused space. Select the segment to implement the recommendation.

Schema | Segment | Partition | Minimum Reclaimable Space (MB) | Search

Implement

Select All | Select None

Select	Schema	Segment	Recommendation	Reclaimable Space (MB)	Allocated Space (MB)	Used Space (MB)	Segment Type
☐	SYS	TVMDS_SHRINK_TABLE_NEW	Shrink	148.20	149.00	0.80	TABLE
☐	SYS	TVMDS_SHRINK_NEW_INDEX	Shrink	98.00	98.00	0.00	INDEX
☐	SYS	TVMDS_SHRINK_NEW_INDEX_AUTO	Shrink	35.00	35.00	0.00	INDEX

Tip: The list entries are sorted in descending order by reclaimable space. You can click column headings to change the sort order or to change from ascending to descending order.

To view Segment Advisor results with EM—Last Automatic Segment Advisor run:

1. On the database Home page, under the Space Summary heading, click the numeric link next to the title **Segment Advisor Recommendations**.

   The Segment Advisor Recommendations page appears. (See Figure 17–3.)

2. In the View drop-down list, select **Recommendations from Last Automatic Run**.

3. If any recommendations are present, click in the **Select** column to select a tablespace, and then click **Recommendation Details**.

   The Recommendation Details page appears. (See Figure 17–4.) You can initiate the recommended activity from this page (shrink or reorganize).

To view Segment Advisor results with EM—Specific run:

1. Start at the Advisor Central page.

   If you ran the Segment Advisor with the Enterprise Manager wizard, the Advisor Central page appears after you submit the Segment Advisor task. Otherwise, to get to this page, on the database Home page, under Related Links, click **Advisor Central**.

2. Check that your task appears in the list under the Results heading. If it does not, complete these steps (See Figure 17–2 on page 17-19):

   a. In the Search section of the page, under Advisor Tasks, select **Segment Advisor** in the Advisory Type list.

   b. In the Advisor Runs list, select **All** or the desired time period.

   c. (Optional) Enter a task name.

   d. Click **Go**.

      Your Segment Advisor task appears in the Results section.

3. Check the status of the job. If it is not `COMPLETED`, click the **Refresh** button at the top of the page until your task status shows `COMPLETED`. (Do not use your browser's refresh icon.)
4. Click the task name.

   The Segment Advisor Task page appears, with recommendations organized by tablespace.
5. Select a tablespace in the list, and then click **Recommendation Details**.

   The Recommendation Details page appears. (See Figure 17–4.) You can initiate the recommended activity from this page (shrink or reorganize).

To view row chaining findings

1. On the database Home page, under the Space Summary heading, click the numeric link next to the title **Segment Advisor Recommendations**.

   The Segment Advisor Recommendations page appears. (See Figure 17–3.)
2. Under the Related Links heading, click **Chained Row Analysis**.

   The Chained Row Analysis page appears, showing all segments that have chained rows, with a chained rows percentage for each.

Viewing Segment Advisor Results by Querying the DBA_ADVISOR_* Views

The headings of Table 17–6 show the columns in the `DBA_ADVISOR_*` views that contain output from the Segment Advisor. Refer to *Oracle Database Reference* for a description of these views. The table contents summarize the possible outcomes. In addition, Table 17–3 on page 17-20 defines the columns in the `DBA_ADVISOR_OBJECTS` view that contain information on the analyzed segments.

Before querying the `DBA_ADVISOR_*` views, you can check that the Segment Advisor task is complete by querying the `STATUS` column in `DBA_ADVISOR_TASKS`.

```
select task_name, status from dba_advisor_tasks
   where owner = 'STEVE' and advisor_name = 'Segment Advisor';

TASK_NAME                      STATUS
------------------------------ -----------
Manual Employees               COMPLETED
```

The following example shows how to query the `DBA_ADVISOR_*` views to retrieve findings from all Segment Advisor runs submitted by user `STEVE`:

```
select af.task_name, ao.attr2 segname, ao.attr3 partition, ao.type, af.message
  from dba_advisor_findings af, dba_advisor_objects ao
  where ao.task_id = af.task_id
  and ao.object_id = af.object_id
  and ao.owner = 'STEVE';


TASK_NAME          SEGNAME      PARTITION       TYPE             MESSAGE
------------------ ------------ --------------- ---------------- --------------------------
Manual_Employees   EMPLOYEES                    TABLE            The free space in the obje
                                                                 ct is less than 10MB.

Manual_Salestable4 SALESTABLE4  SALESTABLE4_P1  TABLE PARTITION  Perform shrink, estimated
                                                                 savings is 74444154 bytes.
```

```
Manual_Salestable4 SALESTABLE4  SALESTABLE4_P2  TABLE PARTITION  The free space in the obje
                                                                 ct is less than 10MB.
```

Table 17–6 Segment Advisor Outcomes: Summary

MESSAGE column of DBA_ADVISOR_FINDINGS	MORE_INFO column of DBA_ADVISOR_FINDINGS	BENEFIT_TYPE column of DBA_ADVISOR_RECOMMENDATIONS	ATTR1 column of DBA_ADVISOR_ACTIONS
Insufficient information to make a recommendation.	None	None	None
The free space in the object is less than 10MB.	Allocated Space:*xxx*: Used Space:*xxx*: Reclaimable Space :*xxx*	None	None
The object has some free space but cannot be shrunk because...	Allocated Space:*xxx*: Used Space:*xxx*: Reclaimable Space :*xxx*	None	None
The free space in the object is less than the size of the last extent.	Allocated Space:*xxx*: Used Space:*xxx*: Reclaimable Space :*xxx*	None	None
Perform shrink, estimated savings is *xxx* bytes.	Allocated Space:*xxx*: Used Space:*xxx*: Reclaimable Space :*xxx*	Perform shrink, estimated savings is *xxx* bytes.	The command to execute. For example: `ALTER` *`object`* `SHRINK SPACE`;)
Enable row movement of the table *schema.table* and perform shrink, estimated savings is *xxx* bytes.	Allocated Space:*xxx*: Used Space:*xxx*: Reclaimable Space :*xxx*	Enable row movement of the table *schema.table* and perform shrink, estimated savings is *xxx* bytes	The command to execute. For example: `ALTER` *`object`* `SHRINK SPACE`;)
Perform re-org on the object *object*, estimated savings is *xxx* bytes. (Note: This finding is for objects with reclaimable space that are not eligible for online segment shrink.)	Allocated Space:*xxx*: Used Space:*xxx*: Reclaimable Space :*xxx*	Perform re-org on the object *object*, estimated savings is *xxx* bytes.	Perform reorg
The object has chained rows that can be removed by re-org.	*xx* percent chained rows can be removed by re-org.	None	None

Viewing Segment Advisor Results with DBMS_SPACE.ASA_RECOMMENDATIONS

The `ASA_RECOMMENDATIONS` procedure in the `DBMS_SPACE` package returns a nested table object that contains findings or recommendations for Automatic Segment Advisor runs and, optionally, manual Segment Advisor runs. Calling this procedure may be easier than working with the `DBA_ADVISOR_*` views, because the procedure performs all the required joins for you and returns information in an easily consumable format.

The following query returns recommendations by the most recent run of the Auto Segment Advisor, with the suggested command to run to follow the recommendations:

```
select tablespace_name, segment_name, segment_type, partition_name,
recommendations, c1 from
table(dbms_space.asa_recommendations('FALSE', 'FALSE', 'FALSE'));


TABLESPACE_NAME                SEGMENT_NAME                   SEGMENT_TYPE
------------------------------ ------------------------------ --------------
PARTITION_NAME
------------------------------
```

```
RECOMMENDATIONS
-----------------------------------------------------------------------------
C1
-----------------------------------------------------------------------------
TVMDS_ASSM                      ORDERS1                          TABLE PARTITION
ORDERS1_P2
Perform shrink, estimated savings is 57666422 bytes.
alter table "STEVE"."ORDERS1" modify partition "ORDERS1_P2" shrink space

TVMDS_ASSM                      ORDERS1                          TABLE PARTITION
ORDERS1_P1
Perform shrink, estimated savings is 45083514 bytes.
alter table "STEVE"."ORDERS1" modify partition "ORDERS1_P1" shrink space

TVMDS_ASSM_NEW                  ORDERS_NEW                       TABLE

Perform shrink, estimated savings is 155398992 bytes.
alter table "STEVE"."ORDERS_NEW" shrink space

TVMDS_ASSM_NEW                  ORDERS_NEW_INDEX                 INDEX

Perform shrink, estimated savings is 102759445 bytes.
alter index "STEVE"."ORDERS_NEW_INDEX" shrink space
```

See *Oracle Database PL/SQL Packages and Types Reference* for details on `DBMS_SPACE.ASA_RECOMMENDATIONS`.

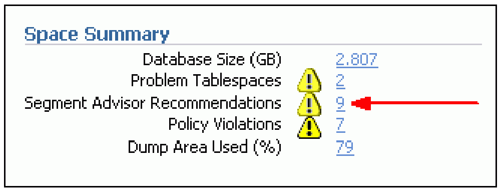
Configuring the Automatic Segment Advisor

The Automatic Segment Advisor is an automated maintenance task. As such, you can use Enterprise Manager or PL/SQL package procedure calls to modify when (and if) this task runs. You can also control the resources allotted to it by modifying the appropriate resource plans.

You can call PL/SQL package procedures to make these changes, but the easier way to is to use Enterprise Manager.

To configure the Automatic Segment Advisor task with Enterprise Manager:

1. Log in to Enterprise Manager as user `SYSTEM`.
2. On the Database Home page, under the Space Summary heading, click the numeric link next to the label **Segment Advisor Recommendations**.



Space Summary

Database Size (GB)		2.807
Problem Tablespaces	⚠	2
Segment Advisor Recommendations	⚠	9
Policy Violations	⚠	7
Dump Area Used (%)		79

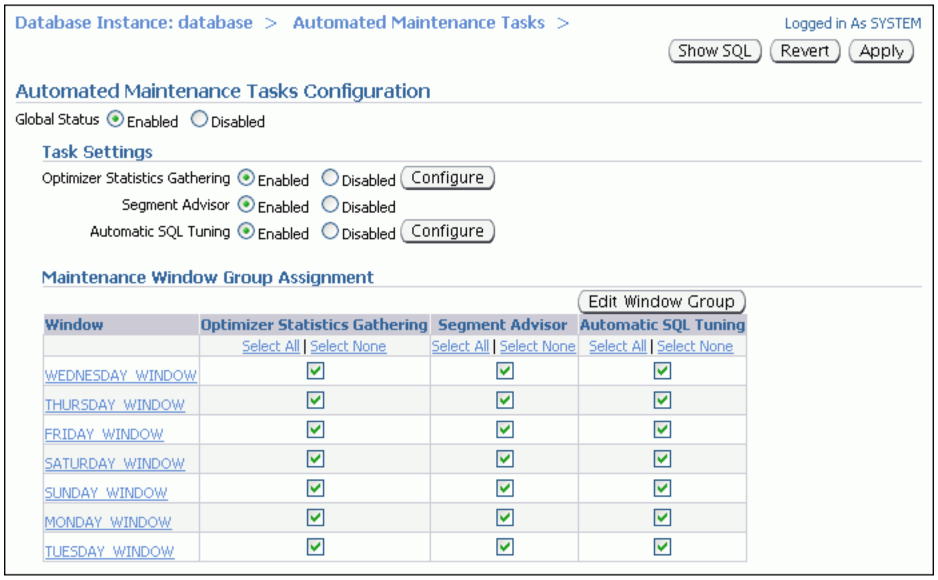
   The Segment Advisor Recommendations page appears.

3. Under the Related Links heading, click the link entitled **Automated Maintenance Tasks**.

   The Automated Maintenance Tasks page appears.

4. Click **Configure**.

   The Automated Maintenance Tasks Configuration page appears.


Database Instance: database > Automated Maintenance Tasks >

Logged in As SYSTEM

Automated Maintenance Tasks Configuration

Global Status [✓ Enabled] Disabled

Task Settings

Optimizer Statistics Gathering [✓ Enabled] Disabled

Segment Advisor [✓ Enabled] Disabled

Automatic SQL Tuning [✓ Enabled] Disabled

Maintenance Window Group Assignment

Window	Optimizer Statistics Gathering	Segment Advisor	Automatic SQL Tuning
	Select All | Select None	Select All | Select None	Select All | Select None
WEDNESDAY_WINDOW	✓	✓	✓
THURSDAY_WINDOW	✓	✓	✓
FRIDAY_WINDOW	✓	✓	✓
SATURDAY_WINDOW	✓	✓	✓
SUNDAY_WINDOW	✓	✓	✓
MONDAY_WINDOW	✓	✓	✓
TUESDAY_WINDOW	✓	✓	✓

5. To completely disable the Automatic Segment Advisor, under Task Settings, select **Disabled** next to the Segment Advisor label, and then click **Apply**.

6. To disable the Automatic Segment Advisor for specific maintenance windows, clear the desired check boxes under the Segment Advisor column, and then click **Apply**.

7. To modify the start and end times and durations of maintenance windows, click **Edit Window Group**.

   The Edit Window Group page appears. Click the name of a maintenance window, and then click **Edit** to change the window's schedule.

See Also:

- Chapter 24, "Managing Automated Database Maintenance Tasks"

Viewing Automatic Segment Advisor Information

The following views display information specific to the Automatic Segment Advisor. For details, see *Oracle Database Reference*.

View	Description
DBA_AUTO_SEGADV_SUMMARY	Each row of this view summarizes one Automatic Segment Advisor run. Fields include number of tablespaces and segments processed, and number of recommendations made.
DBA_AUTO_SEGADV_CTL	Contains control information that the Automatic Segment Advisor uses to select and process segments. Each row contains information on a single object (tablespace or segment), including whether the object has been processed, and if so, the task ID under which it was processed and the reason for selecting it.

Shrinking Database Segments Online

You use online segment shrink to reclaim fragmented free space below the high water mark in an Oracle Database segment. The benefits of segment shrink are these:

- Compaction of data leads to better cache utilization, which in turn leads to better online transaction processing (OLTP) performance.
- The compacted data requires fewer blocks to be scanned in full table scans, which in turns leads to better decision support system (DSS) performance.

Segment shrink is an online, in-place operation. DML operations and queries can be issued during the data movement phase of segment shrink. Concurrent DML operation are blocked for a short time at the end of the shrink operation, when the space is deallocated. Indexes are maintained during the shrink operation and remain usable after the operation is complete. Segment shrink does not require extra disk space to be allocated.

Segment shrink reclaims unused space both above and below the high water mark. In contrast, space deallocation reclaims unused space only above the high water mark. In shrink operations, by default, the database compacts the segment, adjusts the high water mark, and releases the reclaimed space.

Segment shrink requires that rows be moved to new locations. Therefore, you must first enable row movement in the object you want to shrink and disable any rowid-based triggers defined on the object. You enable row movement in a table with the `ALTER TABLE` ... `ENABLE ROW MOVEMENT` command.

Shrink operations can be performed only on segments in locally managed tablespaces with automatic segment space management (ASSM). Within an ASSM tablespace, all segment types are eligible for online segment shrink except these:

- IOT mapping tables
- Tables with rowid based materialized views
- Tables with function-based indexes
- `SECUREFILE` LOBs

See Also: *Oracle Database SQL Language Reference* for more information on the `ALTER TABLE` command.

Invoking Online Segment Shrink

Before invoking online segment shrink, view the findings and recommendations of the Segment Advisor. For more information, see "Using the Segment Advisor" on page 17-16.

You invoke online segment shrink with Enterprise Manager (EM) or with SQL commands in SQL*Plus. The remainder of this section discusses the command line method.

Note: You can invoke segment shrink directly from the Recommendation Details page in EM. (See Figure 17–4.) Or, to invoke segment shrink for an individual table in EM, display the table on the Tables page, select the table, and then click **Shrink Segment** in the Actions list. (See Figure 17–1.) Perform a similar operation in EM to shrink indexes, materialized views, and so on.

You can shrink space in a table, index-organized table, index, partition, subpartition, materialized view, or materialized view log. You do this using `ALTER TABLE`, `ALTER INDEX`, `ALTER MATERIALIZED VIEW`, or `ALTER MATERIALIZED VIEW LOG` statement with the `SHRINK SPACE` clause. Refer to *Oracle Database SQL Language Reference* for the syntax and additional information on shrinking a database object, including restrictions.

Two optional clauses let you control how the shrink operation proceeds:

- The `COMPACT` clause lets you divide the shrink segment operation into two phases. When you specify `COMPACT`, Oracle Database defragments the segment space and compacts the table rows but postpones the resetting of the high water mark and the deallocation of the space until a future time. This option is useful if you have long-running queries that might span the operation and attempt to read from blocks that have been reclaimed. The defragmentation and compaction results are saved to disk, so the data movement does not have to be redone during the second phase. You can reissue the `SHRINK SPACE` clause without the `COMPACT` clause during off-peak hours to complete the second phase.
- The `CASCADE` clause extends the segment shrink operation to all dependent segments of the object. For example, if you specify `CASCADE` when shrinking a table segment, all indexes of the table will also be shrunk. (You need not specify `CASCADE` to shrink the partitions of a partitioned table.) To see a list of dependent segments of a given object, you can run the `OBJECT_DEPENDENT_SEGMENTS` procedure of the `DBMS_SPACE` package.

As with other DDL operations, segment shrink causes subsequent SQL statements to be reparsed because of invalidation of cursors unless you specify the `COMPACT` clause.

Examples

Shrink a table and all of its dependent segments (including `BASICFILE` LOB segments):

```
ALTER TABLE employees SHRINK SPACE CASCADE;
```

Shrink a `BASICFILE` LOB segment only:

```
ALTER TABLE employees MODIFY LOB (perf_review) (SHRINK SPACE);
```

Shrink a single partition of a partitioned table:

```
ALTER TABLE customers MODIFY PARTITION cust_P1 SHRINK SPACE;
```

Shrink an IOT index segment and the overflow segment:

```
ALTER TABLE cities SHRINK SPACE CASCADE;
```

Shrink an IOT overflow segment only:

```
ALTER TABLE cities OVERFLOW SHRINK SPACE;
```

> **See Also:** *Oracle Database SecureFiles and Large Objects Developer's Guide* for more information about LOB segments

Deallocating Unused Space

When you deallocate unused space, the database frees the unused space at the unused (high water mark) end of the database segment and makes the space available for other segments in the tablespace.

Prior to deallocation, you can run the `UNUSED_SPACE` procedure of the `DBMS_SPACE` package, which returns information about the position of the high water mark and the amount of unused space in a segment. For segments in locally managed tablespaces with automatic segment space management, use the `SPACE_USAGE` procedure for more accurate information on unused space.

See Also: *Oracle Database PL/SQL Packages and Types Reference* contains the description of the DBMS_SPACE package

The following statements deallocate unused space in a segment (table, index or cluster):

```
ALTER TABLE table DEALLOCATE UNUSED KEEP integer;
ALTER INDEX index DEALLOCATE UNUSED KEEP integer;
ALTER CLUSTER cluster DEALLOCATE UNUSED KEEP integer;
```

The KEEP clause is optional and lets you specify the amount of space retained in the segment. You can verify that the deallocated space is freed by examining the DBA_FREE_SPACE view.

See Also:

- *Oracle Database SQL Language Reference* for details on the syntax and semantics of deallocating unused space
- *Oracle Database Reference* for more information about the DBA_FREE_SPACE view

Understanding Space Usage of Datatypes

When creating tables and other data structures, you need to know how much space they will require. Each datatype has different space requirements. The *Oracle Database PL/SQL Language Reference* and *Oracle Database SQL Language Reference* contain extensive descriptions of datatypes and their space requirements.

Displaying Information About Space Usage for Schema Objects

Oracle Database provides data dictionary views and PL/SQL packages that allow you to display information about the space usage of schema objects. Views and packages that are unique to a particular schema object are described in the chapter of this book associated with that object. This section describes views and packages that are generic in nature and apply to multiple schema objects.

Using PL/SQL Packages to Display Information About Schema Object Space Usage

These Oracle-supplied PL/SQL packages provide information about schema objects:

Package and Procedure/Function	Description
DBMS_SPACE.UNUSED_SPACE	Returns information about unused space in an object (table, index, or cluster).
DBMS_SPACE.FREE_BLOCKS	Returns information about free data blocks in an object (table, index, or cluster) whose segment free space is managed by free lists (segment space management is MANUAL).
DBMS_SPACE.SPACE_USAGE	Returns information about free data blocks in an object (table, index, or cluster) whose segment space management is AUTO.

See Also: *Oracle Database PL/SQL Packages and Types Reference* for a description of PL/SQL packages

Example: Using DBMS_SPACE.UNUSED_SPACE

The following SQL*Plus example uses the `DBMS_SPACE` package to obtain unused space information.

```
SQL> VARIABLE total_blocks NUMBER
SQL> VARIABLE total_bytes NUMBER
SQL> VARIABLE unused_blocks NUMBER
SQL> VARIABLE unused_bytes NUMBER
SQL> VARIABLE lastextf NUMBER
SQL> VARIABLE last_extb NUMBER
SQL> VARIABLE lastusedblock NUMBER
SQL> exec DBMS_SPACE.UNUSED_SPACE('SCOTT', 'EMP', 'TABLE', :total_blocks, -
>    :total_bytes,:unused_blocks, :unused_bytes, :lastextf, -
>    :last_extb, :lastusedblock);

PL/SQL procedure successfully completed.

SQL> PRINT

TOTAL_BLOCKS
------------
           5

TOTAL_BYTES
-----------
      10240

...

LASTUSEDBLOCK
-------------
            3
```

Schema Objects Space Usage Data Dictionary Views

These views display information about space usage in schema objects:

View	Description
`DBA_SEGMENTS` `USER_SEGMENTS`	DBA view describes storage allocated for all database segments. User view describes storage allocated for segments for the current user.
`DBA_EXTENTS` `USER_EXTENTS`	DBA view describes extents comprising all segments in the database. User view describes extents comprising segments for the current user.
`DBA_FREE_SPACE` `USER_FREE_SPACE`	DBA view lists free extents in all tablespaces. User view shows free space information for tablespaces for which the user has quota.

The following sections contain examples of using some of these views.

> **See Also:** *Oracle Database Reference* for a complete description of data dictionary views

Example 1: Displaying Segment Information

The following query returns the name and size of each index segment in schema `hr`:

```
SELECT SEGMENT_NAME, TABLESPACE_NAME, BYTES, BLOCKS, EXTENTS
```

```
    FROM DBA_SEGMENTS
    WHERE SEGMENT_TYPE = 'INDEX'
    AND OWNER='HR'
    ORDER BY SEGMENT_NAME;
```

The query output is:

```
SEGMENT_NAME              TABLESPACE_NAME    BYTES BLOCKS EXTENTS
------------------------- --------------- -------- ------ -------
COUNTRY_C_ID_PK           EXAMPLE            65536     32       1
DEPT_ID_PK                EXAMPLE            65536     32       1
DEPT_LOCATION_IX          EXAMPLE            65536     32       1
EMP_DEPARTMENT_IX         EXAMPLE            65536     32       1
EMP_EMAIL_UK              EXAMPLE            65536     32       1
EMP_EMP_ID_PK             EXAMPLE            65536     32       1
EMP_JOB_IX                EXAMPLE            65536     32       1
EMP_MANAGER_IX            EXAMPLE            65536     32       1
EMP_NAME_IX               EXAMPLE            65536     32       1
JHIST_DEPARTMENT_IX       EXAMPLE            65536     32       1
JHIST_EMPLOYEE_IX         EXAMPLE            65536     32       1
JHIST_EMP_ID_ST_DATE_PK   EXAMPLE            65536     32       1
JHIST_JOB_IX              EXAMPLE            65536     32       1
JOB_ID_PK                 EXAMPLE            65536     32       1
LOC_CITY_IX               EXAMPLE            65536     32       1
LOC_COUNTRY_IX            EXAMPLE            65536     32       1
LOC_ID_PK                 EXAMPLE            65536     32       1
LOC_STATE_PROVINCE_IX     EXAMPLE            65536     32       1
REG_ID_PK                 EXAMPLE            65536     32       1

19 rows selected.
```

Example 2: Displaying Extent Information

Information about the currently allocated extents in a database is stored in the `DBA_EXTENTS` data dictionary view. For example, the following query identifies the extents allocated to each index segment in the `hr` schema and the size of each of those extents:

```
SELECT SEGMENT_NAME, SEGMENT_TYPE, TABLESPACE_NAME, EXTENT_ID, BYTES, BLOCKS
    FROM DBA_EXTENTS
    WHERE SEGMENT_TYPE = 'INDEX'
    AND OWNER='HR'
    ORDER BY SEGMENT_NAME;
```

The query output is:

```
SEGMENT_NAME              SEGMENT_TYPE TABLESPACE_NAME EXTENT_ID    BYTES BLOCKS
------------------------- ------------ --------------- --------- -------- ------
COUNTRY_C_ID_PK           INDEX        EXAMPLE                 0    65536     32
DEPT_ID_PK                INDEX        EXAMPLE                 0    65536     32
DEPT_LOCATION_IX          INDEX        EXAMPLE                 0    65536     32
EMP_DEPARTMENT_IX         INDEX        EXAMPLE                 0    65536     32
EMP_EMAIL_UK              INDEX        EXAMPLE                 0    65536     32
EMP_EMP_ID_PK             INDEX        EXAMPLE                 0    65536     32
EMP_JOB_IX                INDEX        EXAMPLE                 0    65536     32
EMP_MANAGER_IX            INDEX        EXAMPLE                 0    65536     32
EMP_NAME_IX               INDEX        EXAMPLE                 0    65536     32
JHIST_DEPARTMENT_IX       INDEX        EXAMPLE                 0    65536     32
JHIST_EMPLOYEE_IX         INDEX        EXAMPLE                 0    65536     32
JHIST_EMP_ID_ST_DATE_PK   INDEX        EXAMPLE                 0    65536     32
JHIST_JOB_IX              INDEX        EXAMPLE                 0    65536     32
```

```
JOB_ID_PK                 INDEX        EXAMPLE                0    65536     32
LOC_CITY_IX               INDEX        EXAMPLE                0    65536     32
LOC_COUNTRY_IX            INDEX        EXAMPLE                0    65536     32
LOC_ID_PK                 INDEX        EXAMPLE                0    65536     32
LOC_STATE_PROVINCE_IX     INDEX        EXAMPLE                0    65536     32
REG_ID_PK                 INDEX        EXAMPLE                0    65536     32

19 rows selected.
```

For the `hr` schema, no segment has more than one extent allocated to it.

Example 3: Displaying the Free Space (Extents) in a Tablespace

Information about the free extents (extents not allocated to any segment) in a database is stored in the `DBA_FREE_SPACE` data dictionary view. For example, the following query reveals the amount of free space available as free extents in the `SMUNDO` tablespace:

```
SELECT TABLESPACE_NAME, FILE_ID, BYTES, BLOCKS
    FROM DBA_FREE_SPACE
    WHERE TABLESPACE_NAME='SMUNDO';
```

The query output is:

```
TABLESPACE_NAME  FILE_ID    BYTES BLOCKS
--------------- -------- -------- ------
SMUNDO                 3    65536     32
SMUNDO                 3    65536     32
SMUNDO                 3    65536     32
SMUNDO                 3    65536     32
SMUNDO                 3    65536     32
SMUNDO                 3    65536     32
SMUNDO                 3   131072     64
SMUNDO                 3   131072     64
SMUNDO                 3    65536     32
SMUNDO                 3  3407872   1664

10 rows selected.
```

Example 4: Displaying Segments that Cannot Allocate Additional Extents

It is possible that a segment cannot be allocated to an extent for any of the following reasons:

- The tablespace containing the segment does not have enough room for the next extent.
- The segment has the maximum number of extents.
- The segment has the maximum number of extents allowed by the data block size, which is operating system specific.

The following query returns the names, owners, and tablespaces of all segments that satisfy any of these criteria:

```
SELECT a.SEGMENT_NAME, a.SEGMENT_TYPE, a.TABLESPACE_NAME, a.OWNER
    FROM DBA_SEGMENTS a
    WHERE a.NEXT_EXTENT >= (SELECT MAX(b.BYTES)
        FROM DBA_FREE_SPACE b
        WHERE b.TABLESPACE_NAME = a.TABLESPACE_NAME)
    OR a.EXTENTS = a.MAX_EXTENTS
    OR a.EXTENTS = 'data_block_size' ;
```

Note: When you use this query, replace *`data_block_size`* with the data block size for your system.

Once you have identified a segment that cannot allocate additional extents, you can solve the problem in either of two ways, depending on its cause:

- If the tablespace is full, add a datafile to the tablespace or extend the existing datafile.
- If the segment has too many extents, and you cannot increase `MAXEXTENTS` for the segment, perform the following steps.
  1. Export the data in the segment
  2. Drop and re-create the segment, giving it a larger `INITIAL` storage parameter setting so that it does not need to allocate so many extents. Alternatively, you can adjust the `PCTINCREASE` and `NEXT` storage parameters to allow for more space in the segment.
  3. Import the data back into the segment.

Capacity Planning for Database Objects

Oracle Database provides two ways to plan capacity for database objects:

- With Enterprise Manager
- With the `DBMS_SPACE` PL/SQL package

This section discusses the PL/SQL method. Refer to Enterprise Manager online help and *Oracle Database 2 Day DBA* for details on capacity planning with Enterprise Manager.

Three procedures in the `DBMS_SPACE` package enable you to predict the size of new objects and monitor the size of existing database objects. This section discusses those procedures and contains the following sections:

- Estimating the Space Use of a Table
- Estimating the Space Use of an Index
- Obtaining Object Growth Trends

Estimating the Space Use of a Table

The size of a database table can vary greatly depending on tablespace storage attributes, tablespace block size, and many other factors. The `CREATE_TABLE_COST` procedure of the `DBMS_SPACE` package lets you estimate the space use cost of creating a table. Please refer to *Oracle Database PL/SQL Packages and Types Reference* for details on the parameters of this procedure.

The procedure has two variants. The first variant uses average row size to estimate size. The second variant uses column information to estimate table size. Both variants require as input the following values:

- `TABLESPACE_NAME`: The tablespace in which the object will be created. The default is the `SYSTEM` tablespace.
- `ROW_COUNT`: The anticipated number of rows in the table.

- PCT_FREE: The percentage of free space you want to reserve in each block for future expansion of existing rows due to updates.

In addition, the first variant also requires as input a value for AVG_ROW_SIZE, which is the anticipated average row size in bytes.

The second variant also requires for each anticipated column values for COLINFOS, which is an object type comprising the attributes COL_TYPE (the datatype of the column) and COL_SIZE (the number of characters or bytes in the column).

The procedure returns two values:

- USED_BYTES: The actual bytes used by the data, including overhead for block metadata, PCT_FREE space, and so forth.
- ALLOC_BYTES: The amount of space anticipated to be allocated for the object taking into account the tablespace extent characteristics.

Estimating the Space Use of an Index

The CREATE_INDEX_COST procedure of the DBMS_SPACE package lets you estimate the space use cost of creating an index on an existing table.

The procedure requires as input the following values:

- DDL: The CREATE INDEX statement that would create the index. The table specified in this DDL statement must be an existing table.
- [Optional] PLAN_TABLE: The name of the plan table to use. The default is NULL.

The results returned by this procedure depend on statistics gathered on the segment. Therefore, be sure to obtain statistics shortly before executing this procedure. In the absence of recent statistics, the procedure does not issue an error, but it may return inappropriate results. The procedure returns the following values:

- USED_BYTES: The number of bytes representing the actual index data.
- ALLOC_BYTES: The amount of space allocated for the index in the tablespace.

Obtaining Object Growth Trends

The OBJECT_GROWTH_TREND procedure of the DBMS_SPACE package produces a table of one or more rows, where each row describes the space use of the object at a specific time. The procedure retrieves the space use totals from the Automatic Workload Repository or computes current space use and combines it with historic space use changes retrieved from Automatic Workload Repository. Please refer to [ARPLS] for detailed information on the parameters of this procedure.

The procedure requires as input the following values:

- OBJECT_OWNER: The owner of the object.
- OBJECT_NAME: The name of the object.
- PARTITION_NAME: The name of the table or index partition, is relevant. Specify NULL otherwise.
- OBJECT_TYPE: The type of the object.
- START_TIME: A TIMESTAMP value indicating the beginning of the growth trend analysis.
- END_TIME: A TIMESTAMP value indicating the end of the growth trend analysis. The default is "NOW".

- INTERVAL: The length in minutes of the reporting interval during which the procedure should retrieve space use information.
- SKIP_INTERPOLATED: Determines whether the procedure should omit values based on recorded statistics before and after the INTERVAL ('YES') or not ('NO'). This setting is useful when the result table will be displayed as a table rather than a chart, because you can see more clearly how the actual recording interval relates to the requested reporting interval.

The procedure returns a table, each of row of which provides space use information on the object for one interval. If the return table is very large, the results are pipelined so that another application can consume the information as it is being produced. The output table has the following columns:

- TIMEPOINT: A TIMESTAMP value indicating the time of the reporting interval.

  Records are not produced for values of TIME that precede the oldest recorded statistics for the object.
- SPACE_USAGE: The number of bytes actually being used by the object data.
- SPACE_ALLOC: The number of bytes allocated to the object in the tablespace at that time.
- QUALITY: A value indicating how well the requested reporting interval matches the actual recording of statistics. This information is useful because there is no guaranteed reporting interval for object size use statistics, and the actual reporting interval varies over time and from object to object.

  The values of the QUALITY column are:

  – GOOD: The value whenever the value of TIME is based on recorded statistics with a recorded timestamp within 10% of the INTERVAL specified in the input parameters.

  – INTERPOLATED: The value did not meet the criteria for GOOD, but was based on recorded statistics before and after the value of TIME. Current in-memory statistics can be collected across all instances in a cluster and treated as the "recorded" value for the present time.

  – PROJECTION: The value of TIME is in the future as of the time the table was produced. In an Oracle Real Application Clusters environment, the rules for recording statistics allow each instance to choose independently which objects will be selected.

  The output returned by this procedure is an aggregation of values recorded across all instances in a RAC environment. Each value can be computed from a combination of GOOD and INTERPOLATED values. The aggregate value returned is marked GOOD if at least 80% of that value was derived from GOOD instance values.

18 Managing Tables

This chapter describes the various aspects of managing tables, and includes the following topics:

About Tables

Tables are the basic unit of data storage in an Oracle Database. Data is stored in rows and columns. You define a table with a table name, such as `employees`, and a set of columns. You give each column a column name, such as `employee_id`, `last_name`, and `job_id`; a datatype, such as `VARCHAR2`, `DATE`, or `NUMBER`; and a width. The width can be predetermined by the datatype, as in `DATE`. If columns are of the `NUMBER` datatype, define precision and scale instead of width. A row is a collection of column information corresponding to a single record.

You can specify rules for each column of a table. These rules are called integrity constraints. One example is a `NOT NULL` integrity constraint. This constraint forces the column to contain a value in every row.

You can also invoke *transparent data encryption* to encrypt data before storing it. If users attempt to circumvent the database access control mechanisms by looking inside Oracle datafiles directly with operating system tools, encryption prevents these users from viewing sensitive data.

Tables can also include virtual columns. A **virtual column** is like any other table column, except that its value is derived by evaluating an expression. The expression can include columns from the same table, constants, SQL functions, and user-defined PL/SQL functions. You cannot explicitly write to a virtual column.

After you create a table, you insert rows of data using SQL statements or using an Oracle bulk load utility. Table data can then be queried, deleted, or updated using SQL.

See Also:

- *Oracle Database Concepts* for a more detailed description of tables
- *Oracle Database SQL Language Reference* for descriptions of Oracle datatypes
- Chapter 17, "Managing Space for Schema Objects" for guidelines for managing space for tables
- Chapter 16, "Managing Schema Objects" for information on additional aspects of managing tables, such as specifying integrity constraints and analyzing tables
- *Oracle Database Advanced Security Administrator's Guide* for a discussion of transparent data encryption

Guidelines for Managing Tables

This section describes guidelines to follow when managing tables. Following these guidelines can make the management of your tables easier and can improve performance when creating the table, as well as when loading, updating, and querying the table data.

The following topics are discussed:

- Design Tables Before Creating Them
- Consider Your Options for the Type of Table to Create
- Specify the Location of Each Table
- Consider Parallelizing Table Creation
- Consider Using NOLOGGING When Creating Tables
- Consider Using Table Compression
- Consider Encrypting Columns That Contain Sensitive Data
- Estimate Table Size and Plan Accordingly
- Restrictions to Consider When Creating Tables

Design Tables Before Creating Them

Usually, the application developer is responsible for designing the elements of an application, including the tables. Database administrators are responsible for establishing the attributes of the underlying tablespace that will hold the application tables. Either the DBA or the applications developer, or both working jointly, can be responsible for the actual creation of the tables, depending upon the practices for a site.

Working with the application developer, consider the following guidelines when designing tables:

- Use descriptive names for tables, columns, indexes, and clusters.
- Be consistent in abbreviations and in the use of singular and plural forms of table names and columns.
- Document the meaning of each table and its columns with the `COMMENT` command.
- Normalize each table.
- Select the appropriate datatype for each column.
- Consider whether your applications would benefit from adding one or more virtual columns to some tables.
- Define columns that allow nulls last, to conserve storage space.
- Cluster tables whenever appropriate, to conserve storage space and optimize performance of SQL statements.

Before creating a table, you should also determine whether to use integrity constraints. Integrity constraints can be defined on the columns of a table to enforce the business rules of your database automatically.

Consider Your Options for the Type of Table to Create

What types of tables can you create? Here are some choices:

Type of Table	Description
Ordinary (heap-organized) table	This is the basic, general purpose type of table which is the primary subject of this chapter. Its data is stored as an unordered collection (heap)
Clustered table	A clustered table is a table that is part of a cluster. A cluster is a group of tables that share the same data blocks because they share common columns and are often used together. Clusters and clustered tables are discussed in Chapter 20, "Managing Clusters".
Index-organized table	Unlike an ordinary (heap-organized) table, data for an index-organized table is stored in a B-tree index structure in a primary key sorted manner. Besides storing the primary key column values of an index-organized table row, each index entry in the B-tree stores the nonkey column values as well. Index-organized tables are discussed in "Managing Index-Organized Tables" on page 18-47.
Partitioned table	Partitioned tables allow your data to be broken down into smaller, more manageable pieces called partitions, or even subpartitions. Each partition can be managed individually, and can operate independently of the other partitions, thus providing a structure that can be better tuned for availability and performance. Partitioned tables are discussed in *Oracle Database VLDB and Partitioning Guide*.

Specify the Location of Each Table

It is advisable to specify the `TABLESPACE` clause in a `CREATE TABLE` statement to identify the tablespace that is to store the new table. Ensure that you have the appropriate privileges and quota on any tablespaces that you use. If you do not specify a tablespace in a `CREATE TABLE` statement, the table is created in your default tablespace.

When specifying the tablespace to contain a new table, ensure that you understand implications of your selection. By properly specifying a tablespace during the creation of each table, you can increase the performance of the database system and decrease the time needed for database administration.

The following situations illustrate how not specifying a tablespace, or specifying an inappropriate one, can affect performance:

- If users' objects are created in the `SYSTEM` tablespace, the performance of the database can suffer, since both data dictionary objects and user objects must contend for the same datafiles. Users' objects should not be stored in the `SYSTEM` tablespace. To avoid this, ensure that all users are assigned default tablespaces when they are created in the database.
- If application-associated tables are arbitrarily stored in various tablespaces, the time necessary to complete administrative operations (such as backup and recovery) for the data of that application can be increased.

Consider Parallelizing Table Creation

You can utilize parallel execution when creating tables using a subquery (`AS SELECT`) in the `CREATE TABLE` statement. Because multiple processes work together to create the table, performance of the table creation operation is improved.

Parallelizing table creation is discussed in the section "Parallelizing Table Creation" on page 18-11.

Consider Using NOLOGGING When Creating Tables

To create a table most efficiently use the `NOLOGGING` clause in the `CREATE TABLE...AS SELECT` statement. The `NOLOGGING` clause causes minimal redo information to be generated during the table creation. This has the following benefits:

- Space is saved in the redo log files.
- The time it takes to create the table is decreased.
- Performance improves for parallel creation of large tables.

The `NOLOGGING` clause also specifies that subsequent direct loads using SQL*Loader and direct load `INSERT` operations are not logged. Subsequent DML statements (`UPDATE`, `DELETE`, and conventional path insert) are unaffected by the `NOLOGGING` attribute of the table and generate redo.

If you cannot afford to lose the table after you have created it (for example, you will no longer have access to the data used to create the table) you should take a backup immediately after the table is created. In some situations, such as for tables that are created for temporary use, this precaution may not be necessary.

In general, the relative performance improvement of specifying `NOLOGGING` is greater for larger tables than for smaller tables. For small tables, `NOLOGGING` has little effect on the time it takes to create a table. However, for larger tables the performance improvement can be significant, especially when you are also parallelizing the table creation.

Consider Using Table Compression

As your database grows in size to gigabytes or terabytes and beyond, consider using table compression. Table compression saves disk space and reduces memory use in the buffer cache. Table compression can also speed up query execution during reads. There is, however, a cost in CPU overhead for data loading and DML. Table compression is completely transparent to applications. It is especially useful in online analytical processing (OLAP) systems, where there are lengthy read-only operations, but can also be used in online transaction processing (OLTP) systems.

You specify table compression with the `COMPRESS` clause of the `CREATE TABLE` statement. You can enable compression for an existing table by using this clause in an `ALTER TABLE` statement. In this case, the only data that is compressed is the data inserted or updated after compression is enabled. Similarly, you can disable table compression for an existing compressed table with the `ALTER TABLE...NOCOMPRESS` statement. In this case, all data the was already compressed remains compressed, and new data is inserted uncompressed.

You can enable compression for all table operations or you can enable it for direct-path inserts only. To enable compression for all operations you must use the `COMPRESS FOR ALL OPERATIONS` clause. In this case, compression occurs during all DML statements and when data is inserted with a bulk (direct-path) insert operation. To enable compression for conventional DML, you must set the `COMPATIBLE` initialization parameter to 11.1.0 or higher.

To enable compression for direct-path inserts only, you use the `COMPRESS FOR DIRECT_LOAD OPERATIONS` clause. The keyword `COMPRESS` by itself is the same as the clause `COMPRESS FOR DIRECT_LOAD OPERATIONS`, and invokes the same compression behavior as previous database releases.

Examples

The following example enables compression for all operations on the table `transaction`, which is used in an OLTP application:

```
CREATE TABLE transaction ( ... ) COMPRESS FOR ALL OPERATIONS;
```

The next two examples enable compression for direct-path insert only on the `sales_history` table, which is a fact table in a data warehouse:

```
CREATE TABLE sales_history ( ... ) COMPRESS FOR DIRECT_LOAD OPERATIONS;

CREATE TABLE sales_history ( ... ) COMPRESS;
```

Compression and Partitioned Tables

You can enable or disable compression at the partition level. You can therefore have a table with both compressed and uncompressed partitions. If the compression settings for a table and one of its partitions disagree, the partition setting has precedence for the partition. In the following example, all partitions except the `northeast` partition are compressed.

```
CREATE TABLE sales
      (saleskey number,
       quarter number,
       product number,
       salesperson number,
       amount number(12, 2),
       region varchar2(10)) COMPRESS
   PARTITION BY LIST (region)
      (PARTITION northwest VALUES ('NORTHWEST'),
       PARTITION southwest VALUES ('SOUTHWEST'),
       PARTITION northeast VALUES  ('NORTHEAST') NOCOMPRESS,
       PARTITION southeast VALUES ('SOUTHEAST'),
       PARTITION western VALUES ('WESTERN'));
```

Determining If a Table is Compressed

Compressed tables have `ENABLED` in the `COMPRESSION` column of the `*_TABLES` data dictionary views. For partitioned tables, this column is null, and the `COMPRESSION` column of the `*_TAB_PARTITIONS` data dictionary view indicates the partitions that are compressed.

See Also:

- *Oracle Database SQL Language Reference* for more details on the `CREATE TABLE...COMPRESS` and `ALTER TABLE...COMPRESS` statements, including restrictions
- *Oracle Database VLDB and Partitioning Guide* for more information on table partitioning
- "Inserting Data Into Tables Using Direct-Path INSERT" on page 18-15

Consider Encrypting Columns That Contain Sensitive Data

You can encrypt individual table columns that contain sensitive data. Examples of sensitive data include social security numbers, credit card numbers, and medical records. Column encryption is transparent to your applications, with some restrictions.

Although encryption is not meant to solve all security problems, it does protect your data from users who try to circumvent the security features of the database and access database files directly through the operating system file system.

Column encryption uses the transparent data encryption feature of Oracle Database, which requires that you create an *Oracle wallet* to store the master encryption key for the database. The wallet must be open before you can create a table with encrypted columns and before you can store or retrieve encrypted data. When you open the wallet, it is available to all sessions, and it remains open until you explicitly close it or until the database is shut down.

Transparent data encryption supports industry-standard encryption algorithms, including the following Advanced Encryption Standard (AES) and Triple Data Encryption Standard (3DES) algorithms:

- 3DES168
- AES128
- AES192
- AES256

You choose the algorithm to use when you create the table. All encrypted columns in the table use the same algorithm. The default is AES192. The encryption key length is implied by the algorithm name. For example, the AES128 algorithm uses 128-bit keys.

If you plan on encrypting many columns in one or more tables, you may want to consider encrypting an entire tablespace instead and storing these tables in that tablespace. Tablespace encryption, which also uses the transparent data encryption feature but encrypts at the physical block level, can perform better than encrypting many columns. Another reason to encrypt at the tablespace level is to address the following limitations of column encryption:

- If the `COMPATIBLE` initialization parameter set to 10.2.0, which is the minimum setting to enable transparent data encryption, data from encrypted columns that is involved in a sort or hash-join and that must be written to a temporary tablespace is written in clear text, and thus exposed to attacks. You must set `COMPATIBLE` to 11.1.0 or higher to ensure that encrypted data written to a temporary tablespace remains encrypted. Note that as long as `COMPATIBLE` is set to 10.2.0 or higher, data from encrypted columns remains encrypted when written to the undo tablespace or the redo log.
- Certain data types, such as object data types, are not supported for column encryption.
- You cannot use the transportable tablespace feature for a tablespace that includes tables with encrypted columns.
- Other restrictions, which are detailed in *Oracle Database Advanced Security Administrator's Guide*.

See Also:

- "Encrypted Tablespaces" on page 12-8
- "Example: Creating a Table" on page 18-8
- *Oracle Database Advanced Security Administrator's Guide* for more information about transparent data encryption and for instructions for creating and opening wallets
- *Oracle Database SQL Language Reference* for information about the `CREATE TABLE` statement
- *Oracle Real Application Clusters Administration and Deployment Guide* for information on using an Oracle wallet in an Oracle Real Application Clusters environment
- "Transporting Tablespaces Between Databases" on page 12-29

Estimate Table Size and Plan Accordingly

Estimate the sizes of tables before creating them. Preferably, do this as part of database planning. Knowing the sizes, and uses, for database tables is an important part of database planning.

You can use the combined estimated size of tables, along with estimates for indexes, undo space, and redo log files, to determine the amount of disk space that is required to hold an intended database. From these estimates, you can make correct hardware purchases.

You can use the estimated size and growth rate of an individual table to better determine the attributes of a tablespace and its underlying datafiles that are best suited for the table. This can enable you to more easily manage the table disk space and improve I/O performance of applications that use the table.

Restrictions to Consider When Creating Tables

Here are some restrictions that may affect your table planning and usage:

- Tables containing object types cannot be imported into a pre-Oracle8 database.
- You cannot merge an exported table into a preexisting table having the same name in a different schema.

- You cannot move types and extent tables to a different schema when the original data still exists in the database.
- Oracle Database has a limit on the total number of columns that a table (or attributes that an object type) can have. See *Oracle Database Reference* for this limit.

  Further, when you create a table that contains user-defined type data, the database maps columns of user-defined type to relational columns for storing the user-defined type data. This causes additional relational columns to be created. This results in "hidden" relational columns that are not visible in a `DESCRIBE` table statement and are not returned by a `SELECT *` statement. Therefore, when you create an object table, or a relational table with columns of `REF`, varray, nested table, or object type, be aware that the total number of columns that the database actually creates for the table can be more than those you specify.

> **See Also:** *Oracle Database Object-Relational Developer's Guide* for more information about user-defined types

Creating Tables

To create a new table in your schema, you must have the `CREATE TABLE` system privilege. To create a table in another user's schema, you must have the `CREATE ANY TABLE` system privilege. Additionally, the owner of the table must have a quota for the tablespace that contains the table, or the `UNLIMITED TABLESPACE` system privilege.

Create tables using the SQL statement `CREATE TABLE`.

This section contains the following topics:

- Example: Creating a Table
- Creating a Temporary Table
- Parallelizing Table Creation

> **See Also:** *Oracle Database SQL Language Reference* for exact syntax of the `CREATE TABLE` and other SQL statements discussed in this chapter

Example: Creating a Table

When you issue the following statement, you create a table named `admin_emp` in the `hr` schema and store it in the `admin_tbs` tablespace with an initial extent size of 50K:

```
CREATE TABLE hr.admin_emp (
         empno      NUMBER(5) PRIMARY KEY,
         ename      VARCHAR2(15) NOT NULL,
         ssn        NUMBER(9) ENCRYPT,
         job        VARCHAR2(10),
         mgr        NUMBER(5),
         hiredate   DATE DEFAULT (sysdate),
         photo      BLOB,
         sal        NUMBER(7,2),
         hrly_rate  NUMBER(7,2) GENERATED ALWAYS AS (sal/2080),
         comm       NUMBER(7,2),
         deptno     NUMBER(3) NOT NULL
                     CONSTRAINT admin_dept_fkey REFERENCES hr.departments
                     (department_id))
   TABLESPACE admin_tbs
   STORAGE ( INITIAL 50K);
```

Note the following about this example:

- Integrity constraints are defined on several columns of the table.
- Encryption is defined on one column (`ssn`), through the transparent data encryption feature of Oracle Database. The Oracle Wallet must therefore be open for this `CREATE TABLE` statement to succeed.
- The `photo` column is of data type `BLOB`, which is a member of the set of data types called large objects (LOBs). LOBs are used to store semi-structured data (such as an XML tree) and unstructured data (such as the stream of bits in a color image).
- One column is defined as a virtual column (`hrly_rate`). This column computes the employee's hourly rate as the yearly salary divided by 2,080.

See Also:

- *Oracle Database SQL Language Reference* for a description of the datatypes that can be specified for columns
- "Managing Integrity Constraints" on page 16-9
- *Oracle Database Advanced Security Administrator's Guide* for information on transparent data encryption and the Oracle Wallet
- *Oracle Database SecureFiles and Large Objects Developer's Guide* for more information on LOBs.
- *Oracle Database SQL Language Reference* for information on rules for virtual columns

Creating a Temporary Table

Temporary tables are useful in applications where a result set is to be buffered (temporarily persisted), perhaps because it is constructed by running multiple DML operations. For example, consider the following:

A Web-based airlines reservations application allows a customer to create several optional itineraries. Each itinerary is represented by a row in a temporary table. The application updates the rows to reflect changes in the itineraries. When the customer decides which itinerary she wants to use, the application moves the row for that itinerary to a persistent table.

During the session, the itinerary data is private. At the end of the session, the optional itineraries are dropped.

The definition of a temporary table is visible to all sessions, but the data in a temporary table is visible only to the session that inserts the data into the table.

Use the `CREATE GLOBAL TEMPORARY TABLE` statement to create a temporary table. The `ON COMMIT` clause indicates if the data in the table is **transaction-specific** (the default) or **session-specific**, the implications of which are as follows:

ON COMMIT Setting	Implications
`DELETE ROWS`	This creates a temporary table that is transaction specific. A session becomes bound to the temporary table with a transactions first insert into the table. The binding goes away at the end of the transaction. The database truncates the table (delete all rows) after each commit.

ON COMMIT Setting	Implications
PRESERVE ROWS	This creates a temporary table that is session specific. A session gets bound to the temporary table with the first insert into the table in the session. This binding goes away at the end of the session or by issuing a TRUNCATE of the table in the session. The database truncates the table when you terminate the session.

This statement creates a temporary table that is transaction specific:

```
CREATE GLOBAL TEMPORARY TABLE admin_work_area
        (startdate DATE,
         enddate DATE,
         class CHAR(20))
      ON COMMIT DELETE ROWS;
```

Indexes can be created on temporary tables. They are also temporary and the data in the index has the same session or transaction scope as the data in the underlying table.

By default, rows in a temporary table are stored in the default temporary tablespace of the user who creates it. However, you can assign a temporary table to another tablespace upon creation of the temporary table by using the TABLESPACE clause of CREATE GLOBAL TEMPORARY TABLE. You can use this feature to conserve space used by temporary tables. For example, if you need to perform many small temporary table operations and the default temporary tablespace is configured for sort operations and thus uses a large extent size, these small operations will consume lots of unnecessary disk space. In this case it is better to allocate a second temporary tablespace with a smaller extent size.

The following two statements create a temporary tablespace with a 64 KB extent size, and then a new temporary table in that tablespace.

```
CREATE TEMPORARY TABLESPACE tbs_t1
    TEMPFILE 'tbs_t1.f' SIZE 50m REUSE AUTOEXTEND ON
    MAXSIZE UNLIMITED
    EXTENT MANAGEMENT LOCAL UNIFORM SIZE 64K;

CREATE GLOBAL TEMPORARY TABLE admin_work_area
        (startdate DATE,
         enddate DATE,
         class CHAR(20))
      ON COMMIT DELETE ROWS
      TABLESPACE tbs_t1;
```

See Also: "Temporary Tablespaces" on page 12-10

Unlike permanent tables, temporary tables and their indexes do not automatically allocate a segment when they are created. Instead, segments are allocated when the first INSERT (or CREATE TABLE AS SELECT) is performed. This means that if a SELECT, UPDATE, or DELETE is performed before the first INSERT, the table appears to be empty.

DDL operations (except TRUNCATE) are allowed on an existing temporary table only if no session is currently bound to that temporary table.

If you rollback a transaction, the data you entered is lost, although the table definition persists.

A transaction-specific temporary table allows only one transaction at a time. If there are several autonomous transactions in a single transaction scope, each autonomous transaction can use the table only as soon as the previous one commits.

Because the data in a temporary table is, by definition, temporary, backup and recovery of temporary table data is not available in the event of a system failure. To prepare for such a failure, you should develop alternative methods for preserving temporary table data.

Parallelizing Table Creation

When you specify the `AS SELECT` clause to create a table and populate it with data from another table, you can utilize parallel execution. The `CREATE TABLE...AS SELECT` statement contains two parts: a `CREATE` part (DDL) and a `SELECT` part (query). Oracle Database can parallelize both parts of the statement. The `CREATE` part is parallelized if *one* of the following is true:

- A `PARALLEL` clause is included in the `CREATE TABLE...AS SELECT` statement
- An `ALTER SESSION FORCE PARALLEL DDL` statement is specified

The query part is parallelized if *all* of the following are true:

- The query includes a parallel hint specification (`PARALLEL` or `PARALLEL_INDEX`) *or* the `CREATE` part includes the `PARALLEL` clause *or* the schema objects referred to in the query have a `PARALLEL` declaration associated with them.
- At least one of the tables specified in the query requires either a full table scan *or* an index range scan spanning multiple partitions.

If you parallelize the creation of a table, that table then has a parallel declaration (the `PARALLEL` clause) associated with it. Any subsequent DML or queries on the table, for which parallelization is possible, will attempt to use parallel execution.

The following simple statement parallelizes the creation of a table and stores the result in a compressed format, using table compression:

```
CREATE TABLE hr.admin_emp_dept
     PARALLEL COMPRESS
     AS SELECT * FROM hr.employees
     WHERE department_id = 10;
```

In this case, the `PARALLEL` clause tells the database to select an optimum number of parallel execution servers when creating the table.

See Also:

- *Oracle Database Concepts* for more information about parallel execution
- *Oracle Database Data Warehousing Guide* for a detailed discussion about using parallel execution
- "Managing Processes for Parallel SQL Execution" on page 4-19

Loading Tables

There are several means of inserting or initially loading data into your tables. Most commonly used are the following:

Method	Description
SQL*Loader	This Oracle utility program loads data from external files into tables of an Oracle Database. For information about SQL*Loader, see *Oracle Database Utilities*.
`CREATE TABLE` ... `AS SELECT` statement (CTAS)	Using this SQL statement you can create a table and populate it with data selected from another existing table.
`INSERT` statement	The `INSERT` statement enables you to add rows to a table, either by specifying the column values or by specifying a subquery that selects data from another existing table.
`MERGE` statement	The `MERGE` statement enables you to insert rows into or update rows of a table, by selecting rows from another existing table. If a row in the new data corresponds to an item that already exists in the table, then an `UPDATE` is performed, else an `INSERT` is performed.

See *Oracle Database SQL Language Reference* for details on the `CREATE TABLE` ... `AS SELECT`, `INSERT`, and `MERGE` statements.

Inserting Data with DML Error Logging

When you load a table using an `INSERT` statement with subquery, if an error occurs, the statement is terminated and rolled back in its entirety. This can be wasteful of time and system resources. For such `INSERT` statements, you can avoid this situation by using the DML error logging feature.

To use DML error logging, you add a statement clause that specifies the name of an error logging table into which the database records errors encountered during DML operations. When you add this error logging clause to the `INSERT` statement, certain types of errors no longer terminate and roll back the statement. Instead, each error is logged and the statement continues. You then take corrective action on the erroneous rows at a later time.

DML error logging works with `INSERT`, `UPDATE`, `MERGE`, and `DELETE` statements. This section focuses on `INSERT` statements.

To insert data with DML error logging:

1. Create an error logging table. (Optional)

   You can create the table manually or use the `DBMS_ERRLOG` package to automatically create it for you. See "Creating an Error Logging Table" on page 18-14 for details.

2. Execute an `INSERT` statement and include an error logging clause. This clause:

   - Optionally references the error logging table that you created. If you do not provide an error logging table name, the database logs to an error logging table with a default name. The default error logging table name is `ERR$_` followed by the first 25 characters of the name of the table that is being inserted into.

   - Optionally includes a **tag** (a numeric or string literal in parentheses) that gets added to the error log to help identify the statement that caused the errors. If the tag is omitted, a `NULL` value is used.

   - Optionally includes a `REJECT LIMIT` subclause.

This subclause indicates the maximum number of errors that can be encountered before the INSERT statement terminates and rolls back. You can also specify UNLIMITED. The default reject limit is zero, which means that upon encountering the first error, the error is logged and the statement rolls back. For parallel DML operations, the reject limit is applied to each parallel server.

Note: If the statement exceeds the reject limit and rolls back, the error logging table retains the log entries recorded so far.

See *Oracle Database SQL Language Reference* for error logging clause syntax information.

3. Query the error logging table and take corrective action for the rows that generated errors.

   See "Error Logging Table Format", later in this section, for details on the error logging table structure.

Example The following statement inserts rows into the DW_EMPL table and logs errors to the ERR_EMPL table. The tag 'daily_load' is copied to each log entry. The statement terminates and rolls back if the number of errors exceeds 25.

```
INSERT INTO dw_empl
  SELECT employee_id, first_name, last_name, hire_date, salary, department_id
  FROM employees
  WHERE hire_date > sysdate - 7
  LOG ERRORS INTO err_empl ('daily_load') REJECT LIMIT 25
```

For more examples, see *Oracle Database SQL Language Reference* and *Oracle Database Data Warehousing Guide*.

Error Logging Table Format

The error logging table consists of two parts:

- A mandatory set of columns that describe the error. For example, one column contains the Oracle error number.

  Table 18–1 lists these error description columns.

- An optional set of columns that contain data from the row that caused the error. The column names match the column names from the table being inserted into (the "DML table").

  The number of columns in this part of the error logging table can be zero, one, or more, up to the number of columns in the DML table. If a column exists in the error logging table that has the same name as a column in the DML table, the corresponding data from the offending row being inserted is written to this error logging table column. If a DML table column does not have a corresponding column in the error logging table, the column is not logged. If the error logging table contains a column with a name that does not match a DML table column, the column is ignored.

  Because type conversion errors are one type of error that might occur, the data types of the optional columns in the error logging table must be types that can capture any value without data loss or conversion errors. (If the optional log columns were of the same types as the DML table columns, capturing the problematic data into the log could suffer the same data conversion problem that caused the error.) The database makes a best effort to log a meaningful value for data that causes conversion errors. If a value cannot be derived, `NULL` is logged for the column. An error on insertion into the error logging table causes the statement to terminate.

Table 18–2 lists the recommended error logging table column data types to use for each data type from the DML table. These recommended data types are used when you create the error logging table automatically with the `DBMS_ERRLOG` package.

Table 18–1 Mandatory Error Description Columns

Column Name	Data Type	Description
`ORA_ERR_NUMBER$`	`NUMBER`	Oracle error number
`ORA_ERR_MESG$`	`VARCHAR2(2000)`	Oracle error message text
`ORA_ERR_ROWID$`	`ROWID`	Rowid of the row in error (for update and delete)
`ORA_ERR_OPTYP$`	`VARCHAR2(2)`	Type of operation: insert (`I`), update (`U`), delete (`D`) Note: Errors from the update clause and insert clause of a `MERGE` operation are distinguished by the `U` and `I` values.
`ORA_ERR_TAG$`	`VARCHAR2(2000)`	Value of the tag supplied by the user in the error logging clause

Table 18–2 Error Logging Table Column Data Types

DML Table Column Type	Error Logging Table Column Type	Notes
`NUMBER`	`VARCHAR2(4000)`	Able to log conversion errors
`CHAR/VARCHAR2(n)`	`VARCHAR2(4000)`	Logs any value without information loss
`NCHAR/NVARCHAR2(n)`	`NVARCHAR2(4000)`	Logs any value without information loss
`DATE/TIMESTAMP`	`VARCHAR2(4000)`	Logs any value without information loss. Converts to character format with the default date/time format mask
`RAW`	`RAW(2000)`	Logs any value without information loss
`ROWID`	`UROWID`	Logs any rowid type
`LONG/LOB`		Not supported
User-defined types		Not supported

Creating an Error Logging Table

You can create an error logging table manually, or you can use a PL/SQL package to automatically create one for you.

Creating an Error Logging Table Automatically You use the `DBMS_ERRLOG` package to automatically create an error logging table. The `CREATE_ERROR_LOG` procedure creates an error logging table with all of the mandatory error description columns plus all of the columns from the named DML table, and performs the data type mappings shown in Table 18–2.

The following statement creates the error logging table used in the previous example.

```
EXECUTE DBMS_ERRLOG.CREATE_ERROR_LOG('DW_EMPL', 'ERR_EMPL');
```

See *Oracle Database PL/SQL Packages and Types Reference* for details on DBMS_ERRLOG.

Creating an Error Logging Table Manually You use standard DDL to manually create the error logging table. See "Error Logging Table Format" on page 18-13 for table structure requirements. You must include all mandatory error description columns. They can be in any order, but must be the first columns in the table.

Error Logging Restrictions and Caveats

Oracle Database logs the following errors during DML operations:

- Column values that are too large
- Constraint violations (NOT NULL, unique, referential, and check constraints)
- Errors raised during trigger execution
- Errors resulting from type conversion between a column in a subquery and the corresponding column of the table
- Partition mapping errors
- Certain MERGE operation errors (ORA-30926: Unable to get a stable set of rows for MERGE operation.)

Some errors are not logged, and cause the DML operation to terminate and roll back. For a list of these errors and for other DML logging restrictions, see the discussion of the error_logging_clause in the INSERT section of *Oracle Database SQL Language Reference*.

Space Considerations Ensure that you consider space requirements before using DML error logging. You require available space not only for the table being inserted into, but also for the error logging table.

Security The user who issues the INSERT statement with DML error logging must have INSERT privileges on the error logging table.

> **See Also:** *Oracle Database SQL Language Reference* and *Oracle Database Data Warehousing Guide* for DML error logging examples.

Inserting Data Into Tables Using Direct-Path INSERT

Oracle Database inserts data into a table in one of two ways:

- During **conventional INSERT operations**, the database reuses free space in the table, interleaving newly inserted data with existing data. During such operations, the database also maintains referential integrity constraints.
- During **direct-path INSERT operations**, the database appends the inserted data after existing data in the table. Data is written directly into datafiles, bypassing the buffer cache. Free space in the existing data is not reused, and referential integrity constraints are ignored. These procedures combined can enhance performance.

Further, the data can be inserted either in serial mode, where one process executes the statement, or parallel mode, where multiple processes work together simultaneously to run a single SQL statement. The latter is referred to as parallel execution.

This section discusses one aspect of inserting data into tables. Specifically, using the direct-path form of the INSERT statement. It contains the following topics:

- Advantages of Using Direct-Path INSERT
- Enabling Direct-Path INSERT
- How Direct-Path INSERT Works
- Specifying the Logging Mode for Direct-Path INSERT
- Additional Considerations for Direct-Path INSERT

Note: Only a few details and examples of inserting data into tables are included in this book. Oracle documentation specific to data warehousing and application development provide more extensive information about inserting and manipulating data in tables. For example:

- *Oracle Database Data Warehousing Guide*
- *Oracle Database Advanced Application Developer's Guide*
- *Oracle Database SecureFiles and Large Objects Developer's Guide*

Advantages of Using Direct-Path INSERT

The following are performance benefits of direct-path `INSERT`:

- During direct-path `INSERT`, you can disable the logging of redo and undo entries. Conventional insert operations, in contrast, must always log such entries, because those operations reuse free space and maintain referential integrity.
- To create a new table with data from an existing table, you have the choice of creating the new table and then inserting into it, or executing a `CREATE TABLE` ... `AS SELECT` statement. By creating the table and then using direct-path `INSERT` operations, you update any indexes defined on the target table during the insert operation. The table resulting from a `CREATE TABLE` ... `AS SELECT` statement, in contrast, does not have any indexes defined on it; you must define them later.
- Direct-path `INSERT` operations ensure atomicity of the transaction, even when run in parallel mode. Atomicity cannot be guaranteed during parallel direct-path loads (using SQL*Loader).
- If errors occur during parallel direct-path loads, some indexes could be marked `UNUSABLE` at the end of the load. Parallel direct-path `INSERT`, in contrast, rolls back the statement if errors occur during index update.
- Direct-path `INSERT` must be used if you want to store the data in compressed form using table compression.

Enabling Direct-Path INSERT

You can implement direct-path `INSERT` operations by using direct-path `INSERT` statements, inserting data in parallel mode, or by using the Oracle SQL*Loader utility in direct-path mode. Direct-path inserts can be done in either serial or parallel mode.

To activate direct-path `INSERT` in serial mode, you must specify the `APPEND` hint in each `INSERT` statement, either immediately after the `INSERT` keyword, or immediately after the `SELECT` keyword in the subquery of the `INSERT` statement.

When you are inserting in parallel DML mode, direct-path `INSERT` is the default. In order to run in parallel DML mode, the following requirements must be met:

- You must have Oracle Enterprise Edition installed.

- You must enable parallel DML in your session. To do this, run the following statement:

  ```
  ALTER SESSION { ENABLE | FORCE } PARALLEL DML;
  ```

- You must specify the parallel attribute for the target table, either at create time or subsequently, or you must specify the `PARALLEL` hint for each insert operation.

To disable direct-path `INSERT`, specify the `NOAPPEND` hint in each `INSERT` statement. Doing so overrides parallel DML mode.

Notes:

- Direct-path `INSERT` supports only the subquery syntax of the `INSERT` statement, not the `VALUES` clause. For more information on the subquery syntax of `INSERT` statements, see *Oracle Database SQL Language Reference*.
- There are some additional restrictions for using direct-path `INSERT`. These are listed in the *Oracle Database SQL Language Reference*.

See Also: *Oracle Database Performance Tuning Guide* for more information on using hints

How Direct-Path INSERT Works

You can use direct-path `INSERT` on both partitioned and non-partitioned tables.

Serial Direct-Path INSERT into Partitioned or Non-partitioned Tables The single process inserts data beyond the current high water mark of the table segment or of each partition segment. (The **high-water mark** is the level at which blocks have never been formatted to receive data.) When a `COMMIT` runs, the high-water mark is updated to the new value, making the data visible to users.

Parallel Direct-Path INSERT into Partitioned Tables This situation is analogous to serial direct-path `INSERT`. Each parallel execution server is assigned one or more partitions, with no more than one process working on a single partition. Each parallel execution server inserts data beyond the current high-water mark of its assigned partition segment(s). When a `COMMIT` runs, the high-water mark of each partition segment is updated to its new value, making the data visible to users.

Parallel Direct-Path INSERT into Non-partitioned Tables Each parallel execution server allocates a new temporary segment and inserts data into that temporary segment. When a `COMMIT` runs, the parallel execution coordinator merges the new temporary segments into the primary table segment, where it is visible to users.

Specifying the Logging Mode for Direct-Path INSERT

Direct-path `INSERT` lets you choose whether to log redo and undo information during the insert operation.

- You can specify logging mode for a table, partition, index, or `LOB` storage at create time (in a `CREATE` statement) or subsequently (in an `ALTER` statement).
- If you do not specify either `LOGGING` or `NOLOGGING` at these times:
  - The logging attribute of a partition defaults to the logging attribute of its table.

  - The logging attribute of a table or index defaults to the logging attribute of the tablespace in which it resides.
  - The logging attribute of LOB storage defaults to LOGGING if you specify CACHE for LOB storage. If you do not specify CACHE, then the logging attributes defaults to that of the tablespace in which the LOB values resides.
- You set the logging attribute of a tablespace in a CREATE TABLESPACE or ALTER TABLESPACE statements.

> **Note:** If the database or tablespace is in FORCE LOGGING mode, then direct path INSERT always logs, regardless of the logging setting.

Direct-Path INSERT with Logging In this mode, Oracle Database performs full redo logging for instance and media recovery. If the database is in ARCHIVELOG mode, then you can archive redo logs to tape. If the database is in NOARCHIVELOG mode, then you can recover instance crashes but not disk failures.

Direct-Path INSERT without Logging In this mode, Oracle Database inserts data without redo or undo logging. (Some minimal logging is done to mark new extents invalid, and data dictionary changes are always logged.) This mode improves performance. However, if you subsequently must perform media recovery, the extent invalidation records mark a range of blocks as logically corrupt, because no redo data was logged for them. Therefore, it is important that you back up the data after such an insert operation.

Additional Considerations for Direct-Path INSERT

The following are some additional considerations when using direct-path INSERT.

Index Maintenance with Direct-Path INSERT Oracle Database performs index maintenance at the end of direct-path INSERT operations on tables (partitioned or non-partitioned) that have indexes. This index maintenance is performed by the parallel execution servers for parallel direct-path INSERT or by the single process for serial direct-path INSERT. You can avoid the performance impact of index maintenance by dropping the index before the INSERT operation and then rebuilding it afterward.

Space Considerations with Direct-Path INSERT Direct-path INSERT requires more space than conventional-path INSERT.

All serial direct-path INSERT operations, as well as parallel direct-path INSERT into partitioned tables, insert data above the high-water mark of the affected segment. This requires some additional space.

Parallel direct-path INSERT into non-partitioned tables requires even more space, because it creates a temporary segment for each degree of parallelism. If the non-partitioned table is not in a locally managed tablespace in automatic segment-space management mode, you can modify the values of the NEXT and PCTINCREASE storage parameter and MINIMUM EXTENT tablespace parameter to provide sufficient (but not excess) storage for the temporary segments. Choose values for these parameters so that:

- The size of each extent is not too small (no less than 1 MB). This setting affects the total number of extents in the object.

- The size of each extent is not so large that the parallel INSERT results in wasted space on segments that are larger than necessary.

After the direct-path INSERT operation is complete, you can reset these parameters to settings more appropriate for serial operations.

Locking Considerations with Direct-Path INSERT During direct-path INSERT, the database obtains exclusive locks on the table (or on all partitions of a partitioned table). As a result, users cannot perform any concurrent insert, update, or delete operations on the table, and concurrent index creation and build operations are not permitted. Concurrent queries, however, are supported, but the query will return only the information before the insert operation.

Automatically Collecting Statistics on Tables

The PL/SQL package DBMS_STATS lets you generate and manage statistics for cost-based optimization. You can use this package to gather, modify, view, export, import, and delete statistics. You can also use this package to identify or name statistics that have been gathered.

Formerly, you enabled DBMS_STATS to automatically gather statistics for a table by specifying the MONITORING keyword in the CREATE (or ALTER) TABLE statement. Starting with Oracle Database 11*g*, the MONITORING and NOMONITORING keywords have been deprecated and statistics are collected automatically. If you do specify these keywords, they are ignored.

Monitoring tracks the approximate number of INSERT, UPDATE, and DELETE operations for the table since the last time statistics were gathered. Information about how many rows are affected is maintained in the SGA, until periodically (about every three hours) SMON incorporates the data into the data dictionary. This data dictionary information is made visible through the DBA_TAB_MODIFICATIONS,ALL_TAB_MODIFICATIONS, or USER_TAB_MODIFICATIONS views. The database uses these views to identify tables with stale statistics.

To disable monitoring of a table, set the STATISTICS_LEVEL initialization parameter to BASIC. Its default is TYPICAL, which enables automatic statistics collection. Automatic statistics collection and the DBMS_STATS package enable the optimizer to generate accurate execution plans.

See Also:

- *Oracle Database Reference* for detailed information on the STATISTICS_LEVEL initialization parameter
- *Oracle Database Performance Tuning Guide* for information on managing optimizer statistics
- *Oracle Database PL/SQL Packages and Types Reference* for information about using the DBMS_STATS package
- "About Automated Maintenance Tasks" on page 24-1 for information on using the Scheduler to collect statistics automatically

Altering Tables

You alter a table using the `ALTER TABLE` statement. To alter a table, the table must be contained in your schema, or you must have either the `ALTER` object privilege for the table or the `ALTER ANY TABLE` system privilege.

Many of the usages of the `ALTER TABLE` statement are presented in the following sections:

- Reasons for Using the ALTER TABLE Statement
- Altering Physical Attributes of a Table
- Moving a Table to a New Segment or Tablespace
- Manually Allocating Storage for a Table
- Modifying an Existing Column Definition
- Adding Table Columns
- Renaming Table Columns
- Dropping Table Columns
- Placing a Table in Read-Only Mode

Caution: Before altering a table, familiarize yourself with the consequences of doing so. The *Oracle Database SQL Language Reference* lists many of these consequences in the descriptions of the `ALTER TABLE` clauses.

If a view, materialized view, trigger, domain index, function-based index, check constraint, function, procedure of package depends on a base table, the alteration of the base table or its columns can affect the dependent object. See "Managing Object Dependencies" on page 16-17 for information about how the database manages dependencies.

Reasons for Using the ALTER TABLE Statement

You can use the ALTER TABLE statement to perform any of the following actions that affect a table:

- Modify physical characteristics (`INITRANS` or storage parameters)
- Move the table to a new segment or tablespace
- Explicitly allocate an extent or deallocate unused space
- Add, drop, or rename columns, or modify an existing column definition (datatype, length, default value, `NOT NULL` integrity constraint, column expression (for virtual columns), and encryption properties.)
- Modify the logging attributes of the table
- Modify the `CACHE`/`NOCACHE` attributes
- Add, modify or drop integrity constraints associated with the table
- Enable or disable integrity constraints or triggers associated with the table
- Modify the degree of parallelism for the table
- Rename a table

- Put a table in read-only mode and return it to read/write mode
- Add or modify index-organized table characteristics
- Alter the characteristics of an external table
- Add or modify LOB columns
- Add or modify object type, nested table, or varray columns

Many of these operations are discussed in succeeding sections.

Altering Physical Attributes of a Table

When altering the transaction entry setting INITRANS of a table, note that a new setting for INITRANS applies only to data blocks subsequently allocated for the table. To better understand this transaction entry setting parameter, see "Specifying the INITRANS Parameter" on page 17-4.

The storage parameters INITIAL and MINEXTENTS cannot be altered. All new settings for the other storage parameters (for example, NEXT, PCTINCREASE) affect only extents subsequently allocated for the table. The size of the next extent allocated is determined by the current values of NEXT and PCTINCREASE, and is not based on previous values of these parameters. Storage parameters are discussed in "Managing Storage Parameters" on page 17-5.

Moving a Table to a New Segment or Tablespace

The ALTER TABLE...MOVE statement enables you to relocate data of a non-partitioned table or of a partition of a partitioned table into a new segment, and optionally into a different tablespace for which you have quota. This statement also lets you modify any of the storage attributes of the table or partition, including those which cannot be modified using ALTER TABLE. You can also use the ALTER TABLE...MOVE statement with a COMPRESS clause to store the new segment using table compression.

One important reason to move a table to a new tablespace (with a new datafile) is to eliminate the possibility that old versions of column data—versions left on now unused portions of the disk due to segment shrink, reorganization, or previous table moves—could be viewed by bypassing the access controls of the database (for example with an operating system utility). This is especially important with columns that you intend to modify by adding transparent data encryption.

Note: The ALTER TABLE...MOVE statement does not permit DML against the table while the statement is executing. If you want to leave the table available for DML while moving it, see "Redefining Tables Online" on page 18-26.

The following statement moves the hr.admin_emp table to a new segment, specifying new storage parameters:

```
ALTER TABLE hr.admin_emp MOVE
      STORAGE ( INITIAL 20K
                NEXT 40K
                MINEXTENTS 2
                MAXEXTENTS 20
                PCTINCREASE 0 );
```

Moving a table changes the rowids of the rows in the table. This causes indexes on the table to be marked UNUSABLE, and DML accessing the table using these indexes will receive an ORA-01502 error. The indexes on the table must be dropped or rebuilt. Likewise, any statistics for the table become invalid and new statistics should be collected after moving the table.

If the table includes LOB column(s), this statement can be used to move the table along with LOB data and LOB index segments (associated with this table) which the user explicitly specifies. If not specified, the default is to not move the LOB data and LOB index segments.

> **See Also:** "Consider Encrypting Columns That Contain Sensitive Data" on page 18-6 for more information on transparent data encryption

Manually Allocating Storage for a Table

Oracle Database dynamically allocates additional extents for the data segment of a table, as required. However, perhaps you want to allocate an additional extent for a table explicitly. For example, in an Oracle Real Application Clusters environment, an extent of a table can be allocated explicitly for a specific instance.

A new extent can be allocated for a table using the `ALTER TABLE...ALLOCATE EXTENT` clause.

You can also explicitly deallocate unused space using the `DEALLOCATE UNUSED` clause of `ALTER TABLE`. This is described in "Reclaiming Wasted Space" on page 17-15.

> **See Also:** *Oracle Real Application Clusters Administration and Deployment Guide* for information about using the `ALLOCATE EXTENT` clause in an Oracle Real Application Clusters environment

Modifying an Existing Column Definition

Use the `ALTER TABLE...MODIFY` statement to modify an existing column definition. You can modify column datatype, default value, column constraint, column expression (for virtual columns) and column encryption.

You can increase the length of an existing column, or decrease it, if all existing data satisfies the new length. You can change a column from byte semantics to CHAR semantics or vice versa. You must set the initialization parameter `BLANK_TRIMMING=TRUE` to decrease the length of a non-empty CHAR column.

If you are modifying a table to increase the length of a column of datatype CHAR, realize that this can be a time consuming operation and can require substantial additional storage, especially if the table contains many rows. This is because the CHAR value in each row must be blank-padded to satisfy the new column length.

> **See Also:** *Oracle Database SQL Language Reference* for additional information about modifying table columns and additional restrictions

Adding Table Columns

To add a column to an existing table, use the `ALTER TABLE...ADD` statement.

The following statement alters the `hr.admin_emp` table to add a new column named `bonus`:

```
ALTER TABLE hr.admin_emp
      ADD (bonus NUMBER (7,2));
```

If a new column is added to a table, the column is initially `NULL` unless you specify the `DEFAULT` clause. When you specify a default value, the database immediately updates each row with the default value. Note that this can take some time, and that during the update, there is an exclusive DML lock on the table. For some types of tables (for example, tables without LOB columns), if you specify both a `NOT NULL` constraint and a default value, the database can optimize the column add operation and greatly reduce the amount of time that the table is locked for DML.

You can add a column with a `NOT NULL` constraint only if the table does not contain any rows, or you specify a default value.

Adding a Virtual Column

If the new column is a virtual column, its value is determined by its column expression. (Note that a virtual column's value is calculated only when it is queried.)

See Also: *Oracle Database SQL Language Reference* for additional rules and restrictions for adding table columns

Renaming Table Columns

Oracle Database lets you rename existing columns in a table. Use the `RENAME COLUMN` clause of the `ALTER TABLE` statement to rename a column. The new name must not conflict with the name of any existing column in the table. No other clauses are allowed in conjunction with the `RENAME COLUMN` clause.

The following statement renames the `comm` column of the `hr.admin_emp` table.

```
ALTER TABLE hr.admin_emp
      RENAME COLUMN comm TO commission;
```

As noted earlier, altering a table column can invalidate dependent objects. However, when you rename a column, the database updates associated data dictionary tables to ensure that function-based indexes and check constraints remain valid.

Oracle Database also lets you rename column constraints. This is discussed in "Renaming Constraints" on page 16-13.

Note: The `RENAME TO` clause of `ALTER TABLE` appears similar in syntax to the `RENAME COLUMN` clause, but is used for renaming the table itself.

Dropping Table Columns

You can drop columns that are no longer needed from a table, including an index-organized table. This provides a convenient means to free space in a database, and avoids your having to export/import data then re-create indexes and constraints.

You cannot drop all columns from a table, nor can you drop columns from a table owned by `SYS`. Any attempt to do so results in an error.

See Also: *Oracle Database SQL Language Reference* for information about additional restrictions and options for dropping columns from a table

Removing Columns from Tables

When you issue an `ALTER TABLE...DROP COLUMN` statement, the column descriptor and the data associated with the target column are removed from each row in the table. You can drop multiple columns with one statement.

The following statements are examples of dropping columns from the `hr.admin_emp` table. The first statement drops only the `sal` column:

```
ALTER TABLE hr.admin_emp DROP COLUMN sal;
```

The next statement drops both the `bonus` and `comm` columns:

```
ALTER TABLE hr.admin_emp DROP (bonus, commission);
```

Marking Columns Unused

If you are concerned about the length of time it could take to drop column data from all of the rows in a large table, you can use the `ALTER TABLE...SET UNUSED` statement. This statement marks one or more columns as unused, but does not actually remove the target column data or restore the disk space occupied by these columns. However, a column that is marked as unused is not displayed in queries or data dictionary views, and its name is removed so that a new column can reuse that name. All constraints, indexes, and statistics defined on the column are also removed.

To mark the `hiredate` and `mgr` columns as unused, execute the following statement:

```
ALTER TABLE hr.admin_emp SET UNUSED (hiredate, mgr);
```

You can later remove columns that are marked as unused by issuing an `ALTER TABLE...DROP UNUSED COLUMNS` statement. Unused columns are also removed from the target table whenever an explicit drop of any particular column or columns of the table is issued.

The data dictionary views `USER_UNUSED_COL_TABS`, `ALL_UNUSED_COL_TABS`, or `DBA_UNUSED_COL_TABS` can be used to list all tables containing unused columns. The `COUNT` field shows the number of unused columns in the table.

```
SELECT * FROM DBA_UNUSED_COL_TABS;

OWNER                       TABLE_NAME                  COUNT
--------------------------- --------------------------- -----
HR                          ADMIN_EMP                       2
```

Removing Unused Columns

The `ALTER TABLE...DROP UNUSED COLUMNS` statement is the only action allowed on unused columns. It physically removes unused columns from the table and reclaims disk space.

In the `ALTER TABLE` statement that follows, the optional clause `CHECKPOINT` is specified. This clause causes a checkpoint to be applied after processing the specified number of rows, in this case 250. Checkpointing cuts down on the amount of undo logs accumulated during the drop column operation to avoid a potential exhaustion of undo space.

```
ALTER TABLE hr.admin_emp DROP UNUSED COLUMNS CHECKPOINT 250;
```

Placing a Table in Read-Only Mode

You can place a table in read-only mode with the `ALTER TABLE...READ ONLY` statement, and return it to read/write mode with the `ALTER TABLE...READ WRITE` statement. An example of a table for which read-only mode makes sense is a configuration table. If your application contains configuration tables that are not modified after installation and that must not be modified by users, your application installation scripts can place these tables in read-only mode.

To place a table in read-only mode, you must have the `ALTER TABLE` privilege on the table or the `ALTER ANY TABLE` privilege. In addition, the `COMPATIBILE` initialization parameter must be set to 11.1.0 or greater.

The following example places the `SALES` table in read-only mode:

```
ALTER TABLE SALES READ ONLY;
```

The following example returns the table to read/write mode:

```
ALTER TABLE SALES READ WRITE;
```

When a table is in read-only mode, operations that attempt to modify table data are disallowed. The following operations are not permitted on a read-only table:

- All DML operations on the table or any of its partitions
- `TRUNCATE TABLE`
- `SELECT FOR UPDATE`
- `ALTER TABLE ADD/MODIFY/RENAME/DROP COLUMN`
- `ALTER TABLE SET COLUMN UNUSED`
- `ALTER TABLE DROP/TRUNCATE/EXCHANGE (SUB)PARTITION`
- `ALTER TABLE UPGRADE INCLUDING DATA` or `ALTER TYPE CASCADE INCLUDING TABLE DATA` for a type with read-only table dependents
- Online redefinition
- `FLASHBACK TABLE`

The following operations are permitted on a read-only table:

- `SELECT`
- `CREATE/ALTER/DROP INDEX`
- `ALTER TABLE ADD/MODIFY/DROP/ENABLE/DISABLE CONSTRAINT`
- `ALTER TABLE` for physical property changes
- `ALTER TABLE DROP UNUSED COLUMNS`
- `ALTER TABLE ADD/COALESCE/MERGE/MODIFY/MOVE/RENAME/SPLIT (SUB)PARTITION`
- `ALTER TABLE MOVE`
- `ALTER TABLE ENABLE ROW MOVEMENT` and `ALTER TABLE SHRINK`
- `RENAME TABLE` and `ALTER TABLE RENAME TO`
- `DROP TABLE`
- `ALTER TABLE DEALLOCATE UNUSED`
- `ALTER TABLE ADD/DROP SUPPLEMENTAL LOG`

See Also: *Oracle Database SQL Language Reference* for more information about the `ALTER TABLE` statement

Redefining Tables Online

In any database system, it is occasionally necessary to modify the logical or physical structure of a table to:

- Improve the performance of queries or DML
- Accommodate application changes
- Manage storage

Oracle Database provides a mechanism to make table structure modifications without significantly affecting the availability of the table. The mechanism is called **online table redefinition**. Redefining tables online provides a substantial increase in availability compared to traditional methods of redefining tables.

When a table is redefined online, it is accessible to both queries and DML during much of the redefinition process. The table is locked in the exclusive mode only during a very small window that is independent of the size of the table and complexity of the redefinition, and that is completely transparent to users.

Online table redefinition requires an amount of free space that is approximately equivalent to the space used by the table being redefined. More space may be required if new columns are added.

You can perform online table redefinition with the Enterprise Manager Reorganize Objects wizard or with the `DBMS_REDEFINITION` package.

Note: To invoke the Reorganize Objects wizard:

1. On the Tables page of Enterprise Manager, click in the **Select** column to select the table to redefine.
2. In the Actions list, select **Reorganize**.
3. Click **Go**.

This section describes online redefinition with the `DBMS_REDEFINITION` package. It contains the following topics:

- Features of Online Table Redefinition
- Performing Online Redefinition with DBMS_REDEFINITION
- Results of the Redefinition Process
- Performing Intermediate Synchronization
- Aborting Online Table Redefinition and Cleaning Up After Errors
- Restrictions for Online Redefinition of Tables
- Online Redefinition of a Single Partition
- Online Table Redefinition Examples
- Privileges Required for the DBMS_REDEFINITION Package

See Also: *Oracle Database PL/SQL Packages and Types Reference* for a description of the `DBMS_REDEFINITION` package

Features of Online Table Redefinition

Online table redefinition enables you to:

- Modify the storage parameters of a table or cluster
- Move a table or cluster to a different tablespace in the same schema

---

Note: If it is not important to keep a table available for DML when moving it to another tablespace, you can use the simpler `ALTER TABLE MOVE` command. See "Moving a Table to a New Segment or Tablespace" on page 18-21.

- Add, modify, or drop one or more columns in a table or cluster
- Add or drop partitioning support (non-clustered tables only)
- Change partition structure
- Change physical properties of a single table partition, including moving it to a different tablespace in the same schema
- Change physical properties of a materialized view log or an Oracle Streams Advanced Queueing queue table
- Add support for parallel queries
- Re-create a table or cluster to reduce fragmentation

Note: In many cases, online segment shrink is an easier way to reduce fragmentation. See "Reclaiming Wasted Space" on page 17-15.

- Change the organization of a normal table (heap organized) to an index-organized table, or do the reverse.
- Convert a relational table into a table with object columns, or do the reverse.
- Convert an object table into a relational table or a table with object columns, or do the reverse.

Performing Online Redefinition with DBMS_REDEFINITION

You use the `DBMS_REDEFINITION` package to perform online redefinition of a table. See *Oracle Database PL/SQL Packages and Types Reference* for package details.

To redefine a table online:

1. Choose the redefinition method: by key or by rowid

   By key—Select a primary key or pseudo-primary key to use for the redefinition. Pseudo-primary keys are unique keys with all component columns having `NOT NULL` constraints. For this method, the versions of the tables before and after redefinition should have the same primary key columns. This is the preferred and default method of redefinition.

   By rowid—Use this method if no key is available. In this method, a hidden column named `M_ROW$$` is added to the post-redefined version of the table. It is recommended that this column be dropped or marked as unused after the redefinition is complete. You cannot use this method on index-organized tables.

2. Verify that the table can be redefined online by invoking the `CAN_REDEF_TABLE` procedure. If the table is not a candidate for online redefinition, then this procedure raises an error indicating why the table cannot be redefined online.

3. Create an empty interim table (in the same schema as the table to be redefined) with all of the desired logical and physical attributes. If columns are to be dropped, do not include them in the definition of the interim table. If a column is to be added, then add the column definition to the interim table. If a column is to be modified, create it in the interim table with the properties that you want.

   It is not necessary to create the interim table with all the indexes, constraints, grants, and triggers of the table being redefined, because these will be defined in step 6 when you copy dependent objects.

4. (Optional) If you are redefining a large table and want to improve the performance of the next step by running it in parallel, issue the following statements:

   ```
   alter session force parallel dml parallel degree-of-parallelism;
   alter session force parallel query parallel degree-of-parallelism;
   ```

5. Start the redefinition process by calling `START_REDEF_TABLE`, providing the following:

   - The schema and table name of the table to be redefined
   - The interim table name
   - A column mapping string that maps the columns of table to be redefined to the columns of the interim table

     See "Constructing a Column Mapping String" on page 18-29 for details.
   - The redefinition method

     If not specified, the default method of redefinition (using keys) is assumed.
   - Optionally, the columns to be used in ordering rows
   - If redefining only a single partition of a partitioned table, the partition name

   Because this process involves copying data, it may take a while. The table being redefined remains available for queries and DML during the entire process.

   Note: If `START_REDEF_TABLE` fails for any reason, you must call `ABORT_REDEF_TABLE`, otherwise subsequent attempts to redefine the table will fail.

6. Copy dependent objects (such as triggers, indexes, materialized view logs, grants, and constraints) and statistics from the table being redefined to the interim table, using one of the following two methods. Method 1 is the preferred method because it is more automatic, but there may be times that you would choose to use method 2. Method 1 also enables you to copy table statistics to the interim table.

   - Method 1: Automatically Creating Dependent Objects

     Use the `COPY_TABLE_DEPENDENTS` procedure to automatically create dependent objects on the interim table. This procedure also **registers** the dependent objects. Registering the dependent objects enables the identities of these objects and their copied counterparts to be automatically swapped later as part of the redefinition completion process. The result is that when the redefinition is completed, the names of the dependent objects will be the same as the names of the original dependent objects.

     For more information, see "Creating Dependent Objects Automatically" on page 18-30.

- Method 2: Manually Creating Dependent Objects

  You can manually create dependent objects on the interim table and then register them. For more information, see "Creating Dependent Objects Manually" on page 18-30.

  Note: In Oracle Database Release 9i, you were *required* to manually create the triggers, indexes, grants, and constraints on the interim table, and there may still be situations where you want to or must do so. In such cases, any referential constraints involving the interim table (that is, the interim table is either a parent or a child table of the referential constraint) must be created disabled. When online redefinition completes, the referential constraint is automatically enabled. In addition, until the redefinition process is either completed or aborted, any trigger defined on the interim table does not execute.

  ---

7. Execute the `FINISH_REDEF_TABLE` procedure to complete the redefinition of the table. During this procedure, the original table is locked in exclusive mode for a very short time, independent of the amount of data in the original table. However, `FINISH_REDEF_TABLE` will wait for all pending DML to commit before completing the redefinition.
8. If you used rowids for the redefinition and your `COMPATIBLE` initialization parameter is set to 10.1.0 or lower, set to `UNUSED` the hidden column `M_ROW$$` that is now in the redefined table.

   ```
   ALTER TABLE table_name SET UNUSED (M_ROW$$);
   ```

   If `COMPATIBLE` is 10.2.0 or higher, this hidden column is automatically set to `UNUSED` for you when redefinition completes.

   You can also drop the column if you prefer.

Constructing a Column Mapping String

The column mapping string that you pass as an argument to `START_REDEF_TABLE` contains a comma-separated list of column mapping pairs, where each pair has the following syntax:

```
[expression]  column_name
```

The *`column_name`* term indicates a column in the interim table. The optional *`expression`* can include columns from the table being redefined, constants, operators, function or method calls, and so on, in accordance with the rules for expressions in a SQL `SELECT` statement. However, only simple deterministic subexpressions—that is, subexpressions whose results do not vary between one evaluation and the next—plus sequences and `SYSDATE` can be used. No subqueries are permitted. In the simplest case, the expression consists of just a column name from the table being redefined.

If an expression is present, its value is placed in the designated interim table column during redefinition. If the expression is omitted, it is assumed that both the table being redefined and the interim table have a column named *`column_name`*, and the value of that column in the table being redefined is placed in the same column in the interim table.

For example, if the override column in the table being redefined is to be renamed to override_commission, and every override commission is to be raised by 2%, the correct column mapping pair is:

```
override*1.02  override_commission
```

If you supply '*' or NULL as the column mapping string, it is assumed that all the columns (with their names unchanged) are to be included in the interim table. Otherwise, only those columns specified explicitly in the string are considered. The order of the column mapping pairs is unimportant.

For examples of column mapping strings, see "Online Table Redefinition Examples" on page 18-34.

Data Conversions When mapping columns, you can convert data types, with some restrictions.

If you provide '*' or NULL as the column mapping string, only the implicit conversions permitted by SQL are supported. For example, you can convert from CHAR to VARCHAR2, from INTEGER to NUMBER, and so on.

If you want to perform other data type conversions, including converting from one object type to another or one collection type to another, you must provide a column mapping pair with an expression that performs the conversion. The expression can include the CAST function, built-in functions like TO_NUMBER, conversion functions that you create, and so on.

Creating Dependent Objects Automatically

You use the COPY_TABLE_DEPENDENTS procedure to automatically create dependent objects on the interim table.

You can discover if errors occurred while copying dependent objects by checking the num_errors output argument. If the ignore_errors argument is set to TRUE, the COPY_TABLE_DEPENDENTS procedure continues copying dependent objects even if an error is encountered when creating an object. You can view these errors by querying the DBA_REDEFINITION_ERRORS view.

Reasons for errors include:

- A lack of system resources
- A change in the logical structure of the table that would require recoding the dependent object.

  See Example 3 in "Online Table Redefinition Examples" on page 18-34 for a discussion of this type of error.

If ignore_errors is set to FALSE, the COPY_TABLE_DEPENDENTS procedure stops copying objects as soon as any error is encountered.

After you correct any errors you can again attempt to copy the dependent objects by reexecuting the COPY_TABLE_DEPENDENTS procedure. Optionally you can create the objects manually and then register them as explained in "Creating Dependent Objects Manually". The COPY_TABLE_DEPENDENTS procedure can be used multiple times as necessary. If an object has already been successfully copied, it is not copied again.

Creating Dependent Objects Manually

If you manually create dependent objects on the interim table with SQL*Plus or Enterprise Manager, you must then use the REGISTER_DEPENDENT_OBJECT procedure to register the dependent objects. Registering dependent objects enables the redefinition completion process to restore dependent object names to what they were before redefinition.

You would also use the `REGISTER_DEPENDENT_OBJECT` procedure if the `COPY_TABLE_DEPENDENTS` procedure failed to copy a dependent object and manual intervention is required.

You can query the `DBA_REDEFINITION_OBJECTS` view to determine which dependent objects are registered. This view shows dependent objects that were registered explicitly with the `REGISTER_DEPENDENT_OBJECT` procedure or implicitly with the `COPY_TABLE_DEPENDENTS` procedure. Only current information is shown in the view.

The `UNREGISTER_DEPENDENT_OBJECT` procedure can be used to unregister a dependent object on the table being redefined and on the interim table.

Note: Manually created dependent objects do not have to be identical to their corresponding original dependent objects. For example, when manually creating a materialized view log on the interim table, you can log different columns. In addition, the interim table can have more or fewer dependent objects.

Results of the Redefinition Process

The following are the end results of the redefinition process:

- The original table is redefined with the columns, indexes, constraints, grants, triggers, and statistics of the interim table.
- Dependent objects that were registered, either explicitly using `REGISTER_DEPENDENT_OBJECT` or implicitly using `COPY_TABLE_DEPENDENTS`, are renamed automatically so that dependent object names on the redefined table are the same as before redefinition.

  Note: If no registration is done or no automatic copying is done, then you must manually rename the dependent objects.

- The referential constraints involving the interim table now involve the redefined table and are enabled.
- Any indexes, triggers, materialized view logs, grants, and constraints defined on the original table (prior to redefinition) are transferred to the interim table and are dropped when the user drops the interim table. Any referential constraints involving the original table before the redefinition now involve the interim table and are disabled.
- Some PL/SQL objects that depend on the original table (prior to redefinition) may become invalidated. Only those objects that depend on elements of the table that were changed are invalidated. For example, if a PL/SQL procedure queries only columns of the redefined table that were unchanged by the redefinition, the procedure remains valid. See *Oracle Database Concepts* for more information about schema object dependencies.

Performing Intermediate Synchronization

After the redefinition process has been started by calling `START_REDEF_TABLE` and before `FINISH_REDEF_TABLE` has been called, it is possible that a large number of

DML statements have been executed on the original table. If you know that this is the case, it is recommended that you periodically synchronize the interim table with the original table. This is done by calling the `SYNC_INTERIM_TABLE` procedure. Calling this procedure reduces the time taken by `FINISH_REDEF_TABLE` to complete the redefinition process. There is no limit to the number of times that you can call `SYNC_INTERIM_TABLE`.

The small amount of time that the original table is locked during `FINISH_REDEF_TABLE` is independent of whether `SYNC_INTERIM_TABLE` has been called.

Aborting Online Table Redefinition and Cleaning Up After Errors

In the event that an error is raised during the redefinition process, or if you choose to terminate the redefinition process, call `ABORT_REDEF_TABLE`. This procedure drops temporary logs and tables associated with the redefinition process. After this procedure is called, you can drop the interim table and its dependent objects.

If the online redefinition process must be restarted, if you do not first call `ABORT_REDEF_TABLE`, subsequent attempts to redefine the table will fail.

Restrictions for Online Redefinition of Tables

The following restrictions apply to the online redefinition of tables:

- If the table is to be redefined using primary key or pseudo-primary keys (unique keys or constraints with all component columns having *not null* constraints), then the post-redefinition table must have the same primary key or pseudo-primary key columns. If the table is to be redefined using rowids, then the table must not be an index-organized table.
- After redefining a table that has a materialized view log, the subsequent refresh of any dependent materialized view must be a complete refresh.
- Tables that are replicated in an n-way master configuration can be redefined, but horizontal subsetting (subset of rows in the table), vertical subsetting (subset of columns in the table), and column transformations are not allowed.
- The overflow table of an index-organized table cannot be redefined online independently.
- Tables with fine-grained access control (row-level security) cannot be redefined online.
- Tables with `BFILE` columns cannot be redefined online.
- Tables with `LONG` columns can be redefined online, but those columns must be converted to `CLOBS`. Also, `LONG RAW` columns must be converted to `BLOBS`. Tables with `LOB` columns are acceptable.
- On a system with sufficient resources for parallel execution, and in the case where the interim table is not partitioned, redefinition of a `LONG` column to a `LOB` column can be executed in parallel, provided that:
  - The segment used to store the `LOB` column in the interim table belongs to a locally managed tablespace with Automatic Segment Space Management (ASSM) enabled.
  - There is a simple mapping from one `LONG` column to one `LOB` column, and the interim table has only one `LOB` column.

In the case where the interim table is partitioned, the normal methods for parallel execution for partitioning apply.

- Tables in the `SYS` and `SYSTEM` schema cannot be redefined online.
- Temporary tables cannot be redefined.
- A subset of rows in the table cannot be redefined.
- Only simple deterministic expressions, sequences, and `SYSDATE` can be used when mapping the columns in the interim table to those of the original table. For example, subqueries are not allowed.
- If new columns are being added as part of the redefinition and there are no column mappings for these columns, then they must not be declared `NOT NULL` until the redefinition is complete.
- There cannot be any referential constraints between the table being redefined and the interim table.
- Table redefinition cannot be done `NOLOGGING`.
- For materialized view logs and queue tables, online redefinition is restricted to changes in physical properties. No horizontal or vertical subsetting is permitted, nor are any column transformations. The only valid value for the column mapping string is `NULL`.
- You can convert a `VARRAY` to a nested table with the `CAST` operator in the column mapping. However, you cannot convert a nested table to a `VARRAY`.

Online Redefinition of a Single Partition

Beginning with Oracle Database 10g Release 2, you can redefine online a single partition of a table. This is useful if, for example, you want to move a partition to a different tablespace and keep the partition available for DML during the operation.

Another use for this capability is redefining online an entire table, but doing it one partition at a time to reduce resource requirements. For example, if you want to move a table to a different tablespace, you can move it one partition at a time to minimize the free space and undo space required to complete the move.

Redefining a single partition differs from redefining a table in the following ways:

- There is no need to copy dependent objects. It is not valid to use the `COPY_TABLE_DEPENDENTS` procedure when redefining a single partition.
- You must manually create any local indexes on the interim table.
- The column mapping string for `START_REDEF_TABLE` must be `NULL`.

Note: If it is not important to keep a partition available for DML when moving it to another tablespace, you can use the simpler `ALTER TABLE MOVE PARTITION` command.

See also:

- The section "Moving Partitions" in *Oracle Database VLDB and Partitioning Guide*
- *Oracle Database SQL Language Reference*

Rules for Online Redefinition of a Single Partition

The underlying mechanism for redefinition of a single partition is the **exchange partition** capability of the database (`ALTER TABLE...EXCHANGE PARTITION`). Rules and restrictions for online redefinition of a single partition are therefore governed by this mechanism. Here are some general restrictions:

- No logical changes (such as adding or dropping a column) are permitted.
- No changes to the partitioning method (such as changing from range partitioning to hash partitioning) are permitted.
- If a global index is present, it is marked as `UNUSABLE` when redefinition of any table partition is complete.

Here are the rules for defining the interim table:

- If the partition being redefined is a range, hash, or list partition, the interim table must be non-partitioned.
- If the partition being redefined is a range partition of a composite range-hash partitioned table, the interim table must be a hash partitioned table. In addition, the partitioning key of the interim table must be identical to the subpartitioning key of the range-hash partitioned table, and the number of partitions in the interim table must be identical to the number of subpartitions in the range partition being redefined.
- If the partition being redefined is a range partition of a composite range-list partitioned table, the interim table must be a list partitioned table. In addition, the partitioning key of the interim table must be identical to the subpartitioning key of the range-list partitioned table, and the values lists of the interim table's list partitions must exactly match the values lists of the list subpartitions in the range partition being redefined.

These additional rules apply if the table being redefined is a partitioned index-organized table:

- The interim table must also be index-organized.
- The original and interim tables must have primary keys on the same columns, in the same order.
- If key compression is enabled, it must be enabled for both the original and interim tables, with the same prefix length.
- Both the original and interim tables must have overflow segments, or neither can have them. Likewise for mapping tables.
- Both the original and interim tables must have identical storage attributes for any LOB columns.

See Also: The section "Exchanging Partitions" in *Oracle Database VLDB and Partitioning Guide*

Online Table Redefinition Examples

For the following examples, see *Oracle Database PL/SQL Packages and Types Reference* for descriptions of all `DBMS_REDEFINITION` subprograms.

Example	Description
Example 1	Redefines a table by adding new columns and adding partitioning.

Example	Description
Example 2	Demonstrates redefinition with object datatypes.
Example 3	Demonstrates redefinition with manually registered dependent objects.
Example 4	Redefines a single table partition, moving it to a different tablespace.

Example 1

This example illustrates online redefinition of the previously created table `hr.admin_emp`, which at this point only contains columns: `empno`, `ename`, `job`, `deptno`. The table is redefined as follows:

- New columns `mgr`, `hiredate`, `sal`, and `bonus` are added. (These existed in the original table but were dropped in previous examples.)
- The new column `bonus` is initialized to 0
- The column `deptno` has its value increased by 10.
- The redefined table is partitioned by range on `empno`.

The steps in this redefinition are illustrated below.

1. Verify that the table is a candidate for online redefinition. In this case you specify that the redefinition is to be done using primary keys or pseudo-primary keys.

```
BEGIN
DBMS_REDEFINITION.CAN_REDEF_TABLE('hr','admin_emp',
      DBMS_REDEFINITION.CONS_USE_PK);
END;
/
```

2. Create an interim table `hr.int_admin_emp`.

```
CREATE TABLE hr.int_admin_emp
        (empno      NUMBER(5) PRIMARY KEY,
         ename      VARCHAR2(15) NOT NULL,
         job        VARCHAR2(10),
         mgr        NUMBER(5),
         hiredate   DATE DEFAULT (sysdate),
         sal        NUMBER(7,2),
         deptno     NUMBER(3) NOT NULL,
         bonus      NUMBER (7,2) DEFAULT(1000))
     PARTITION BY RANGE(empno)
       (PARTITION emp1000 VALUES LESS THAN (1000) TABLESPACE admin_tbs,
        PARTITION emp2000 VALUES LESS THAN (2000) TABLESPACE admin_tbs2);
```

3. Start the redefinition process.

```
BEGIN
DBMS_REDEFINITION.START_REDEF_TABLE('hr', 'admin_emp','int_admin_emp',
       'empno empno, ename ename, job job, deptno+10 deptno, 0 bonus',
        dbms_redefinition.cons_use_pk);
END;
/
```

4. Copy dependent objects. (Automatically create any triggers, indexes, materialized view logs, grants, and constraints on `hr.int_admin_emp`.)

```
DECLARE
num_errors PLS_INTEGER;
BEGIN
```

```
DBMS_REDEFINITION.COPY_TABLE_DEPENDENTS('hr', 'admin_emp','int_admin_emp',
   DBMS_REDEFINITION.CONS_ORIG_PARAMS, TRUE, TRUE, TRUE, TRUE, num_errors);
END;
```

Note that the `ignore_errors` argument is set to `TRUE` for this call. The reason is that the interim table was created with a primary key constraint, and when `COPY_TABLE_DEPENDENTS` attempts to copy the primary key constraint and index from the original table, errors occurs. You can ignore these errors, but you must run the query shown in the next step to see if there are other errors.

5. Query the `DBA_REDEFINITION_ERRORS` view to check for errors.

```
SQL> select object_name, base_table_name, ddl_txt from
         DBA_REDEFINITION_ERRORS;

OBJECT_NAME   BASE_TABLE_NAME  DDL_TXT
------------- ---------------- ------------------------------
SYS_C005836   ADMIN_EMP        CREATE UNIQUE INDEX "HR"."TMP$
                               $_SYS_C0058360" ON "HR"."INT_A
                               DMIN_EMP" ("EMPNO")

SYS_C005836   ADMIN_EMP        ALTER TABLE "HR"."INT_ADMIN_EM
                               P" ADD CONSTRAINT "TMP$$_SYS_C
                               0058360" PRIMARY KEY
```

These errors are caused by the existing primary key constraint on the interim table and can be ignored. Note that with this approach, the names of the primary key constraint and index on the post-redefined table are changed. An alternate approach, one that avoids errors and name changes, would be to define the interim table without a primary key constraint. In this case, the primary key constraint and index are copied from the original table.

Note: The best approach is to define the interim table with a primary key constraint, use `REGISTER_DEPENDENT_OBJECT` to register the primary key constraint and index, and then copy the remaining dependent objects with `COPY_TABLE_DEPENDENTS`. This approach avoids errors and ensures that the redefined table always has a primary key and that the dependent object names do not change.

6. Optionally, synchronize the interim table `hr.int_admin_emp`.

```
BEGIN
DBMS_REDEFINITION.SYNC_INTERIM_TABLE('hr', 'admin_emp', 'int_admin_emp');
END;
/
```

7. Complete the redefinition.

```
BEGIN
DBMS_REDEFINITION.FINISH_REDEF_TABLE('hr', 'admin_emp', 'int_admin_emp');
END;
/
```

The table `hr.admin_emp` is locked in the exclusive mode only for a small window toward the end of this step. After this call the table `hr.admin_emp` is redefined such that it has all the attributes of the `hr.int_admin_emp` table.

8. Drop the interim table.

Example 2

This example redefines a table to change columns into object attributes. The redefined table gets a new column that is an object type.

The original table, named `CUSTOMER`, is defined as follows:

```
Name         Type
------------ -------------
CID          NUMBER           <- Primary key
NAME         VARCHAR2(30)
STREET       VARCHAR2(100)
CITY         VARCHAR2(30)
STATE        VARCHAR2(2)
ZIP          NUMBER(5)
```

The type definition for the new object is:

```
CREATE TYPE ADDR_T AS OBJECT (
   street VARCHAR2(100),
   city VARCHAR2(30),
   state VARCHAR2(2),
   zip NUMBER(5, 0) );
```

Here are the steps for this redefinition:

1. Verify that the table is a candidate for online redefinition. Specify that the redefinition is to be done using primary keys or pseudo-primary keys.

   ```
   BEGIN
   DBMS_REDEFINITION.CAN_REDEF_TABLE('STEVE','CUSTOMER',
           DBMS_REDEFINITION.CONS_USE_PK);
   END;
   /
   ```

2. Create the interim table `int_customer`.

   ```
   CREATE TABLE INT_CUSTOMER(
     CID NUMBER,
     NAME  VARCHAR2(30),
     ADDR  ADDR_T);
   ```

   Note that no primary key is defined on the interim table. When dependent objects are copied in step 5, the primary key constraint and index are copied.

3. Because `CUSTOMER` is a very large table, specify parallel operations for the next step.

   ```
   alter session force parallel dml parallel 4;
   alter session force parallel query parallel 4;
   ```

4. Start the redefinition process using primary keys.

   ```
   BEGIN
   DBMS_REDEFINITION.START_REDEF_TABLE(
      uname       => 'STEVE',
      orig_table  => 'CUSTOMER',
      int_table   => 'INT_CUSTOMER',
      col_mapping => 'cid cid,  name name,
         addr_t(street, city, state, zip) addr');
   END;
   /
   ```

Note that `addr_t(street, city, state, zip)` is a call to the object constructor.

5. Copy dependent objects.

```
DECLARE
num_errors PLS_INTEGER;
BEGIN
DBMS_REDEFINITION.COPY_TABLE_DEPENDENTS(
   'STEVE','CUSTOMER','INT_CUSTOMER',DBMS_REDEFINITION.CONS_ORIG_PARAMS,
    TRUE, TRUE, TRUE, FALSE, num_errors, TRUE);
END;
/
```

Note that for this call, the final argument indicates that table statistics are to be copied to the interim table.

6. Optionally synchronize the interim table.

```
BEGIN
DBMS_REDEFINITION.SYNC_INTERIM_TABLE('STEVE', 'CUSTOMER', 'INT_CUSTOMER');
END;
/
```

7. Complete the redefinition.

```
BEGIN
DBMS_REDEFINITION.FINISH_REDEF_TABLE('STEVE', 'CUSTOMER', 'INT_CUSTOMER');
END;
/
```

8. Drop the interim table.

Example 3

This example addresses the situation where a dependent object must be manually created and registered.

Consider the case where a table `T1` has a column named `C1`, and where this column becomes `C2` after the redefinition. Assume that there is an index `Index1` on `C1`. In this case, `COPY_TABLE_DEPENDENTS` tries to create an index on the interim table corresponding to `Index1`, and tries to create it on a column `C1`, which does not exist on the interim table. This results in an error. You must therefore manually create the index on column `C2` and register it. Here are the steps:

1. Create the interim table `INT_T1` and create an index `Int_Index1` on column `C2`.
2. Ensure that `T1` is a candidate for online redefinition with `CAN_REDEF_TABLE`, and then begin the redefinition process with `START_REDEF_TABLE`.
3. Register the original (`Index1`) and interim (`Int_Index1`) dependent objects.

```
BEGIN
DBMS_REDEFINITION.REGISTER_DEPENDENT_OBJECT(
   uname         => 'STEVE',
   orig_table    => 'T1',
   int_table     => 'INT_T1',
   dep_type      => DBMS_REDEFINITION.CONS_INDEX,
   dep_owner     => 'STEVE',
   dep_orig_name => 'Index1',
   dep_int_name  => 'Int_Index1');
END;
/
```

4. Use `COPY_TABLE_DEPENDENTS` to copy the remaining dependent objects.
5. Optionally synchronize the interim table.
6. Complete the redefinition and drop the interim table.

Example 4

This example demonstrates redefining a single partition. It moves the oldest partition of a range-partitioned sales table to a tablespace named `TBS_LOW_FREQ`. The table containing the partition to be redefined is defined as follows:

```
CREATE TABLE salestable
(s_productid NUMBER,
s_saledate DATE,
s_custid NUMBER,
s_totalprice NUMBER)
TABLESPACE users
PARTITION BY RANGE(s_saledate)
(PARTITION sal03q1 VALUES LESS THAN (TO_DATE('01-APR-2003', 'DD-MON-YYYY')),
PARTITION sal03q2 VALUES LESS THAN (TO_DATE('01-JUL-2003', 'DD-MON-YYYY')),
PARTITION sal03q3 VALUES LESS THAN (TO_DATE('01-OCT-2003', 'DD-MON-YYYY')),
PARTITION sal03q4 VALUES LESS THAN (TO_DATE('01-JAN-2004', 'DD-MON-YYYY')));
```

The table has a local partitioned index that is defined as follows:

```
CREATE INDEX sales_index ON salestable
   (s_saledate, s_productid, s_custid) LOCAL;
```

Here are the steps. In the following procedure calls, note the extra argument: partition name (`part_name`).

1. Ensure that `salestable` is a candidate for redefinition.

   ```
   BEGIN
   DBMS_REDEFINITION.CAN_REDEF_TABLE(
      uname        => 'STEVE',
      tname        => 'SALESTABLE',
      options_flag => DBMS_REDEFINITION.CONS_USE_ROWID,
      part_name    => 'sal03q1');
   END;
   /
   ```

2. Create the interim table in the `TBS_LOW_FREQ` tablespace. Because this is a redefinition of a range partition, the interim table is non-partitioned.

   ```
   CREATE TABLE int_salestable
   (s_productid NUMBER,
   s_saledate DATE,
   s_custid NUMBER,
   s_totalprice NUMBER)
   TABLESPACE tbs_low_freq;
   ```

3. Start the redefinition process using rowid.

   ```
   BEGIN
   DBMS_REDEFINITION.START_REDEF_TABLE(
      uname        => 'STEVE',
      orig_table   => 'salestable',
      int_table    => 'int_salestable',
      col_mapping  => NULL,
      options_flag => DBMS_REDEFINITION.CONS_USE_ROWID,
   ```

```
   part_name    => 'sal03q1');
END;
/
```

4. Manually create any local indexes on the interim table.

```
CREATE INDEX int_sales_index ON int_salestable
(s_saledate, s_productid, s_custid)
TABLESPACE tbs_low_freq;
```

5. Optionally synchronize the interim table.

```
BEGIN
DBMS_REDEFINITION.SYNC_INTERIM_TABLE(
   uname      => 'STEVE',
   orig_table => 'salestable',
   int_table  => 'int_salestable',
   part_name  => 'sal03q1');
END;
/
```

6. Complete the redefinition.

```
BEGIN
DBMS_REDEFINITION.FINISH_REDEF_TABLE(
   uname      => 'STEVE',
   orig_table => 'salestable',
   int_table  => 'int_salestable',
   part_name  => 'sal03q1');
END;
/
```

7. Drop the interim table.

The following query shows that the oldest partition has been moved to the new tablespace:

```
select partition_name, tablespace_name from user_tab_partitions
 where table_name = 'SALESTABLE';

PARTITION_NAME                 TABLESPACE_NAME
------------------------------ ------------------------------
SAL03Q1                        TBS_LOW_FREQ
SAL03Q2                        USERS
SAL03Q3                        USERS
SAL03Q4                        USERS

4 rows selected.
```

Privileges Required for the DBMS_REDEFINITION Package

Execute privileges on the `DBMS_REDEFINITION` package are granted to `EXECUTE_CATALOG_ROLE`. In addition to having execute privileges on this package, you must be granted the following privileges:

- `CREATE ANY TABLE`
- `ALTER ANY TABLE`
- `DROP ANY TABLE`
- `LOCK ANY  TABLE`

- `SELECT ANY TABLE`

The following additional privileges are required to execute `COPY_TABLE_DEPENDENTS`:

- `CREATE ANY TRIGGER`
- `CREATE ANY INDEX`

Auditing Table Changes Using Flashback Transaction Query

Note: You must be using automatic undo management to use the Flashback Transaction Query feature. It is based on undo information stored in an undo tablespace.

To understand how to configure your database for the Flashback Transaction Query feature, see "Undo Space Data Dictionary Views" on page 14-11.

You may discover that somehow data in a table has been inappropriately changed. To research this change, you can use multiple flashback queries to view row data at specific points in time. More efficiently, you can use the Flashback Version Query feature to view all changes to a row over a period of time. That feature lets you append a `VERSIONS` clause to a `SELECT` statement that specifies an SCN or timestamp range between which you want to view changes to row values. The query also can return associated metadata, such as the transaction responsible for the change.

Further, once you identify an erroneous transaction, you can then use the Flashback Transaction Query feature to identify other changes that were done by the transaction, and to request the undo SQL to reverse those changes. But using the undo SQL is only one means of recovering your data. You also have the option of using the Flashback Table feature, described in "Recovering Tables Using the Flashback Table Feature" on page 18-41, to restore the table to a state before the changes were made.

See Also: *Oracle Database Advanced Application Developer's Guide* for directions for using Oracle Flashback Query and Flashback Version Query.

Recovering Tables Using the Flashback Table Feature

Note: You must be using automatic undo management to use the Flashback Table feature. It is based on undo information stored in an undo tablespace.

To understand how to configure your undo tablespace for the Flashback Table feature, see "Undo Space Data Dictionary Views" on page 14-11.

The `FLASHBACK TABLE` statement enables users to recover a table to a previous point in time. It provides a fast, online solution for recovering a table that has been accidentally modified or deleted by a user or application. In many cases, this Flashback Table feature alleviates the need for you, as the administrator, to perform more complicated point in time recovery operations.

The functionality of the Flashback Table feature can be summarized as follows:

- Restores all data in a specified table to a previous point in time described by a timestamp or SCN.
- Performs the restore operation online.
- Automatically maintains all of the table attributes, such as indexes, triggers, and constraints that are necessary for an application to function with the flashed-back table.
- Maintains any remote state in a distributed environment. For example, all of the table modifications required by replication if a replicated table is flashed back.
- Maintains data integrity as specified by constraints. Tables are flashed back provided none of the table constraints are violated. This includes any referential integrity constraints specified between a table included in the `FLASHBACK TABLE` statement and another table that is not included in the `FLASHBACK TABLE` statement.
- Even after a flashback operation, the data in the original table is not lost. You can later revert to the original state.

See Also: *Oracle Database Backup and Recovery User's Guide* for more information about the `FLASHBACK TABLE` statement.

Dropping Tables

To drop a table that you no longer need, use the `DROP TABLE` statement. The table must be contained in your schema or you must have the `DROP ANY TABLE` system privilege.

Caution: Before dropping a table, familiarize yourself with the consequences of doing so:

- Dropping a table removes the table definition from the data dictionary. All rows of the table are no longer accessible.
- All indexes and triggers associated with a table are dropped.
- All views and PL/SQL program units dependent on a dropped table remain, yet become invalid (not usable). See "Managing Object Dependencies" on page 16-17 for information about how the database manages dependencies.
- All synonyms for a dropped table remain, but return an error when used.
- All extents allocated for a table that is dropped are returned to the free space of the tablespace and can be used by any other object requiring new extents or new objects. All rows corresponding to a clustered table are deleted from the blocks of the cluster. Clustered tables are the subject of Chapter 20, "Managing Clusters".

The following statement drops the `hr.int_admin_emp` table:

```
DROP TABLE hr.int_admin_emp;
```

If the table to be dropped contains any primary or unique keys referenced by foreign keys of other tables and you intend to drop the `FOREIGN KEY` constraints of the child tables, then include the CASCADE clause in the DROP TABLE statement, as shown below:

```
DROP TABLE hr.admin_emp CASCADE CONSTRAINTS;
```

When you drop a table, normally the database does not immediately release the space associated with the table. Rather, the database renames the table and places it in a recycle bin, where it can later be recovered with the FLASHBACK TABLE statement if you find that you dropped the table in error. If you should want to immediately release the space associated with the table at the time you issue the DROP TABLE statement, include the PURGE clause as shown in the following statement:

```
DROP TABLE hr.admin_emp PURGE;
```

Perhaps instead of dropping a table, you want to truncate it. The TRUNCATE statement provides a fast, efficient method for deleting all rows from a table, but it does not affect any structures associated with the table being truncated (column definitions, constraints, triggers, and so forth) or authorizations. The TRUNCATE statement is discussed in "Truncating Tables and Clusters" on page 16-6.

Using Flashback Drop and Managing the Recycle Bin

When you drop a table, the database does not immediately remove the space associated with the table. The database renames the table and places it and any associated objects in a recycle bin, where, in case the table was dropped in error, it can be recovered at a later time. This feature is called Flashback Drop, and the FLASHBACK TABLE statement is used to restore the table. Before discussing the use of the FLASHBACK TABLE statement for this purpose, it is important to understand how the recycle bin works, and how you manage its contents.

This section contains the following topics:

- What Is the Recycle Bin?
- Viewing and Querying Objects in the Recycle Bin
- Purging Objects in the Recycle Bin
- Restoring Tables from the Recycle Bin

What Is the Recycle Bin?

The recycle bin is actually a data dictionary table containing information about dropped objects. Dropped tables and any associated objects such as indexes, constraints, nested tables, and the likes are not removed and still occupy space. They continue to count against user space quotas, until specifically purged from the recycle bin or the unlikely situation where they must be purged by the database because of tablespace space constraints.

Each user can be thought of as having his own recycle bin, since unless a user has the SYSDBA privilege, the only objects that the user has access to in the recycle bin are those that the user owns. A user can view his objects in the recycle bin using the following statement:

```
SELECT * FROM RECYCLEBIN;
```

When you drop a tablespace including its contents, the objects in the tablespace are not placed in the recycle bin and the database purges any entries in the recycle bin for objects located in the tablespace. The database also purges any recycle bin entries for objects in a tablespace when you drop the tablespace, not including contents, and the tablespace is otherwise empty. Likewise:

- When you drop a user, any objects belonging to the user are not placed in the recycle bin and any objects in the recycle bin are purged.
- When you drop a cluster, its member tables are not placed in the recycle bin and any former member tables in the recycle bin are purged.
- When you drop a type, any dependent objects such as subtypes are not placed in the recycle bin and any former dependent objects in the recycle bin are purged.

Object Naming in the Recycle Bin

When a dropped table is moved to the recycle bin, the table and its associated objects are given system-generated names. This is necessary to avoid name conflicts that may arise if multiple tables have the same name. This could occur under the following circumstances:

- A user drops a table, re-creates it with the same name, then drops it again.
- Two users have tables with the same name, and both users drop their tables.

The renaming convention is as follows:

```
BIN$unique_id$version
```

where:

- `unique_id` is a 26-character globally unique identifier for this object, which makes the recycle bin name unique across all databases
- `version` is a version number assigned by the database

Enabling and Disabling the Recycle Bin

You can enable and disable the recycle bin with the `recyclebin` initialization parameter. When the recycle bin is enabled, dropped tables and their dependent objects are placed in the recycle bin. When the recycle bin is disabled, dropped tables and their dependent objects are *not* placed in the recycle bin; they are just dropped, and you must use other means to recover them (such as recovering from backup).

The recycle bin is enabled by default.

To disable the recycle bin:

- Issue one of the following statements:

  ```
  ALTER SESSION SET recyclebin = OFF;

  ALTER SYSTEM SET recyclebin = OFF;
  ```

To enable the recycle bin:

- Issue one of the following statements:

  ```
  ALTER SESSION SET recyclebin = ON;

  ALTER SYSTEM SET recyclebin = ON;
  ```

Enabling and disabling the recycle bin with an `ALTER SYSTEM` or `ALTER SESSION` statement takes effect immediately. Disabling the recycle bin does not purge or otherwise affect objects already in the recycle bin.

Like any other initialization parameter, you can set the initial value of the `recyclebin` parameter in the text initialization file `init`*SID*`.ora`:

```
recyclebin=on
```

> **See Also:** "Understanding Initialization Parameters" on page 2-19 for more information on initialization parameters.

Viewing and Querying Objects in the Recycle Bin

Oracle Database provides two views for obtaining information about objects in the recycle bin:

View	Description
`USER_RECYCLEBIN`	This view can be used by users to see their own dropped objects in the recycle bin. It has a synonym `RECYCLEBIN`, for ease of use.
`DBA_RECYCLEBIN`	This view gives administrators visibility to all dropped objects in the recycle bin

One use for these views is to identify the name that the database has assigned to a dropped object, as shown in the following example:

```
SELECT object_name, original_name FROM dba_recyclebin
   WHERE owner = 'HR';

OBJECT_NAME                    ORIGINAL_NAME
------------------------------ --------------------------------
BIN$yrMKlZaLMhfgNAgAIMenRA==$0 EMPLOYEES
```

You can also view the contents of the recycle bin using the SQL*Plus command `SHOW RECYCLEBIN`.

```
SQL> show recyclebin

ORIGINAL NAME    RECYCLEBIN NAME                OBJECT TYPE  DROP TIME
---------------- ------------------------------ ------------ -------------------
EMPLOYEES        BIN$yrMKlZaVMhfgNAgAIMenRA==$0 TABLE        2003-10-27:14:00:19
```

You can query objects that are in the recycle bin, just as you can query other objects. However, you must specify the name of the object as it is identified in the recycle bin. For example:

```
SELECT * FROM "BIN$yrMKlZaVMhfgNAgAIMenRA==$0";
```

Purging Objects in the Recycle Bin

If you decide that you are never going to restore an item from the recycle bin, you can use the `PURGE` statement to remove the items and their associated objects from the recycle bin and release their storage space. You need the same privileges as if you were dropping the item.

When you use the `PURGE` statement to purge a table, you can use the name that the table is known by in the recycle bin or the original name of the table. The recycle bin name can be obtained from either the `DBA_` or `USER_RECYCLEBIN` view as shown in "Viewing and Querying Objects in the Recycle Bin" on page 18-45. The following hypothetical example purges the table `hr.int_admin_emp`, which was renamed to `BIN$jsleilx392mk2=293$0` when it was placed in the recycle bin:

```
PURGE TABLE BIN$jsleilx392mk2=293$0;
```

You can achieve the same result with the following statement:

```
PURGE TABLE int_admin_emp;
```

You can use the `PURGE` statement to purge all the objects in the recycle bin that are from a specified tablespace or only the tablespace objects belonging to a specified user, as shown in the following examples:

```
PURGE TABLESPACE example;
PURGE TABLESPACE example USER oe;
```

Users can purge the recycle bin of their own objects, and release space for objects, by using the following statement:

```
PURGE RECYCLEBIN;
```

If you have the `SYSDBA` privilege, then you can purge the entire recycle bin by specifying `DBA_RECYCLEBIN`, instead of `RECYCLEBIN` in the previous statement.

You can also use the `PURGE` statement to purge an index from the recycle bin or to purge from the recycle bin all objects in a specified tablespace.

See Also: *Oracle Database SQL Language Reference* for more information on the `PURGE` statement

Restoring Tables from the Recycle Bin

Use the `FLASHBACK TABLE ... TO BEFORE DROP` statement to recover objects from the recycle bin. You can specify either the name of the table in the recycle bin or the original table name. An optional `RENAME TO` clause lets you rename the table as you recover it. The recycle bin name can be obtained from either the `DBA_` or `USER_RECYCLEBIN` view as shown in "Viewing and Querying Objects in the Recycle Bin" on page 18-45. To use the `FLASHBACK TABLE ... TO BEFORE DROP` statement, you need the same privileges you need to drop the table.

The following example restores `int_admin_emp` table and assigns to it a new name:

```
FLASHBACK TABLE int_admin_emp TO BEFORE DROP
   RENAME TO int2_admin_emp;
```

The system-generated recycle bin name is very useful if you have dropped a table multiple times. For example, suppose you have three versions of the `int2_admin_emp` table in the recycle bin and you want to recover the second version. You can do this by issuing two `FLASHBACK TABLE` statements, or you can query the recycle bin and then flashback to the appropriate system-generated name, as shown in the following example. Including the create time in the query can help you verify that you are restoring the correct table.

```
SELECT object_name, original_name, createtime FROM recyclebin;

OBJECT_NAME                    ORIGINAL_NAME   CREATETIME
------------------------------ --------------- -------------------
BIN$yrMKlZaLMhfgNAgAIMenRA==$0 INT2_ADMIN_EMP  2006-02-05:21:05:52
BIN$yrMKlZaVMhfgNAgAIMenRA==$0 INT2_ADMIN_EMP  2006-02-05:21:25:13
BIN$yrMKlZaQMhfgNAgAIMenRA==$0 INT2_ADMIN_EMP  2006-02-05:22:05:53

FLASHBACK TABLE BIN$yrMKlZaVMhfgNAgAIMenRA==$0 TO BEFORE DROP;
```

Restoring Dependent Objects

When you restore a table from the recycle bin, dependent objects such as indexes do not get their original names back; they retain their system-generated recycle bin names. You must manually rename dependent objects if you want to restore their original names. If you plan to manually restore original names for dependent objects, ensure that you make note of each dependent object's system-generated recycle bin name *before* you restore the table.

The following is an example of restoring the original names of some of the indexes of the dropped table `JOB_HISTORY`, from the `HR` sample schema. The example assumes that you are logged in as the `HR` user.

1. After dropping `JOB_HISTORY` and before restoring it from the recycle bin, run the following query:

```
SELECT OBJECT_NAME, ORIGINAL_NAME, TYPE FROM RECYCLEBIN;

OBJECT_NAME                    ORIGINAL_NAME             TYPE
------------------------------ ------------------------- --------
BIN$DBo9UChtZSbgQFeMiAdCcQ==$0 JHIST_JOB_IX              INDEX
BIN$DBo9UChuZSbgQFeMiAdCcQ==$0 JHIST_EMPLOYEE_IX         INDEX
BIN$DBo9UChvZSbgQFeMiAdCcQ==$0 JHIST_DEPARTMENT_IX       INDEX
BIN$DBo9UChwZSbgQFeMiAdCcQ==$0 JHIST_EMP_ID_ST_DATE_PK   INDEX
BIN$DBo9UChxZSbgQFeMiAdCcQ==$0 JOB_HISTORY               TABLE
```

2. Restore the table with the following command:

```
FLASHBACK TABLE JOB_HISTORY TO BEFORE DROP;
```

3. Run the following query to verify that all `JOB_HISTORY` indexes retained their system-generated recycle bin names:

```
SELECT INDEX_NAME FROM USER_INDEXES WHERE TABLE_NAME = 'JOB_HISTORY';

INDEX_NAME
------------------------------
BIN$DBo9UChwZSbgQFeMiAdCcQ==$0
BIN$DBo9UChtZSbgQFeMiAdCcQ==$0
BIN$DBo9UChuZSbgQFeMiAdCcQ==$0
BIN$DBo9UChvZSbgQFeMiAdCcQ==$0
```

4. Restore the original names of the first two indexes as follows:

```
ALTER INDEX "BIN$DBo9UChtZSbgQFeMiAdCcQ==$0" RENAME TO JHIST_JOB_IX;
ALTER INDEX "BIN$DBo9UChuZSbgQFeMiAdCcQ==$0" RENAME TO JHIST_EMPLOYEE_IX;
```

   Note that double quotes are required around the system-generated names.

Managing Index-Organized Tables

This section describes aspects of managing index-organized tables, and contains the following topics:

- What Are Index-Organized Tables?
- Creating Index-Organized Tables
- Maintaining Index-Organized Tables
- Creating Secondary Indexes on Index-Organized Tables
- Analyzing Index-Organized Tables

- Using the ORDER BY Clause with Index-Organized Tables
- Converting Index-Organized Tables to Regular Tables

What Are Index-Organized Tables?

An **index-organized table** has a storage organization that is a variant of a primary B-tree. Unlike an ordinary (heap-organized) table whose data is stored as an unordered collection (heap), data for an index-organized table is stored in a B-tree index structure in a primary key sorted manner. Each leaf block in the index structure stores both the key and nonkey columns.

The structure of an index-organized table provides the following benefits:

- Fast random access on the primary key because an index-only scan is sufficient. And, because there is no separate table storage area, changes to the table data (such as adding new rows, updating rows, or deleting rows) result only in updating the index structure.
- Fast range access on the primary key because the rows are clustered in primary key order.
- Lower storage requirements because duplication of primary keys is avoided. They are not stored both in the index and underlying table, as is true with heap-organized tables.

Index-organized tables have full table functionality. They support features such as constraints, triggers, LOB and object columns, partitioning, parallel operations, online reorganization, and replication. And, they offer these additional features:

- Key compression
- Overflow storage area and specific column placement
- Secondary indexes, including bitmap indexes.

Index-organized tables are ideal for OLTP applications, which require fast primary key access and high availability. Queries and DML on an orders table used in electronic order processing are predominantly primary-key based and heavy volume causes fragmentation resulting in a frequent need to reorganize. Because an index-organized table can be reorganized online and without invalidating its secondary indexes, the window of unavailability is greatly reduced or eliminated.

Index-organized tables are suitable for modeling application-specific index structures. For example, content-based information retrieval applications containing text, image and audio data require inverted indexes that can be effectively modeled using index-organized tables. A fundamental component of an internet search engine is an inverted index that can be modeled using index-organized tables.

These are but a few of the applications for index-organized tables.

See Also:

- *Oracle Database Concepts* for a more thorough description of index-organized tables
- *Oracle Database VLDB and Partitioning Guide* for information about partitioning index-organized tables

Creating Index-Organized Tables

You use the `CREATE TABLE` statement to create index-organized tables, but you must provide additional information:

- An ORGANIZATION INDEX qualifier, which indicates that this is an index-organized table
- A primary key, specified through a column constraint clause (for a single column primary key) or a table constraint clause (for a multiple-column primary key).

Optionally, you can specify the following:

- An OVERFLOW clause, which preserves dense clustering of the B-tree index by storing the row column values exceeding a specified threshold in a separate overflow data segment.
- A PCTTHRESHOLD value, which defines the percentage of space reserved in the index block for an index-organized table. Any portion of the row that exceeds the specified threshold is stored in the overflow segment. In other words, the row is broken at a column boundary into two pieces, a head piece and tail piece. The head piece fits in the specified threshold and is stored along with the key in the index leaf block. The tail piece is stored in the overflow area as one or more row pieces. Thus, the index entry contains the key value, the nonkey column values that fit the specified threshold, and a pointer to the rest of the row.
- An INCLUDING clause, which can be used to specify nonkey columns that are to be stored in the overflow data segment.

Creating an Index-Organized Table

The following statement creates an index-organized table:

```
CREATE TABLE admin_docindex(
        token char(20),
        doc_id NUMBER,
        token_frequency NUMBER,
        token_offsets VARCHAR2(512),
        CONSTRAINT pk_admin_docindex PRIMARY KEY (token, doc_id))
    ORGANIZATION INDEX
    TABLESPACE admin_tbs
    PCTTHRESHOLD 20
    OVERFLOW TABLESPACE admin_tbs2;
```

Specifying ORGANIZATION INDEX causes the creation of an index-organized table, admin_docindex, where the key columns and nonkey columns reside in an index defined on columns that designate the primary key or keys for the table. In this case, the primary keys are token and doc_id. An overflow segment is specified and is discussed in "Using the Overflow Clause" on page 18-50.

Note: Index-organized tables cannot have virtual columns.

Creating Index-Organized Tables that Contain Object Types

Index-organized tables can store object types. The following example creates object type admin_typ, then creates an index-organized table containing a column of object type admin_typ:

```
CREATE OR REPLACE TYPE admin_typ AS OBJECT
    (col1 NUMBER, col2 VARCHAR2(6));
CREATE TABLE admin_iot (c1 NUMBER primary key, c2 admin_typ)
    ORGANIZATION INDEX;
```

You can also create an index-organized table of object types. For example:

```
CREATE TABLE admin_iot2 OF admin_typ (col1 PRIMARY KEY)
```

```
    ORGANIZATION INDEX;
```

Another example, that follows, shows that index-organized tables store nested tables efficiently. For a nested table column, the database internally creates a storage table to hold all the nested table rows.

```
CREATE TYPE project_t AS OBJECT(pno NUMBER, pname VARCHAR2(80));
/
CREATE TYPE project_set AS TABLE OF project_t;
/
CREATE TABLE proj_tab (eno NUMBER, projects PROJECT_SET)
    NESTED TABLE projects STORE AS emp_project_tab
                ((PRIMARY KEY(nested_table_id, pno))
    ORGANIZATION INDEX)
    RETURN AS LOCATOR;
```

The rows belonging to a single nested table instance are identified by a `nested_table_id` column. If an ordinary table is used to store nested table columns, the nested table rows typically get de-clustered. But when you use an index-organized table, the nested table rows can be clustered based on the `nested_table_id` column.

See Also:

- *Oracle Database SQL Language Reference* for details of the syntax used for creating index-organized tables
- *Oracle Database VLDB and Partitioning Guide* for information about creating partitioned index-organized tables
- *Oracle Database Object-Relational Developer's Guide* for information about object types

Using the Overflow Clause

The overflow clause specified in the statement shown in "Creating an Index-Organized Table" on page 18-49 indicates that any nonkey columns of rows exceeding 20% of the block size are placed in a data segment stored in the `admin_tbs2` tablespace. The key columns should fit the specified threshold.

If an update of a nonkey column causes the row to decrease in size, the database identifies the row piece (head or tail) to which the update is applicable and rewrites that piece.

If an update of a nonkey column causes the row to increase in size, the database identifies the piece (head or tail) to which the update is applicable and rewrites that row piece. If the target of the update turns out to be the head piece, note that this piece can again be broken into two to keep the row size below the specified threshold.

The nonkey columns that fit in the index leaf block are stored as a row head-piece that contains a `rowid` field linking it to the next row piece stored in the overflow data segment. The only columns that are stored in the overflow area are those that do not fit.

Choosing and Monitoring a Threshold Value

You should choose a threshold value that can accommodate your key columns, as well as the first few nonkey columns (if they are frequently accessed).

After choosing a threshold value, you can monitor tables to verify that the value you specified is appropriate. You can use the `ANALYZE TABLE ... LIST CHAINED ROWS` statement to determine the number and identity of rows exceeding the threshold value.

See Also:

- "Listing Chained Rows of Tables and Clusters" on page 16-4 for more information about chained rows
- *Oracle Database SQL Language Reference* for syntax of the `ANALYZE` statement

Using the INCLUDING Clause

In addition to specifying `PCTTHRESHOLD`, you can use the `INCLUDING` clause to control which nonkey columns are stored with the key columns. The database accommodates all nonkey columns up to the column specified in the `INCLUDING` clause in the index leaf block, provided it does not exceed the specified threshold. All nonkey columns beyond the column specified in the `INCLUDING` clause are stored in the overflow area.

Note: Oracle Database moves all primary key columns of an indexed-organized table to the beginning of the table (in their key order), in order to provide efficient primary key based access. As an example:

```
CREATE TABLE admin_iot4(a INT, b INT, c INT, d INT,
                primary key(c,b))
    ORGANIZATION INDEX;
```

The stored column order is: `c b a d` (instead of: `a b c d`). The last primary key column is `b`, based on the stored column order. The `INCLUDING` column can be the last primary key column (`b` in this example), or any nonkey column (that is, any column after `b` in the stored column order).

The following `CREATE TABLE` statement is similar to the one shown earlier in "Creating an Index-Organized Table" on page 18-49 but is modified to create an index-organized table where the `token_offsets` column value is always stored in the overflow area:

```
CREATE TABLE admin_docindex2(
        token CHAR(20),
        doc_id NUMBER,
        token_frequency NUMBER,
        token_offsets VARCHAR2(512),
        CONSTRAINT pk_admin_docindex2 PRIMARY KEY (token, doc_id))
    ORGANIZATION INDEX
    TABLESPACE admin_tbs
    PCTTHRESHOLD 20
    INCLUDING token_frequency
    OVERFLOW TABLESPACE admin_tbs2;
```

Here, only nonkey columns prior to `token_offsets` (in this case a single column only) are stored with the key column values in the index leaf block.

Parallelizing Index-Organized Table Creation

The CREATE TABLE...AS SELECT statement enables you to create an index-organized table and load data from an existing table into it. By including the PARALLEL clause, the load can be done in parallel.

The following statement creates an index-organized table in parallel by selecting rows from the conventional table hr.jobs:

```
CREATE TABLE admin_iot3(i PRIMARY KEY, j, k, l)
     ORGANIZATION INDEX
     PARALLEL
     AS SELECT * FROM hr.jobs;
```

This statement provides an alternative to parallel bulk-load using SQL*Loader.

Using Key Compression

Creating an index-organized table using key compression enables you to eliminate repeated occurrences of key column prefix values.

Key compression breaks an index key into a prefix and a suffix entry. Compression is achieved by sharing the prefix entries among all the suffix entries in an index block. This sharing can lead to huge savings in space, allowing you to store more keys in each index block while improving performance.

You can enable key compression using the COMPRESS clause while:

- Creating an index-organized table
- Moving an index-organized table

You can also specify the prefix length (as the number of key columns), which identifies how the key columns are broken into a prefix and suffix entry.

```
CREATE TABLE admin_iot5(i INT, j INT, k INT, l INT, PRIMARY KEY (i, j, k))
    ORGANIZATION INDEX COMPRESS;
```

The preceding statement is equivalent to the following statement:

```
CREATE TABLE admin_iot6(i INT, j INT, k INT, l INT, PRIMARY KEY(i, j, k))
    ORGANIZATION INDEX COMPRESS 2;
```

For the list of values (1,2,3), (1,2,4), (1,2,7), (1,3,5), (1,3,4), (1,4,4) the repeated occurrences of (1,2), (1,3) are compressed away.

You can also override the default prefix length used for compression as follows:

```
CREATE TABLE admin_iot7(i INT, j INT, k INT, l INT, PRIMARY KEY (i, j, k))
    ORGANIZATION INDEX COMPRESS 1;
```

For the list of values (1,2,3), (1,2,4), (1,2,7), (1,3,5), (1,3,4), (1,4,4), the repeated occurrences of 1 are compressed away.

You can disable compression as follows:

```
ALTER TABLE admin_iot5 MOVE NOCOMPRESS;
```

One application of key compression is in a time-series application that uses a set of time-stamped rows belonging to a single item, such as a stock price. Index-organized tables are attractive for such applications because of the ability to cluster rows based on the primary key. By defining an index-organized table with primary key (stock symbol, time stamp), you can store and manipulate time-series data efficiently. You can achieve more storage savings by compressing repeated occurrences of the item identifier (for example, the stock symbol) in a time series by using an index-organized table with key compression.

> **See Also:** *Oracle Database Concepts* for more information about key compression

Maintaining Index-Organized Tables

Index-organized tables differ from ordinary tables only in physical organization. Logically, they are manipulated in the same manner as ordinary tables. You can specify an index-organized table just as you would specify a regular table in INSERT, SELECT, DELETE, and UPDATE statements.

Altering Index-Organized Tables

All of the alter options available for ordinary tables are available for index-organized tables. This includes ADD, MODIFY, and DROP COLUMNS and CONSTRAINTS. However, the primary key constraint for an index-organized table cannot be dropped, deferred, or disabled

You can use the ALTER TABLE statement to modify physical and storage attributes for both primary key index and overflow data segments. All the attributes specified prior to the OVERFLOW keyword are applicable to the primary key index segment. All attributes specified after the OVERFLOW key word are applicable to the overflow data segment. For example, you can set the INITRANS of the primary key index segment to 4 and the overflow of the data segment INITRANS to 6 as follows:

```
ALTER TABLE admin_docindex INITRANS 4 OVERFLOW INITRANS 6;
```

You can also alter PCTTHRESHOLD and INCLUDING column values. A new setting is used to break the row into head and overflow tail pieces during subsequent operations. For example, the PCTHRESHOLD and INCLUDING column values can be altered for the admin_docindex table as follows:

```
ALTER TABLE admin_docindex PCTTHRESHOLD 15 INCLUDING doc_id;
```

By setting the INCLUDING column to doc_id, all the columns that follow token_frequency and token_offsets, are stored in the overflow data segment.

For index-organized tables created without an overflow data segment, you can add an overflow data segment by using the ADD OVERFLOW clause. For example, you can add an overflow segment to table admin_iot3 as follows:

```
ALTER TABLE admin_iot3 ADD OVERFLOW TABLESPACE admin_tbs2;
```

Moving (Rebuilding) Index-Organized Tables

Because index-organized tables are primarily stored in a B-tree index, you can encounter fragmentation as a consequence of incremental updates. However, you can use the ALTER TABLE...MOVE statement to rebuild the index and reduce this fragmentation.

The following statement rebuilds the index-organized table admin_docindex:

```
ALTER TABLE admin_docindex MOVE;
```

You can rebuild index-organized tables online using the ONLINE keyword. The overflow data segment, if present, is rebuilt when the OVERFLOW keyword is specified. For example, to rebuild the admin_docindex table but not the overflow data segment, perform a move online as follows:

```
ALTER TABLE admin_docindex MOVE ONLINE;
```

To rebuild the `admin_docindex` table along with its overflow data segment perform the move operation as shown in the following statement. This statement also illustrates moving both the table and overflow data segment to new tablespaces.

```
ALTER TABLE admin_docindex MOVE TABLESPACE admin_tbs2
    OVERFLOW TABLESPACE admin_tbs3;
```

In this last statement, an index-organized table with a LOB column (CLOB) is created. Later, the table is moved with the `LOB` index and data segment being rebuilt and moved to a new tablespace.

```
CREATE TABLE admin_iot_lob
   (c1 number (6) primary key,
    admin_lob CLOB)
   ORGANIZATION INDEX
   LOB (admin_lob) STORE AS (TABLESPACE admin_tbs2);
.
.
.
ALTER TABLE admin_iot_lob MOVE LOB (admin_lob) STORE AS (TABLESPACE admin_tbs3);
```

See Also: *Oracle Database SecureFiles and Large Objects Developer's Guide* contains information about LOBs in index-organized tables

Creating Secondary Indexes on Index-Organized Tables

You can create secondary indexes on an index-organized tables to provide multiple access paths. Secondary indexes on index-organized tables differ from indexes on ordinary tables in two ways:

- They store logical rowids instead of physical rowids. This is necessary because the inherent movability of rows in a B-tree index results in the rows having no permanent physical addresses. If the physical location of a row changes, its logical rowid remains valid. One effect of this is that a table maintenance operation, such as `ALTER TABLE` ... `MOVE`, does not make the secondary index unusable.
- The logical rowid also includes a physical guess which identifies the database block address at which the row is likely to be found. If the physical guess is correct, a secondary index scan would incur a single additional I/O once the secondary key is found. The performance would be similar to that of a secondary index-scan on an ordinary table.

Unique and non-unique secondary indexes, function-based secondary indexes, and bitmap indexes are supported as secondary indexes on index-organized tables.

Creating a Secondary Index on an Index-Organized Table

The following statement shows the creation of a secondary index on the `docindex` index-organized table where `doc_id` and `token` are the key columns:

```
CREATE INDEX Doc_id_index on Docindex(Doc_id, Token);
```

This secondary index allows the database to efficiently process a query, such as the following, the involves a predicate on `doc_id`:

```
SELECT Token FROM Docindex WHERE Doc_id = 1;
```

Maintaining Physical Guesses in Logical Rowids

A logical rowid can include a guess, which identifies the block location of a row at the time the guess is made. Instead of doing a full key search, the database uses the guess to search the block directly. However, as new rows are inserted, guesses can become stale. The indexes are still usable through the primary key-component of the logical rowid, but access to rows is slower.

Collect index statistics with the `DBMS_STATS` package to monitor the staleness of guesses. The database checks whether the existing guesses are still valid and records the percentage of rows with valid guesses in the data dictionary. This statistic is stored in the `PCT_DIRECT_ACCESS` column of the `DBA_INDEXES` view (and related views).

To obtain fresh guesses, you can rebuild the secondary index. Note that rebuilding a secondary index on an index-organized table involves reading the base table, unlike rebuilding an index on an ordinary table. A quicker, more light weight means of fixing the guesses is to use the `ALTER INDEX` ... `UPDATE BLOCK REFERENCES` statement. This statement is performed online, while DML is still allowed on the underlying index-organized table.

After you rebuild a secondary index, or otherwise update the block references in the guesses, collect index statistics again.

Bitmap Indexes

Bitmap indexes on index-organized tables are supported, provided the index-organized table is created with a mapping table. This is done by specifying the `MAPPING TABLE` clause in the `CREATE TABLE` statement that you use to create the index-organized table, or in an `ALTER TABLE` statement to add the mapping table later.

See Also: *Oracle Database Concepts* for a description of mapping tables

Analyzing Index-Organized Tables

Just like ordinary tables, index-organized tables are analyzed using the `DBMS_STATS` package, or the `ANALYZE` statement.

Collecting Optimizer Statistics for Index-Organized Tables

To collect optimizer statistics, use the `DBMS_STATS` package.

For example, the following statement gathers statistics for the index-organized `countries` table in the `hr` schema:

```
EXECUTE DBMS_STATS.GATHER_TABLE_STATS ('HR','COUNTRIES');
```

The `DBMS_STATS` package analyzes both the primary key index segment and the overflow data segment, and computes logical as well as physical statistics for the table.

- The logical statistics can be queried using `USER_TABLES`, `ALL_TABLES` or `DBA_TABLES`.
- You can query the physical statistics of the primary key index segment using `USER_INDEXES`, `ALL_INDEXES` or `DBA_INDEXES` (and using the primary key index name). For example, you can obtain the primary key index segment physical statistics for the table `admin_docindex` as follows:

```
SELECT LAST_ANALYZED, BLEVEL,LEAF_BLOCKS, DISTINCT_KEYS
   FROM DBA_INDEXES WHERE INDEX_NAME= 'PK_ADMIN_DOCINDEX';
```

- You can query the physical statistics for the overflow data segment using the `USER_TABLES`, `ALL_TABLES` or `DBA_TABLES`. You can identify the overflow entry by searching for `IOT_TYPE = 'IOT_OVERFLOW'`. For example, you can obtain overflow data segment physical attributes associated with the `admin_docindex` table as follows:

```
SELECT LAST_ANALYZED, NUM_ROWS, BLOCKS, EMPTY_BLOCKS
   FROM DBA_TABLES WHERE IOT_TYPE='IOT_OVERFLOW'
          and IOT_NAME= 'ADMIN_DOCINDEX';
```

See Also:

- *Oracle Database Performance Tuning Guide* for more information about collecting optimizer statistics
- *Oracle Database PL/SQL Packages and Types Reference* for more information about of the DBMS_STATS package

Validating the Structure of Index-Organized Tables

Use the `ANALYZE` statement if you want to validate the structure of your index-organized table or to list any chained rows. These operations are discussed in the following sections located elsewhere in this book:

- "Validating Tables, Indexes, Clusters, and Materialized Views" on page 16-3
- "Listing Chained Rows of Tables and Clusters" on page 16-4

Note: There are special considerations when listing chained rows for index-organized tables. These are discussed in the *Oracle Database SQL Language Reference*.

Using the ORDER BY Clause with Index-Organized Tables

If an `ORDER BY` clause only references the primary key column or a prefix of it, then the optimizer avoids the sorting overhead, as the rows are returned sorted on the primary key columns.

The following queries avoid sorting overhead because the data is already sorted on the primary key:

```
SELECT * FROM admin_docindex2 ORDER BY token, doc_id;
SELECT * FROM admin_docindex2 ORDER BY token;
```

If, however, you have an `ORDER BY` clause on a suffix of the primary key column or non-primary-key columns, additional sorting is required (assuming no other secondary indexes are defined).

```
SELECT * FROM admin_docindex2 ORDER BY doc_id;
SELECT * FROM admin_docindex2 ORDER BY token_frequency;
```

Converting Index-Organized Tables to Regular Tables

You can convert index-organized tables to regular tables using the Oracle import or export utilities, or the `CREATE TABLE...AS SELECT` statement.

To convert an index-organized table to a regular table:

- Export the index-organized table data using conventional path.
- Create a regular table definition with the same definition.

- Import the index-organized table data, making sure `IGNORE=y` (ensures that object exists error is ignored).

Note: Before converting an index-organized table to a regular table, be aware that index-organized tables cannot be exported using pre-Oracle8 versions of the Export utility.

See Also: *Oracle Database Utilities* for more details about using the `IMPORT` and `EXPORT` utilities

Managing External Tables

Oracle Database allows you read-only access to data in external tables. **External tables** are defined as tables that do not reside in the database, and can be in any format for which an access driver is provided. By providing the database with metadata describing an external table, the database is able to expose the data in the external table as if it were data residing in a regular database table. The external data can be queried directly and in parallel using SQL.

You can, for example, select, join, or sort external table data. You can also create views and synonyms for external tables. However, no DML operations (`UPDATE`, `INSERT`, or `DELETE`) are possible, and no indexes can be created, on external tables.

External tables also provide a framework to unload the result of an arbitrary `SELECT` statement into a platform-independent Oracle-proprietary format that can be used by Oracle Data Pump.

Note: The `DBMS_STATS` package can be used for gathering statistics for external tables. The `ANALYZE` statement is not supported for gathering statistics for external tables.

For information about using the `DBMS_STATS` package, see *Oracle Database Performance Tuning Guide*

The means of defining the metadata for external tables is through the `CREATE TABLE...ORGANIZATION EXTERNAL` statement. This external table definition can be thought of as a view that allows running any SQL query against external data without requiring that the external data first be loaded into the database. An access driver is the actual mechanism used to read the external data in the table. When you use external tables to unload data, the metadata is automatically created based on the datatypes in the `SELECT` statement (sometimes referred to as the shape of the query).

Oracle Database provides two access drivers for external tables. The default access driver is `ORACLE_LOADER`, which allows the reading of data from external files using the Oracle loader technology. The `ORACLE_LOADER` access driver provides data mapping capabilities which are a subset of the control file syntax of SQL*Loader utility. The second access driver, `ORACLE_DATAPUMP`, lets you unload data--that is, read data from the database and insert it into an external table, represented by one or more external files--and then reload it into an Oracle Database.

The Oracle Database external tables feature provides a valuable means for performing basic extraction, transformation, and loading (ETL) tasks that are common for data warehousing.

These following sections discuss the DDL statements that are supported for external tables. Only DDL statements discussed are supported, and not all clauses of these statements are supported.

- Creating External Tables
- Altering External Tables
- Dropping External Tables
- System and Object Privileges for External Tables

See Also:

- *Oracle Database Utilities* contains more information about external tables and describes the access drivers and their access parameters
- *Oracle Database Data Warehousing Guide* for information about using external tables in a data warehousing environment

Creating External Tables

You create external tables using the `ORGANIZATION EXTERNAL` clause of the `CREATE TABLE` statement. You are not in fact creating a table; that is, an external table does not have any extents associated with it. Rather, you are creating metadata in the data dictionary that enables you to access external data.

Note: External tables cannot have virtual columns.

The following example creates an external table and then uploads the data to a database table. Alternatively, you can unload data through the external table framework by specifying the `AS` *`subquery`* clause of the `CREATE TABLE` statement. External table data pump unload can use only the `ORACLE_DATAPUMP` access driver.

EXAMPLE: Creating an External Table and Loading Data

The file `empxt1.dat` contains the following sample data:

```
360,Jane,Janus,ST_CLERK,121,17-MAY-2001,3000,0,50,jjanus
361,Mark,Jasper,SA_REP,145,17-MAY-2001,8000,.1,80,mjasper
362,Brenda,Starr,AD_ASST,200,17-MAY-2001,5500,0,10,bstarr
363,Alex,Alda,AC_MGR,145,17-MAY-2001,9000,.15,80,aalda
```

The file `empxt2.dat` contains the following sample data:

```
401,Jesse,Cromwell,HR_REP,203,17-MAY-2001,7000,0,40,jcromwel
402,Abby,Applegate,IT_PROG,103,17-MAY-2001,9000,.2,60,aapplega
403,Carol,Cousins,AD_VP,100,17-MAY-2001,27000,.3,90,ccousins
404,John,Richardson,AC_ACCOUNT,205,17-MAY-2001,5000,0,110,jrichard
```

The following hypothetical SQL statements create an external table in the `hr` schema named `admin_ext_employees` and load its data into the `hr.employees` table.

```
CONNECT  /  AS SYSDBA;
-- Set up directories and grant access to hr
CREATE OR REPLACE DIRECTORY admin_dat_dir
    AS '/flatfiles/data';
CREATE OR REPLACE DIRECTORY admin_log_dir
    AS '/flatfiles/log';
CREATE OR REPLACE DIRECTORY admin_bad_dir
```

```
    AS '/flatfiles/bad';
GRANT READ ON DIRECTORY admin_dat_dir TO hr;
GRANT WRITE ON DIRECTORY admin_log_dir TO hr;
GRANT WRITE ON DIRECTORY admin_bad_dir TO hr;
-- hr connects
CONNECT hr/hr
-- create the external table
CREATE TABLE admin_ext_employees
                   (employee_id       NUMBER(4),
                    first_name        VARCHAR2(20),
                    last_name         VARCHAR2(25),
                    job_id            VARCHAR2(10),
                    manager_id        NUMBER(4),
                    hire_date         DATE,
                    salary            NUMBER(8,2),
                    commission_pct    NUMBER(2,2),
                    department_id     NUMBER(4),
                    email             VARCHAR2(25)
                   )
     ORGANIZATION EXTERNAL
     (
       TYPE ORACLE_LOADER
       DEFAULT DIRECTORY admin_dat_dir
       ACCESS PARAMETERS
       (
         records delimited by newline
         badfile admin_bad_dir:'empxt%a_%p.bad'
         logfile admin_log_dir:'empxt%a_%p.log'
         fields terminated by ','
         missing field values are null
         ( employee_id, first_name, last_name, job_id, manager_id,
           hire_date char date_format date mask "dd-mon-yyyy",
           salary, commission_pct, department_id, email
         )
       )
       LOCATION ('empxt1.dat', 'empxt2.dat')
     )
     PARALLEL
     REJECT LIMIT UNLIMITED;
-- enable parallel for loading (good if lots of data to load)
ALTER SESSION ENABLE PARALLEL DML;
-- load the data in hr employees table
INSERT INTO employees (employee_id, first_name, last_name, job_id, manager_id,
                       hire_date, salary, commission_pct, department_id, email)
            SELECT * FROM admin_ext_employees;
```

The following paragraphs contain descriptive information about this example.

The first few statements in this example create the directory objects for the operating system directories that contain the data sources, and for the bad record and log files specified in the access parameters. You must also grant `READ` or `WRITE` directory object privileges, as appropriate.

Note: When creating a directory object or BFILEs, ensure that the following conditions are met:

- The operating system file must not be a symbolic or hard link.
- The operating system directory path named in the Oracle Database directory object must be an existing OS directory path.
- The operating system directory path named in the directory object should not contain any symbolic links in its components.

The TYPE specification indicates the access driver of the external table. The access driver is the API that interprets the external data for 5the database. Oracle Database provides two access drivers: ORACLE_LOADER and ORACLE_DATAPUMP. If you omit the TYPE specification, ORACLE_LOADER is the default access driver. You must specify the ORACLE_DATAPUMP access driver if you specify the AS *subquery* clause to unload data from one Oracle Database and reload it into the same or a different Oracle Database.

The access parameters, specified in the ACCESS PARAMETERS clause, are opaque to the database. These access parameters are defined by the access driver, and are provided to the access driver by the database when the external table is accessed. See *Oracle Database Utilities* for a description of the ORACLE_LOADER access parameters.

The PARALLEL clause enables parallel query on the data sources. The granule of parallelism is by default a data source, but parallel access within a data source is implemented whenever possible. For example, if PARALLEL=3 were specified, then more than one parallel execution server could be working on a data source. But, parallel access within a data source is provided by the access driver only if all of the following conditions are met:

- The media allows random positioning within a data source
- It is possible to find a record boundary from a random position
- The data files are large enough to make it worthwhile to break up into multiple chunks

---

Note: Specifying a PARALLEL clause is of value *only* when dealing with large amounts of data. Otherwise, it is not advisable to specify a PARALLEL clause, and doing so can be detrimental.

The REJECT LIMIT clause specifies that there is no limit on the number of errors that can occur during a query of the external data. For parallel access, this limit applies to each parallel execution server independently. For example, if REJECT LIMIT is specified, each parallel query process is allowed 10 rejections. Hence, the only precisely enforced values for REJECT LIMIT on parallel query are 0 and UNLIMITED.

In this example, the INSERT INTO TABLE statement generates a dataflow from the external data source to the Oracle Database SQL engine where data is processed. As data is parsed by the access driver from the external table sources and provided to the external table interface, the external data is converted from its external representation to its Oracle Database internal datatype.

See Also: *Oracle Database SQL Language Reference* provides details of the syntax of the `CREATE TABLE` statement for creating external tables and specifies restrictions on the use of clauses

Altering External Tables

You can use any of the `ALTER TABLE` clauses shown in Table 18–3 to change the characteristics of an external table. No other clauses are permitted.

Table 18–3 ALTER TABLE Clauses for External Tables

ALTER TABLE Clause	Description	Example

`REJECT LIMIT`	Changes the reject limit	`ALTER TABLE admin_ext_employees`
		`   REJECT LIMIT 100;`

`PROJECT COLUMN`	Determines how the access driver validates rows in subsequent queries:
	■ `PROJECT COLUMN REFERENCED`: the access driver processes only the columns in the select list of the query. This setting may not provide a consistent set of rows when querying a different column list from the same external table. This is the default.
	■ `PROJECT COLUMN ALL`: the access driver processes all of the columns defined on the external table. This setting always provides a consistent set of rows when querying an external table.
		`ALTER TABLE admin_ext_employees`
		`   PROJECT COLUMN REFERNCED;`
		
		`ALTER TABLE admin_ext_employees`
		`   PROJECT COLUMN ALL;`

`DEFAULT DIRECTORY`	Changes the default directory specification	`ALTER TABLE admin_ext_employees`
		`    DEFAULT DIRECTORY admin_dat2_dir;`

`ACCESS PARAMETERS`	Allows access parameters to be changed without dropping and re-creating the external table metadata	`ALTER TABLE admin_ext_employees`
		`    ACCESS PARAMETERS`
		`       (FIELDS TERMINATED BY ';');`

`LOCATION`	Allows data sources to be changed without dropping and re-creating the external table metadata	`ALTER TABLE admin_ext_employees`
		`   LOCATION ('empxt3.txt',`
		`             'empxt4.txt');`

`PARALLEL`	No difference from regular tables. Allows degree of parallelism to be changed.	No new syntax
`ADD COLUMN`	No difference from regular tables. Allows a column to be added to an external table. Virtual columns are not permitted.	No new syntax
`MODIFY COLUMN`	No difference from regular tables. Allows an external table column to be modified. Virtual columns are not permitted.	No new syntax
`DROP COLUMN`	No difference from regular tables. Allows an external table column to be dropped.	No new syntax
`RENAME TO`	No difference from regular tables. Allows external table to be renamed.	No new syntax

Dropping External Tables

For an external table, the `DROP TABLE` statement removes only the table metadata in the database. It has no affect on the actual data, which resides outside of the database.

System and Object Privileges for External Tables

System and object privileges for external tables are a subset of those for regular table. Only the following system privileges are applicable to external tables:

- `CREATE ANY TABLE`
- `ALTER ANY TABLE`
- `DROP ANY TABLE`
- `SELECT ANY TABLE`

Only the following object privileges are applicable to external tables:

- `ALTER`
- `SELECT`

However, object privileges associated with a directory are:

- `READ`
- `WRITE`

For external tables, `READ` privileges are required on directory objects that contain data sources, while `WRITE` privileges are required for directory objects containing bad, log, or discard files.

Tables Data Dictionary Views

The following views allow you to access information about tables.

View	Description

`DBA_TABLES`
`ALL_TABLES`
`USER_TABLES`
	`DBA` view describes all relational tables in the database. `ALL` view describes all tables accessible to the user. `USER` view is restricted to tables owned by the user. Some columns in these views contain statistics that are generated by the `DBMS_STATS` package or `ANALYZE` statement.

`DBA_TAB_COLUMNS`
`ALL_TAB_COLUMNS`
`USER_TAB_COLUMNS`
	These views describe the columns of tables, views, and clusters in the database. Some columns in these views contain statistics that are generated by the `DBMS_STATS` package or `ANALYZE` statement.

`DBA_ALL_TABLES`
`ALL_ALL_TABLES`
`USER_ALL_TABLES`
	These views describe all relational and object tables in the database. Object tables are not specifically discussed in this book.

`DBA_TAB_COMMENTS`
`ALL_TAB_COMMENTS`
`USER_TAB_COMMENTS`
	These views display comments for tables and views. Comments are entered using the `COMMENT` statement.

`DBA_COL_COMMENTS`
`ALL_COL_COMMENTS`
`USER_COL_COMMENTS`
	These views display comments for table and view columns. Comments are entered using the `COMMENT` statement.

`DBA_EXTERNAL_TABLES`
`ALL_EXTERNAL_TABLES`
`USER_EXTERNAL_TABLES`
	These views list the specific attributes of external tables in the database.

View	Description
DBA_EXTERNAL_LOCATIONS ALL_EXTERNAL_LOCATIONS USER_EXTERNAL_LOCATIONS	These views list the data sources for external tables.
DBA_TAB_HISTOGRAMS ALL_TAB_HISTOGRAMS USER_TAB_HISTOGRAMS	These views describe histograms on tables and views.
DBA_TAB_STATISTICS ALL_TAB_STATISTICS USER_TAB_STATISTICS	These views contain optimizer statistics for tables.
DBA_TAB_COL_STATISTICS ALL_TAB_COL_STATISTICS USER_TAB_COL_STATISTICS	These views provide column statistics and histogram information extracted from the related `TAB_COLUMNS` views.
DBA_TAB_MODIFICATIONS ALL_TAB_MODIFICATIONS USER_TAB_MODIFICATIONS	These views describe tables that have been modified since the last time table statistics were gathered on them. They are not populated immediately, but after a time lapse (usually 3 hours).
DBA_ENCRYPTED_COLUMNS USER_ENCRYPTED_COLUMNS ALL_ENCRYPTED_COLUMNS	These views list table columns that are encrypted, and for each column, lists the encryption algorithm in use.
DBA_UNUSED_COL_TABS ALL_UNUSED_COL_TABS USER_UNUSED_COL_TABS	These views list tables with unused columns, as marked by the `ALTER TABLE ... SET UNUSED` statement.
DBA_PARTIAL_DROP_TABS ALL_PARTIAL_DROP_TABS USER_PARTIAL_DROP_TABS	These views list tables that have partially completed `DROP COLUMN` operations. These operations could be incomplete because the operation was interrupted by the user or a system failure.

Example: Displaying Column Information

Column information, such as name, datatype, length, precision, scale, and default data values can be listed using one of the views ending with the `_COLUMNS` suffix. For example, the following query lists all of the default column values for the `emp` and `dept` tables:

```
SELECT TABLE_NAME, COLUMN_NAME, DATA_TYPE, DATA_LENGTH, LAST_ANALYZED
    FROM DBA_TAB_COLUMNS
    WHERE OWNER = 'HR'
    ORDER BY TABLE_NAME;
```

The following is the output from the query:

```
TABLE_NAME           COLUMN_NAME          DATA_TYPE   DATA_LENGTH LAST_ANALYZED
-------------------- -------------------- ---------- ------------ -------------
COUNTRIES            COUNTRY_ID           CHAR                  2 05-FEB-03
COUNTRIES            COUNTRY_NAME         VARCHAR2             40 05-FEB-03
COUNTRIES            REGION_ID            NUMBER               22 05-FEB-03
DEPARTMENTS          DEPARTMENT_ID        NUMBER               22 05-FEB-03
DEPARTMENTS          DEPARTMENT_NAME      VARCHAR2             30 05-FEB-03
DEPARTMENTS          MANAGER_ID           NUMBER               22 05-FEB-03
DEPARTMENTS          LOCATION_ID          NUMBER               22 05-FEB-03
EMPLOYEES            EMPLOYEE_ID          NUMBER               22 05-FEB-03
EMPLOYEES           FIRST_NAME          VARCHAR2                20 05-FEB-03
EMPLOYEES           LAST_NAME           VARCHAR2                25 05-FEB-03
EMPLOYEES           EMAIL               VARCHAR2                25 05-FEB-03
.
.
.
LOCATIONS           COUNTRY_ID          CHAR                     2 05-FEB-03
REGIONS             REGION_ID           NUMBER                  22 05-FEB-03
REGIONS             REGION_NAME         VARCHAR2                25 05-FEB-03

51 rows selected.
```

See Also:

- *Oracle Database Reference* for complete descriptions of these views
- *Oracle Database Object-Relational Developer's Guide* for information about object tables
- *Oracle Database Performance Tuning Guide* for information about histograms and generating statistics for tables
- "Analyzing Tables, Indexes, and Clusters" on page 16-2

19 Managing Indexes

This chapter discusses the management of indexes, and contains the following topics:

About Indexes

Indexes are optional structures associated with tables and clusters that allow SQL statements to execute more quickly against a table. Just as the index in this manual helps you locate information faster than if there were no index, an Oracle Database index provides a faster access path to table data. You can use indexes without rewriting any queries. Your results are the same, but you see them more quickly.

Oracle Database provides several indexing schemes that provide complementary performance functionality. These are:

- B-tree indexes: the default and the most common
- B-tree cluster indexes: defined specifically for cluster
- Hash cluster indexes: defined specifically for a hash cluster
- Global and local indexes: relate to partitioned tables and indexes
- Reverse key indexes: most useful for Oracle Real Application Clusters applications
- Bitmap indexes: compact; work best for columns with a small set of values
- Function-based indexes: contain the precomputed value of a function/expression
- Domain indexes: specific to an application or cartridge.

Indexes are logically and physically independent of the data in the associated table. Being independent structures, they require storage space. You can create or drop an index without affecting the base tables, database applications, or other indexes. The database automatically maintains indexes when you insert, update, and delete rows of the associated table. If you drop an index, all applications continue to work. However, access to previously indexed data might be slower.

See Also: Chapter 17, "Managing Space for Schema Objects" is recommended reading before attempting tasks described in this chapter.

Guidelines for Managing Indexes

This section discusses guidelines for managing indexes and contains the following topics:

- Create Indexes After Inserting Table Data
- Index the Correct Tables and Columns
- Order Index Columns for Performance
- Limit the Number of Indexes for Each Table
- Drop Indexes That Are No Longer Required
- Estimate Index Size and Set Storage Parameters
- Specify the Tablespace for Each Index
- Consider Parallelizing Index Creation
- Consider Creating Indexes with NOLOGGING
- Consider Costs and Benefits of Coalescing or Rebuilding Indexes
- Consider Cost Before Disabling or Dropping Constraints

See Also:

- *Oracle Database Concepts* for conceptual information about indexes and indexing, including descriptions of the various indexing schemes offered by Oracle
- *Oracle Database Performance Tuning Guide* and *Oracle Database Data Warehousing Guide* for information about bitmap indexes
- *Oracle Database Data Cartridge Developer's Guide* for information about defining domain-specific operators and indexing schemes and integrating them into the Oracle Database server

Create Indexes After Inserting Table Data

Data is often inserted or loaded into a table using either the SQL*Loader or an import utility. It is more efficient to create an index for a table after inserting or loading the data. If you create one or more indexes before loading data, the database then must update every index as each row is inserted.

Creating an index on a table that already has data requires sort space. Some sort space comes from memory allocated for the index creator. The amount for each user is determined by the initialization parameter `SORT_AREA_SIZE`. The database also swaps sort information to and from temporary segments that are only allocated during the index creation in the users temporary tablespace.

Under certain conditions, data can be loaded into a table with SQL*Loader direct-path load and an index can be created as data is loaded.

See Also: *Oracle Database Utilities* for information about using SQL*Loader for direct-path load

Index the Correct Tables and Columns

Use the following guidelines for determining when to create an index:

- Create an index if you frequently want to retrieve less than 15% of the rows in a large table. The percentage varies greatly according to the relative speed of a table scan and how the distribution of the row data in relation to the index key. The faster the table scan, the lower the percentage; the more clustered the row data, the higher the percentage.
- To improve performance on joins of multiple tables, index columns used for joins.

> **Note:** Primary and unique keys automatically have indexes, but you might want to create an index on a foreign key.

- Small tables do not require indexes. If a query is taking too long, then the table might have grown from small to large.

Columns That Are Suitable for Indexing

Some columns are strong candidates for indexing. Columns with one or more of the following characteristics are candidates for indexing:

- Values are relatively unique in the column.
- There is a wide range of values (good for regular indexes).
- There is a small range of values (good for bitmap indexes).
- The column contains many nulls, but queries often select all rows having a value. In this case, use the following phrase:

  ```
  WHERE COL_X > -9.99 * power(10,125)
  ```

  Using the preceding phrase is preferable to:

  ```
  WHERE COL_X IS NOT NULL
  ```

  This is because the first uses an index on `COL_X` (assuming that `COL_X` is a numeric column).

Columns That Are Not Suitable for Indexing

Columns with the following characteristics are less suitable for indexing:

- There are many nulls in the column and you do not search on the not null values.

`LONG` and `LONG RAW` columns cannot be indexed.

Virtual Columns

You can create unique or non-unique indexes on virtual columns.

Order Index Columns for Performance

The order of columns in the `CREATE INDEX` statement can affect query performance. In general, specify the most frequently used columns first.

If you create a single index across columns to speed up queries that access, for example, `col1`, `col2`, and `col3`; then queries that access just `col1`, or that access just `col1` and `col2`, are also speeded up. But a query that accessed just `col2`, just `col3`, or just `col2` and `col3` does not use the index.

Limit the Number of Indexes for Each Table

A table can have any number of indexes. However, the more indexes there are, the more overhead is incurred as the table is modified. Specifically, when rows are inserted or deleted, all indexes on the table must be updated as well. Also, when a column is updated, all indexes that contain the column must be updated.

Thus, there is a trade-off between the speed of retrieving data from a table and the speed of updating the table. For example, if a table is primarily read-only, having more indexes can be useful; but if a table is heavily updated, having fewer indexes could be preferable.

Drop Indexes That Are No Longer Required

Consider dropping an index if:

- It does not speed up queries. The table could be very small, or there could be many rows in the table but very few index entries.
- The queries in your applications do not use the index.
- The index must be dropped before being rebuilt.

See Also: "Monitoring Index Usage" on page 19-14

Estimate Index Size and Set Storage Parameters

Estimating the size of an index before creating one can facilitate better disk space planning and management. You can use the combined estimated size of indexes, along with estimates for tables, the undo tablespace, and redo log files, to determine the amount of disk space that is required to hold an intended database. From these estimates, you can make correct hardware purchases and other decisions.

Use the estimated size of an individual index to better manage the disk space that the index uses. When an index is created, you can set appropriate storage parameters and improve I/O performance of applications that use the index. For example, assume that you estimate the maximum size of an index before creating it. If you then set the storage parameters when you create the index, fewer extents are allocated for the table data segment, and all of the index data is stored in a relatively contiguous section of disk space. This decreases the time necessary for disk I/O operations involving this index.

The maximum size of a single index entry is approximately one-half the data block size.

See Also: "Managing Storage Parameters" on page 17-5 for specific information about storage parameters

Specify the Tablespace for Each Index

Indexes can be created in any tablespace. An index can be created in the same or different tablespace as the table it indexes. If you use the same tablespace for a table and its index, it can be more convenient to perform database maintenance (such as tablespace or file backup) or to ensure application availability. All the related data is always online together.

Using different tablespaces (on different disks) for a table and its index produces better performance than storing the table and index in the same tablespace. Disk contention is reduced. But, if you use different tablespaces for a table and its index and one tablespace is offline (containing either data or index), then the statements referencing that table are not guaranteed to work.

Consider Parallelizing Index Creation

You can parallelize index creation, much the same as you can parallelize table creation. Because multiple processes work together to create the index, the database can create the index more quickly than if a single server process created the index sequentially.

When creating an index in parallel, storage parameters are used separately by each query server process. Therefore, an index created with an `INITIAL` value of 5M and a parallel degree of 12 consumes at least 60M of storage during index creation.

See Also:

- *Oracle Database Concepts* for more information about parallel execution
- *Oracle Database Data Warehousing Guide* for information about utilizing parallel execution in a data warehousing environment

Consider Creating Indexes with NOLOGGING

You can create an index and generate minimal redo log records by specifying `NOLOGGING` in the `CREATE INDEX` statement.

Note: Because indexes created using `NOLOGGING` are not archived, perform a backup after you create the index.

Creating an index with `NOLOGGING` has the following benefits:

- Space is saved in the redo log files.
- The time it takes to create the index is decreased.
- Performance improves for parallel creation of large indexes.

In general, the relative performance improvement is greater for larger indexes created without `LOGGING` than for smaller ones. Creating small indexes without `LOGGING` has little effect on the time it takes to create an index. However, for larger indexes the performance improvement can be significant, especially when you are also parallelizing the index creation.

Consider Costs and Benefits of Coalescing or Rebuilding Indexes

Improper sizing or increased growth can produce index fragmentation. To eliminate or reduce fragmentation, you can rebuild or coalesce the index. But before you perform either task weigh the costs and benefits of each option and choose the one that works best for your situation. Table 19–1 is a comparison of the costs and benefits associated with rebuilding and coalescing indexes.

Table 19–1 To Rebuild or Coalesce ... That Is the Question

Rebuild Index	Coalesce Index
Quickly moves index to another tablespace	Cannot move index to another tablespace
Higher costs: requires more disk space	Lower costs: does not require more disk space

Table 19–1 (Cont.) To Rebuild or Coalesce ... That Is the Question

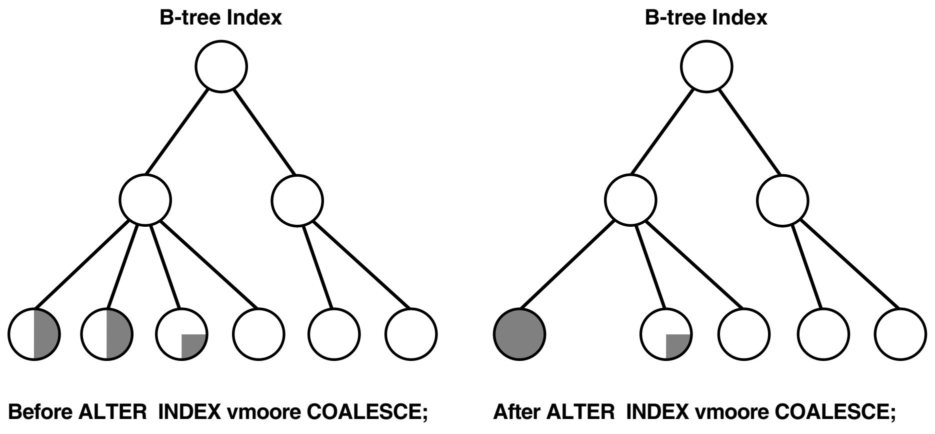
Rebuild Index	Coalesce Index
Creates new tree, shrinks height if applicable	Coalesces leaf blocks within same branch of tree
Enables you to quickly change storage and tablespace parameters without having to drop the original index.	Quickly frees up index leaf blocks for use.

In situations where you have B-tree index leaf blocks that can be freed up for reuse, you can merge those leaf blocks using the following statement:

```
ALTER INDEX vmoore COALESCE;
```

Figure 19–1 illustrates the effect of an `ALTER INDEX COALESCE` on the index `vmoore`. Before performing the operation, the first two leaf blocks are 50% full. This means you have an opportunity to reduce fragmentation and completely fill the first block, while freeing up the second.

Figure 19–1 Coalescing Indexes


B-tree Index
B-tree Index
Before ALTER INDEX vmoore COALESCE;
After ALTER INDEX vmoore COALESCE;

Consider Cost Before Disabling or Dropping Constraints

Because unique and primary keys have associated indexes, you should factor in the cost of dropping and creating indexes when considering whether to disable or drop a `UNIQUE` or `PRIMARY KEY` constraint. If the associated index for a `UNIQUE` key or `PRIMARY KEY` constraint is extremely large, you can save time by leaving the constraint enabled rather than dropping and re-creating the large index. You also have the option of explicitly specifying that you want to keep or drop the index when dropping or disabling a `UNIQUE` or `PRIMARY KEY` constraint.

See Also: "Managing Integrity Constraints" on page 16-9

Creating Indexes

This section describes how to create indexes. To create an index in your own schema, *at least one* of the following conditions must be true:

- The table or cluster to be indexed is in your own schema.
- You have `INDEX` privilege on the table to be indexed.
- You have `CREATE ANY INDEX` system privilege.

To create an index in another schema, *all* of the following conditions must be true:

- You have `CREATE ANY INDEX` system privilege.
- The owner of the other schema has a quota for the tablespaces to contain the index or index partitions, or `UNLIMITED TABLESPACE` system privilege.

This section contains the following topics:

Creating an Index Explicitly

You can create indexes explicitly (outside of integrity constraints) using the SQL statement `CREATE INDEX`. The following statement creates an index named `emp_ename` for the `ename` column of the `emp` table:

```
CREATE INDEX emp_ename ON emp(ename)
      TABLESPACE users
      STORAGE (INITIAL 20K
      NEXT 20k
      PCTINCREASE 75);
```

Notice that several storage settings and a tablespace are explicitly specified for the index. If you do not specify storage options (such as `INITIAL` and `NEXT`) for an index, the default storage options of the default or specified tablespace are automatically used.

See Also: *Oracle Database SQL Language Reference* for syntax and restrictions on the use of the `CREATE INDEX` statement

Creating a Unique Index Explicitly

Indexes can be unique or non-unique. Unique indexes guarantee that no two rows of a table have duplicate values in the key column (or columns). Non-unique indexes do not impose this restriction on the column values.

Use the `CREATE UNIQUE INDEX` statement to create a unique index. The following example creates a unique index:

```
CREATE UNIQUE INDEX dept_unique_index ON dept (dname)
      TABLESPACE indx;
```

Alternatively, you can define `UNIQUE` integrity constraints on the desired columns. The database enforces `UNIQUE` integrity constraints by automatically defining a unique index on the unique key. This is discussed in the following section. However, it is advisable that any index that exists for query performance, including unique indexes, be created explicitly.

See Also: *Oracle Database Performance Tuning Guide* for more information about creating an index for performance

Creating an Index Associated with a Constraint

Oracle Database enforces a `UNIQUE` key or `PRIMARY KEY` integrity constraint on a table by creating a unique index on the unique key or primary key. This index is automatically created by the database when the constraint is enabled. No action is required by you when you issue the `CREATE TABLE` or `ALTER TABLE` statement to create the index, but you can optionally specify a `USING INDEX` clause to exercise control over its creation. This includes both when a constraint is defined and enabled, and when a defined but disabled constraint is enabled.

To enable a `UNIQUE` or `PRIMARY KEY` constraint, thus creating an associated index, the owner of the table must have a quota for the tablespace intended to contain the index, or the `UNLIMITED TABLESPACE` system privilege. The index associated with a constraint always takes the name of the constraint, unless you optionally specify otherwise.

Note: An efficient procedure for enabling a constraint that can make use of parallelism is described in"Efficient Use of Integrity Constraints: A Procedure" on page 16-11.

Specifying Storage Options for an Index Associated with a Constraint

You can set the storage options for the indexes associated with `UNIQUE` and `PRIMARY KEY` constraints using the `USING INDEX` clause. The following `CREATE TABLE` statement enables a `PRIMARY KEY` constraint and specifies the storage options of the associated index:

```
CREATE TABLE emp (
     empno NUMBER(5) PRIMARY KEY, age INTEGER)
     ENABLE PRIMARY KEY USING INDEX
     TABLESPACE users;
```

Specifying the Index Associated with a Constraint

If you require more explicit control over the indexes associated with `UNIQUE` and `PRIMARY KEY` constraints, the database lets you:

- Specify an existing index that the database is to use to enforce the constraint
- Specify a `CREATE INDEX` statement that the database is to use to create the index and enforce the constraint

These options are specified using the `USING INDEX` clause. The following statements present some examples.

Example 1:

```
CREATE TABLE a (
     a1 INT PRIMARY KEY USING INDEX (create index ai on a (a1)));
```

Example 2:

```
CREATE TABLE b(
     b1 INT,
     b2 INT,
     CONSTRAINT bu1 UNIQUE (b1, b2)
                    USING INDEX (create unique index bi on b(b1, b2)),
     CONSTRAINT bu2 UNIQUE (b2, b1) USING INDEX bi);
```

Example 3:

```
CREATE TABLE c(c1 INT, c2 INT);
CREATE INDEX ci ON c (c1, c2);
ALTER TABLE c ADD CONSTRAINT cpk PRIMARY KEY (c1) USING INDEX ci;
```

If a single statement creates an index with one constraint and also uses that index for another constraint, the system will attempt to rearrange the clauses to create the index before reusing it.

See Also: "Managing Integrity Constraints" on page 16-9

Collecting Incidental Statistics when Creating an Index

Oracle Database provides you with the opportunity to collect statistics at very little resource cost during the creation or rebuilding of an index. These statistics are stored in the data dictionary for ongoing use by the optimizer in choosing a plan for the execution of SQL statements. The following statement computes index, table, and column statistics while building index `emp_ename` on column `ename` of table `emp`:

```
CREATE INDEX emp_ename ON emp(ename)
     COMPUTE STATISTICS;
```

See Also:

- *Oracle Database Performance Tuning Guide* for information about collecting statistics and their use by the optimizer
- "Analyzing Tables, Indexes, and Clusters" on page 16-2

Creating a Large Index

When creating an extremely large index, consider allocating a larger temporary tablespace for the index creation using the following procedure:

1. Create a new temporary tablespace using the `CREATE TABLESPACE` or `CREATE TEMPORARY TABLESPACE` statement.
2. Use the `TEMPORARY TABLESPACE` option of the `ALTER USER` statement to make this your new temporary tablespace.
3. Create the index using the `CREATE INDEX` statement.
4. Drop this tablespace using the `DROP TABLESPACE` statement. Then use the `ALTER USER` statement to reset your temporary tablespace to your original temporary tablespace.

Using this procedure can avoid the problem of expanding your usual, and usually shared, temporary tablespace to an unreasonably large size that might affect future performance.

Creating an Index Online

You can create and rebuild indexes online. This enables you to update base tables at the same time you are building or rebuilding indexes on that table. You can perform DML operations while the index build is taking place, but DDL operations are not allowed. Parallel execution is not supported when creating or rebuilding an index online.

The following statements illustrate online index build operations:

```
CREATE INDEX emp_name ON emp (mgr, emp1, emp2, emp3) ONLINE;
```

Note: Keep in mind that the time that it takes on online index build to complete is proportional to the size of the table and the number of concurrently executing DML statements. Therefore, it is best to start online index builds when DML activity is low.

See Also: "Rebuilding an Existing Index" on page 19-13

Creating a Function-Based Index

Function-based indexes facilitate queries that qualify a value returned by a function or expression. The value of the function or expression is precomputed and stored in the index.

In addition to the prerequisites for creating a conventional index, if the index is based on user-defined functions, then those functions must be marked `DETERMINISTIC`. Also, you just have the `EXECUTE` object privilege on any user-defined function(s) used in the function-based index if those functions are owned by another user.

Additionally, to use a function-based index:

- The table must be analyzed after the index is created.
- The query must be guaranteed not to need any `NULL` values from the indexed expression, since `NULL` values are not stored in indexes.

Note: `CREATE INDEX` stores the timestamp of the most recent function used in the function-based index. This timestamp is updated when the index is validated. When performing tablespace point-in-time recovery of a function-based index, if the timestamp on the most recent function used in the index is newer than the timestamp stored in the index, then the index is marked invalid. You must use the `ANALYZE INDEX...VALIDATE STRUCTURE` statement to validate this index.

To illustrate a function-based index, consider the following statement that defines a function-based index (`area_index`) defined on the function `area(geo)`:

```
CREATE INDEX area_index ON rivers (area(geo));
```

In the following SQL statement, when `area(geo)` is referenced in the `WHERE` clause, the optimizer considers using the index `area_index`.

```
SELECT id, geo, area(geo), desc
     FROM rivers
     WHERE Area(geo) >5000;
```

Table owners should have `EXECUTE` privileges on the functions used in function-based indexes.

Because a function-based index depends upon any function it is using, it can be invalidated when a function changes. If the function is valid, you can use an `ALTER INDEX...ENABLE` statement to enable a function-based index that has been disabled. The `ALTER INDEX...DISABLE` statement lets you disable the use of a function-based index. Consider doing this if you are working on the body of the function.

Note: An alternative to creating a function-based index is to add a virtual column to the target table and index the virtual column. See "About Tables" on page 18-1 for more information.

See Also:

- *Oracle Database Concepts* for more information about function-based indexes
- *Oracle Database Advanced Application Developer's Guide* for information about using function-based indexes in applications and examples of their use

Creating a Key-Compressed Index

Creating an index using key compression enables you to eliminate repeated occurrences of key column prefix values.

Key compression breaks an index key into a prefix and a suffix entry. Compression is achieved by sharing the prefix entries among all the suffix entries in an index block. This sharing can lead to huge savings in space, allowing you to store more keys for each index block while improving performance.

Key compression can be useful in the following situations:

- You have a non-unique index where ROWID is appended to make the key unique. If you use key compression here, the duplicate key is stored as a prefix entry on the index block without the ROWID. The remaining rows become suffix entries consisting of only the ROWID.
- You have a unique multicolumn index.

You enable key compression using the COMPRESS clause. The prefix length (as the number of key columns) can also be specified to identify how the key columns are broken into a prefix and suffix entry. For example, the following statement compresses duplicate occurrences of a key in the index leaf block:

```
CREATE INDEX  emp_ename ON emp(ename)
   TABLESPACE users
   COMPRESS 1;
```

The COMPRESS clause can also be specified during rebuild. For example, during rebuild you can disable compression as follows:

```
ALTER INDEX emp_ename REBUILD NOCOMPRESS;
```

See Also: *Oracle Database Concepts* for a more detailed discussion of key compression

Creating an Invisible Index

Beginning with Release 11*g*, you can create invisible indexes. An **invisible index** is an index that is ignored by the optimizer unless you explicitly set the OPTIMIZER_USE_INVISIBLE_INDEXES initialization parameter to TRUE at the session or system level. Making an index invisible is an alternative to making it unusable or dropping it. Using invisible indexes, you can do the following:

- Test the removal of an index before dropping it.

- Use temporary index structures for certain operations or modules of an application without affecting the overall application.

Unlike unusable indexes, an invisible index is maintained during DML statements.

To create an invisible index, use the SQL statement `CREATE INDEX` with the `INVISIBLE` clause. The following statement creates an invisible index named `emp_ename` for the `ename` column of the `emp` table:

```
CREATE INDEX emp_ename ON emp(ename)
      TABLESPACE users
      STORAGE (INITIAL 20K
      NEXT 20k
      PCTINCREASE 75)
      INVISIBLE;
```

See Also:

- "Making an Index Invisible" on page 19-14
- *Oracle Database SQL Language Reference* for information about using comments in a `SELECT` statement to pass hints to the Oracle Database optimizer

Altering Indexes

To alter an index, your schema must contain the index or you must have the `ALTER ANY INDEX` system privilege. With the `ALTER INDEX` statement, you can:

- Rebuild or coalesce an existing index
- Deallocate unused space or allocate a new extent
- Specify parallel execution (or not) and alter the degree of parallelism
- Alter storage parameters or physical attributes
- Specify `LOGGING` or `NOLOGGING`
- Enable or disable key compression
- Mark the index unusable
- Make the index invisible
- Start or stop the monitoring of index usage

You cannot alter index column structure.

More detailed discussions of some of these operations are contained in the following sections:

- Altering Storage Characteristics of an Index
- Rebuilding an Existing Index
- Making an Index Invisible
- Monitoring Index Usage

See Also:

- *Oracle Database SQL Language Reference* for details on the `ALTER INDEX` statement

Altering Storage Characteristics of an Index

Alter the storage parameters of any index, including those created by the database to enforce primary and unique key integrity constraints, using the `ALTER INDEX` statement. For example, the following statement alters the `emp_ename` index:

```
ALTER INDEX emp_ename
     STORAGE (PCTINCREASE 50);
```

The storage parameters `INITIAL` and `MINEXTENTS` cannot be altered. All new settings for the other storage parameters affect only extents subsequently allocated for the index.

For indexes that implement integrity constraints, you can adjust storage parameters by issuing an `ALTER TABLE` statement that includes the `USING INDEX` subclause of the `ENABLE` clause. For example, the following statement changes the storage options of the index created on table `emp` to enforce the primary key constraint:

```
ALTER TABLE emp
     ENABLE PRIMARY KEY USING INDEX;
```

See Also: *Oracle Database SQL Language Reference* for syntax and restrictions on the use of the `ALTER INDEX` statement

Rebuilding an Existing Index

Before rebuilding an existing index, compare the costs and benefits associated with rebuilding to those associated with coalescing indexes as described in Table 19–1 on page 19-5.

When you rebuild an index, you use an existing index as the data source. Creating an index in this manner enables you to change storage characteristics or move to a new tablespace. Rebuilding an index based on an existing data source removes intra-block fragmentation. Compared to dropping the index and using the `CREATE INDEX` statement, re-creating an existing index offers better performance.

The following statement rebuilds the existing index `emp_name`:

```
ALTER INDEX emp_name REBUILD;
```

The `REBUILD` clause must immediately follow the index name, and precede any other options. It cannot be used in conjunction with the `DEALLOCATE UNUSED` clause.

You have the option of rebuilding the index online. Rebuilding online enables you to update base tables at the same time that you are rebuilding. The following statement rebuilds the `emp_name` index online:

```
ALTER INDEX emp_name REBUILD ONLINE;
```

Note: Online index rebuilding has stricter limitations on the maximum key length that can be handled, compared to other methods of rebuilding an index. If an ORA-1450 (maximum key length exceeded) error occurs when rebuilding online, try rebuilding offline, coalescing, or dropping and recreating the index.

If you do not have the space required to rebuild an index, you can choose instead to coalesce the index. Coalescing an index is an online operation.

See Also:

- "Creating an Index Online" on page 19-9
- "Monitoring Space Use of Indexes" on page 19-14

Making an Index Invisible

To make a visible index invisible, issue this statement:

```
ALTER INDEX index INVISIBLE;
```

To make an invisible index visible, issue this statement:

```
ALTER INDEX index VISIBLE;
```

To find out whether an index is visible or invisible, query the dictionary views USER_INDEXES, ALL_INDEXES, or DBA_INDEXES. For example, to determine if the index IND1 is invisible, issue the following query:

```
SELECT INDEX_NAME, VISIBILITY FROM USER_INDEXES
   WHERE INDEX_NAME = 'IND1';

INDEX_NAME   VISIBILITY
----------   ----------
IND1         VISIBLE
```

See Also: "Creating an Invisible Index" on page 19-11 for a definition of invisible indexes.

Monitoring Index Usage

Oracle Database provides a means of monitoring indexes to determine whether they are being used. If an index is not being used, then it can be dropped, eliminating unnecessary statement overhead.

To start monitoring the usage of an index, issue this statement:

```
ALTER INDEX index MONITORING USAGE;
```

Later, issue the following statement to stop the monitoring:

```
ALTER INDEX index NOMONITORING USAGE;
```

The view V$OBJECT_USAGE can be queried for the index being monitored to see if the index has been used. The view contains a USED column whose value is YES or NO, depending upon if the index has been used within the time period being monitored. The view also contains the start and stop times of the monitoring period, and a MONITORING column (YES/NO) to indicate if usage monitoring is currently active.

Each time that you specify MONITORING USAGE, the V$OBJECT_USAGE view is reset for the specified index. The previous usage information is cleared or reset, and a new start time is recorded. When you specify NOMONITORING USAGE, no further monitoring is performed, and the end time is recorded for the monitoring period. Until the next ALTER INDEX...MONITORING USAGE statement is issued, the view information is left unchanged.

Monitoring Space Use of Indexes

If key values in an index are inserted, updated, and deleted frequently, the index can lose its acquired space efficiently over time. Monitor index efficiency of space usage at regular intervals by first analyzing the index structure, using the ANALYZE INDEX...VALIDATE STRUCTURE statement, and then querying the INDEX_STATS view:

```
SELECT PCT_USED FROM INDEX_STATS WHERE NAME = 'index';
```

The percentage of index space usage varies according to how often index keys are inserted, updated, or deleted. Develop a history of average efficiency of space usage for an index by performing the following sequence of operations several times:

- Analyzing statistics
- Validating the index
- Checking PCT_USED
- Dropping and rebuilding (or coalescing) the index

When you find that index space usage drops below its average, you can condense the index space by dropping the index and rebuilding it, or coalescing it.

See Also: "Analyzing Tables, Indexes, and Clusters" on page 16-2

Dropping Indexes

To drop an index, the index must be contained in your schema, or you must have the DROP ANY INDEX system privilege.

Some reasons for dropping an index include:

- The index is no longer required.
- The index is not providing anticipated performance improvements for queries issued against the associated table. For example, the table might be very small, or there might be many rows in the table but very few index entries.
- Applications do not use the index to query the data.
- The index has become invalid and must be dropped before being rebuilt.
- The index has become too fragmented and must be dropped before being rebuilt.

When you drop an index, all extents of the index segment are returned to the containing tablespace and become available for other objects in the tablespace.

How you drop an index depends on whether you created the index explicitly with a CREATE INDEX statement, or implicitly by defining a key constraint on a table. If you created the index explicitly with the CREATE INDEX statement, then you can drop the index with the DROP INDEX statement. The following statement drops the emp_ename index:

```
DROP INDEX emp_ename;
```

You cannot drop only the index associated with an enabled UNIQUE key or PRIMARY KEY constraint. To drop a constraints associated index, you must disable or drop the constraint itself.

Note: If a table is dropped, all associated indexes are dropped automatically.

See Also:

- *Oracle Database SQL Language Reference* for syntax and restrictions on the use of the DROP INDEX statement
- "Managing Integrity Constraints" on page 16-9
- "Making an Index Invisible" on page 19-14 for an alternative to dropping indexes

Indexes Data Dictionary Views

The following views display information about indexes:

View	Description
DBA_INDEXES ALL_INDEXES USER_INDEXES	DBA view describes indexes on all tables in the database. ALL view describes indexes on all tables accessible to the user. USER view is restricted to indexes owned by the user. Some columns in these views contain statistics that are generated by the DBMS_STATS package or ANALYZE statement.
DBA_IND_COLUMNS ALL_IND_COLUMNS USER_IND_COLUMNS	These views describe the columns of indexes on tables. Some columns in these views contain statistics that are generated by the DBMS_STATS package or ANALYZE statement.
DBA_IND_EXPRESSIONS ALL_IND_EXPRESSIONS USER_IND_EXPRESSIONS	These views describe the expressions of function-based indexes on tables.
DBA_IND_STATISTICS ALL_IND_STATISTICS USER_IND_STATISTICS	These views contain optimizer statistics for indexes.
INDEX_STATS	Stores information from the last ANALYZE INDEX...VALIDATE STRUCTURE statement.
INDEX_HISTOGRAM	Stores information from the last ANALYZE INDEX...VALIDATE STRUCTURE statement.
V$OBJECT_USAGE	Contains index usage information produced by the ALTER INDEX...MONITORING USAGE functionality.

See Also: *Oracle Database Reference* for a complete description of these views

20 Managing Clusters

This chapter describes aspects of managing clusters. It contains the following topics relating to the management of indexed clusters, clustered tables, and cluster indexes:

About Clusters

A **cluster** provides an optional method of storing table data. A cluster is made up of a group of tables that share the same data blocks. The tables are grouped together because they share common columns and are often used together. For example, the `emp` and `dept` table share the `deptno` column. When you cluster the `emp` and `dept` tables (see Figure 20–1), Oracle Database physically stores all rows for each department from both the `emp` and `dept` tables in the same data blocks.

Because clusters store related rows of different tables together in the same data blocks, properly used clusters offer two primary benefits:

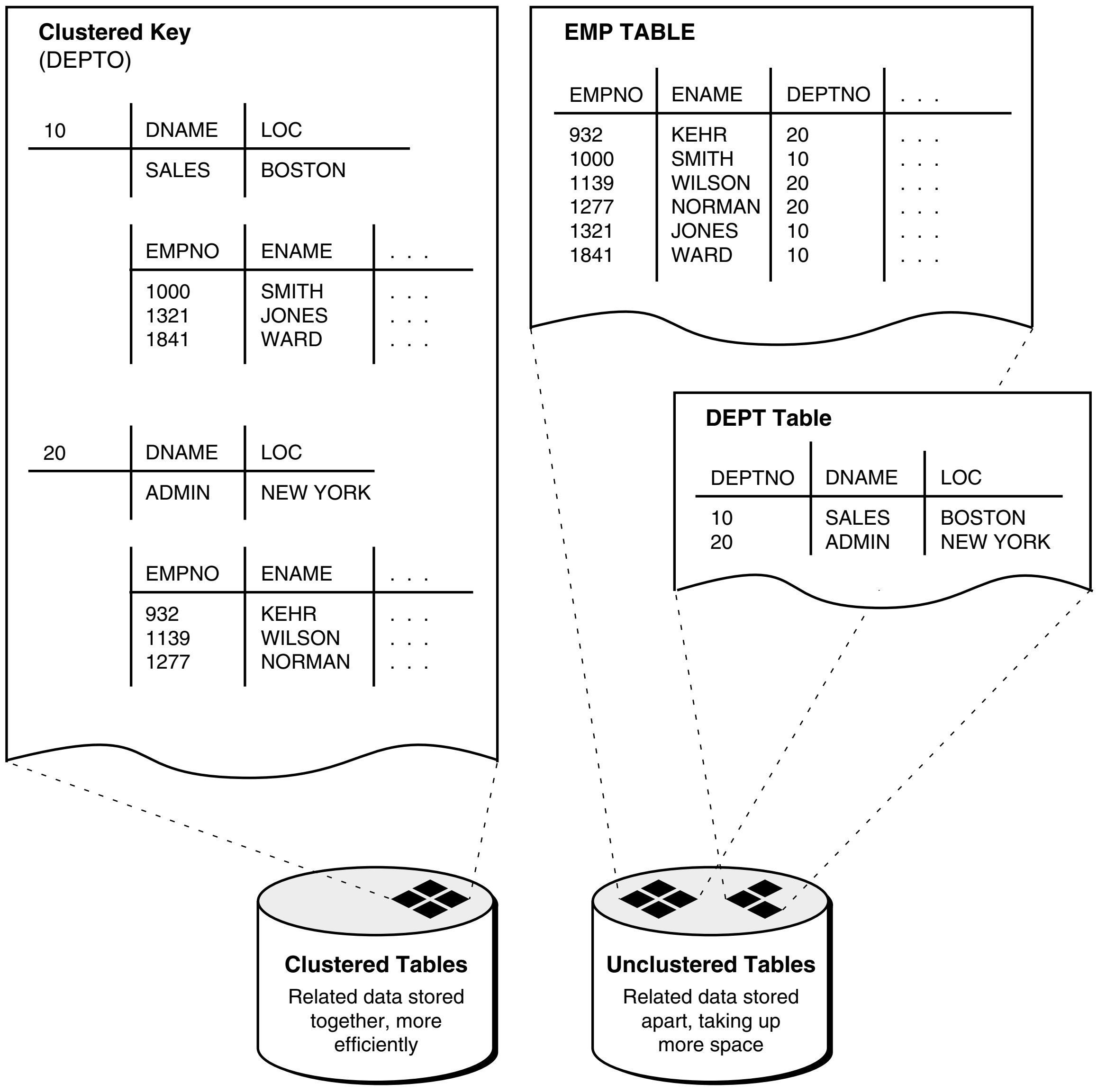
- Disk I/O is reduced and access time improves for joins of clustered tables.
- The **cluster key** is the column, or group of columns, that the clustered tables have in common. You specify the columns of the cluster key when creating the cluster. You subsequently specify the same columns when creating every table added to the cluster. Each cluster key value is stored only once each in the cluster and the cluster index, no matter how many rows of different tables contain the value.

  Therefore, less storage might be required to store related table and index data in a cluster than is necessary in non-clustered table format. For example, in Figure 20–1, notice how each cluster key (each `deptno`) is stored just once for many rows that contain the same value in both the `emp` and `dept` tables.

After creating a cluster, you can create tables in the cluster. However, before any rows can be inserted into the clustered tables, a cluster index must be created. Using clusters does not affect the creation of additional indexes on the clustered tables; they can be created and dropped as usual.

You should not use clusters for tables that are frequently accessed individually.

Figure 20–1 Clustered Table Data



See Also:

- Chapter 21, "Managing Hash Clusters" for a description of another type of cluster: a hash cluster
- Chapter 17, "Managing Space for Schema Objects" is recommended reading before attempting tasks described in this chapter

Guidelines for Managing Clusters

The following sections describe guidelines to consider when managing clusters, and contains the following topics:

- Choose Appropriate Tables for the Cluster
- Choose Appropriate Columns for the Cluster Key
- Specify the Space Required by an Average Cluster Key and Its Associated Rows
- Specify the Location of Each Cluster and Cluster Index Rows
- Estimate Cluster Size and Set Storage Parameters

See Also:

- *Oracle Database Concepts* for more information about clusters
- *Oracle Database Performance Tuning Guide* for guidelines on when to use clusters

Choose Appropriate Tables for the Cluster

Use clusters for tables for which the following conditions are true:

- The tables are primarily queried--that is, tables that are *not* predominantly inserted into or updated.
- Records from the tables are frequently queried together or joined.

Choose Appropriate Columns for the Cluster Key

Choose cluster key columns carefully. If multiple columns are used in queries that join the tables, make the cluster key a composite key. In general, the characteristics that indicate a good cluster index are the same as those for any index. For information about characteristics of a good index, see "Guidelines for Managing Indexes" on page 19-2.

A good cluster key has enough unique values so that the group of rows corresponding to each key value fills approximately one data block. Having too few rows for each cluster key value can waste space and result in negligible performance gains. Cluster keys that are so specific that only a few rows share a common value can cause wasted space in blocks, unless a small `SIZE` was specified at cluster creation time (see "Specify the Space Required by an Average Cluster Key and Its Associated Rows" on page 20-3).

Too many rows for each cluster key value can cause extra searching to find rows for that key. Cluster keys on values that are too general (for example, `male` and `female`) result in excessive searching and can result in worse performance than with no clustering.

A cluster index cannot be unique or include a column defined as `long`.

Specify the Space Required by an Average Cluster Key and Its Associated Rows

The `CREATE CLUSTER` statement has an optional clause, `SIZE`, which is the estimated number of bytes required by an average cluster key and its associated rows. The database uses the `SIZE` parameter when performing the following tasks:

- Estimating the number of cluster keys (and associated rows) that can fit in a clustered data block
- Limiting the number of cluster keys placed in a clustered data block. This maximizes the storage efficiency of keys within a cluster.

SIZE does not limit the space that can be used by a given cluster key. For example, if SIZE is set such that two cluster keys can fit in one data block, any amount of the available data block space can still be used by either of the cluster keys.

By default, the database stores only one cluster key and its associated rows in each data block of the cluster data segment. Although block size can vary from one operating system to the next, the rule of one key for each block is maintained as clustered tables are imported to other databases on other machines.

If all the rows for a given cluster key value cannot fit in one block, the blocks are chained together to speed access to all the values with the given key. The cluster index points to the beginning of the chain of blocks, each of which contains the cluster key value and associated rows. If the cluster SIZE is such that more than one key fits in a block, blocks can belong to more than one chain.

Specify the Location of Each Cluster and Cluster Index Rows

If you have the proper privileges and tablespace quota, you can create a new cluster and the associated cluster index in any tablespace that is currently online. Always specify the TABLESPACE clause in a CREATE CLUSTER/INDEX statement to identify the tablespace to store the new cluster or index.

The cluster and its cluster index can be created in different tablespaces. In fact, creating a cluster and its index in different tablespaces that are stored on different storage devices allows table data and index data to be retrieved simultaneously with minimal disk contention.

Estimate Cluster Size and Set Storage Parameters

The following are benefits of estimating cluster size before creating the cluster:

- You can use the combined estimated size of clusters, along with estimates for indexes and redo log files, to determine the amount of disk space that is required to hold an intended database. From these estimates, you can make correct hardware purchases and other decisions.
- You can use the estimated size of an individual cluster to better manage the disk space that the cluster will use. When a cluster is created, you can set appropriate storage parameters and improve I/O performance of applications that use the cluster.

Whether or not you estimate table size before creation, you can explicitly set storage parameters when creating each nonclustered table. Any storage parameter that you do not explicitly set when creating or subsequently altering a table automatically uses the corresponding default storage parameter set for the tablespace in which the table resides. Clustered tables also automatically use the storage parameters of the cluster.

Creating Clusters

To create a cluster in your schema, you must have the CREATE CLUSTER system privilege and a quota for the tablespace intended to contain the cluster or the UNLIMITED TABLESPACE system privilege.

To create a cluster in another user's schema you must have the CREATE ANY CLUSTER system privilege, and the owner must have a quota for the tablespace intended to contain the cluster or the UNLIMITED TABLESPACE system privilege.

You create a cluster using the `CREATE CLUSTER` statement. The following statement creates a cluster named `emp_dept`, which stores the `emp` and `dept` tables, clustered by the `deptno` column:

```
CREATE CLUSTER emp_dept (deptno NUMBER(3))
   SIZE 600
   TABLESPACE users
   STORAGE (INITIAL 200K
      NEXT 300K
      MINEXTENTS 2
      MAXEXTENTS 20
      PCTINCREASE 33);
```

If no `INDEX` keyword is specified, as is true in this example, an index cluster is created by default. You can also create a `HASH` cluster, when hash parameters (`HASHKEYS`, `HASH IS`, or `SINGLE TABLE HASHKEYS`) are specified. Hash clusters are described in Chapter 21, "Managing Hash Clusters".

Creating Clustered Tables

To create a table in a cluster, you must have either the `CREATE TABLE` or `CREATE ANY TABLE` system privilege. You do not need a tablespace quota or the `UNLIMITED TABLESPACE` system privilege to create a table in a cluster.

You create a table in a cluster using the `CREATE TABLE` statement with the `CLUSTER` clause. The `emp` and `dept` tables can be created in the `emp_dept` cluster using the following statements:

```
CREATE TABLE emp (
   empno NUMBER(5) PRIMARY KEY,
   ename VARCHAR2(15) NOT NULL,
   . . .
   deptno NUMBER(3) REFERENCES dept)
   CLUSTER emp_dept (deptno);

CREATE TABLE dept (
   deptno NUMBER(3) PRIMARY KEY, . . . )
   CLUSTER emp_dept (deptno);
```

Note: You can specify the schema for a clustered table in the `CREATE TABLE` statement. A clustered table can be in a different schema than the schema containing the cluster. Also, the names of the columns are not required to match, but their structure must match.

See Also: *Oracle Database SQL Language Reference* for syntax of the `CREATE TABLE` statement for creating cluster tables

Creating Cluster Indexes

To create a cluster index, one of the following conditions must be true:

- Your schema contains the cluster.
- You have the `CREATE ANY INDEX` system privilege.

In either case, you must also have either a quota for the tablespace intended to contain the cluster index, or the `UNLIMITED TABLESPACE` system privilege.

A cluster index must be created before any rows can be inserted into any clustered table. The following statement creates a cluster index for the `emp_dept` cluster:

```
CREATE INDEX emp_dept_index
   ON CLUSTER emp_dept
   TABLESPACE users
   STORAGE (INITIAL 50K
      NEXT 50K
      MINEXTENTS 2
      MAXEXTENTS 10
      PCTINCREASE 33);
```

The cluster index clause (`ON CLUSTER`) identifies the cluster, `emp_dept`, for which the cluster index is being created. The statement also explicitly specifies several storage settings for the cluster and cluster index.

> **See Also:** *Oracle Database SQL Language Reference* for syntax of the `CREATE INDEX` statement for creating cluster indexes

Altering Clusters

To alter a cluster, your schema must contain the cluster or you must have the `ALTER ANY CLUSTER` system privilege. You can alter an existing cluster to change the following settings:

- Physical attributes (`INITRANS` and storage characteristics)
- The average amount of space required to store all the rows for a cluster key value (`SIZE`)
- The default degree of parallelism

Additionally, you can explicitly allocate a new extent for the cluster, or deallocate any unused extents at the end of the cluster. The database dynamically allocates additional extents for the data segment of a cluster as required. In some circumstances, however, you might want to explicitly allocate an additional extent for a cluster. For example, when using Real Application Clusters, you can allocate an extent of a cluster explicitly for a specific instance. You allocate a new extent for a cluster using the `ALTER CLUSTER` statement with the `ALLOCATE EXTENT` clause.

When you alter the cluster size parameter (`SIZE`) of a cluster, the new settings apply to all data blocks used by the cluster, including blocks already allocated and blocks subsequently allocated for the cluster. Blocks already allocated for the table are reorganized when necessary (not immediately).

When you alter the transaction entry setting `INITRANS` of a cluster, the new setting for `INITRANS` applies only to data blocks subsequently allocated for the cluster.

The storage parameters `INITIAL` and `MINEXTENTS` cannot be altered. All new settings for the other storage parameters affect only extents subsequently allocated for the cluster.

To alter a cluster, use the `ALTER CLUSTER` statement.

> **See Also:** *Oracle Database SQL Language Reference* for syntax of the `ALTER CLUSTER` statement

Altering Clustered Tables

You can alter clustered tables using the `ALTER TABLE` statement. However, any data block space parameters, transaction entry parameters, or storage parameters you set in an ALTER TABLE statement for a clustered table generate an error message (ORA-01771, illegal option for a clustered table). The database uses the parameters of the cluster for all clustered tables. Therefore, you can use the ALTER TABLE statement only to add or modify columns, drop non-cluster-key columns, or add, drop, enable, or disable integrity constraints or triggers for a clustered table. For information about altering tables, see "Altering Tables" on page 18-20.

See Also: *Oracle Database SQL Language Reference* for syntax of the ALTER TABLE statement

Altering Cluster Indexes

You alter cluster indexes exactly as you do other indexes. See "Altering Indexes" on page 19-12.

Note: When estimating the size of cluster indexes, remember that the index is on each cluster key, not the actual rows. Therefore, each key appears only once in the index.

Dropping Clusters

A cluster can be dropped if the tables within the cluster are no longer needed. When a cluster is dropped, so are the tables within the cluster and the corresponding cluster index. All extents belonging to both the cluster data segment and the index segment of the cluster index are returned to the containing tablespace and become available for other segments within the tablespace.

To drop a cluster that contains no tables, and its cluster index, use the DROP CLUSTER statement. For example, the following statement drops the empty cluster named emp_dept:

```
DROP CLUSTER emp_dept;
```

If the cluster contains one or more clustered tables and you intend to drop the tables as well, add the INCLUDING TABLES clause of the DROP CLUSTER statement, as follows:

```
DROP CLUSTER emp_dept INCLUDING TABLES;
```

If the INCLUDING TABLES clause is not included and the cluster contains tables, an error is returned.

If one or more tables in a cluster contain primary or unique keys that are referenced by FOREIGN KEY constraints of tables outside the cluster, the cluster cannot be dropped unless the dependent FOREIGN KEY constraints are also dropped. This can be easily done using the CASCADE CONSTRAINTS clause of the DROP CLUSTER statement, as shown in the following example:

```
DROP CLUSTER emp_dept INCLUDING TABLES CASCADE CONSTRAINTS;
```

The database returns an error if you do not use the CASCADE CONSTRAINTS clause and constraints exist.

See Also: *Oracle Database SQL Language Reference* for syntax of the DROP CLUSTER statement

Dropping Clustered Tables

To drop a cluster, your schema must contain the cluster or you must have the DROP ANY CLUSTER system privilege. You do not need additional privileges to drop a cluster that contains tables, even if the clustered tables are not owned by the owner of the cluster.

Clustered tables can be dropped individually without affecting the cluster, other clustered tables, or the cluster index. A clustered table is dropped just as a nonclustered table is dropped, with the DROP TABLE statement. See "Dropping Table Columns" on page 18-23.

Note: When you drop a single table from a cluster, the database deletes each row of the table individually. To maximize efficiency when you intend to drop an entire cluster, drop the cluster including all tables by using the DROP CLUSTER statement with the INCLUDING TABLES clause. Drop an individual table from a cluster (using the DROP TABLE statement) only if you want the rest of the cluster to remain.

Dropping Cluster Indexes

A cluster index can be dropped without affecting the cluster or its clustered tables. However, clustered tables cannot be used if there is no cluster index; you must re-create the cluster index to allow access to the cluster. Cluster indexes are sometimes dropped as part of the procedure to rebuild a fragmented cluster index. For information about dropping an index, see "Dropping Indexes" on page 19-15.

Clusters Data Dictionary Views

The following views display information about clusters:

View	Description
DBA_CLUSTERS ALL_CLUSTERS USER_CLUSTERS	DBA view describes all clusters in the database. ALL view describes all clusters accessible to the user. USER view is restricted to clusters owned by the user. Some columns in these views contain statistics that are generated by the DBMS_STATS package or ANALYZE statement.
DBA_CLU_COLUMNS USER_CLU_COLUMNS	These views map table columns to cluster columns

See Also: *Oracle Database Reference* for complete descriptions of these views

21 Managing Hash Clusters

This chapter describes how to manage hash clusters, and contains the following topics:

About Hash Clusters

Storing a table in a hash cluster is an optional way to improve the performance of data retrieval. A hash cluster provides an alternative to a non-clustered table with an index or an index cluster. With an indexed table or index cluster, Oracle Database locates the rows in a table using key values that the database stores in a separate index. To use hashing, you create a hash cluster and load tables into it. The database physically stores the rows of a table in a hash cluster and retrieves them according to the results of a **hash function**.

Oracle Database uses a hash function to generate a distribution of numeric values, called **hash values**, that are based on specific cluster key values. The key of a hash cluster, like the key of an index cluster, can be a single column or composite key (multiple column key). To find or store a row in a hash cluster, the database applies the hash function to the cluster key value of the row. The resulting hash value corresponds to a data block in the cluster, which the database then reads or writes on behalf of the issued statement.

To find or store a row in an indexed table or cluster, a minimum of two (there are usually more) I/Os must be performed:

- One or more I/Os to find or store the key value in the index
- Another I/O to read or write the row in the table or cluster

In contrast, the database uses a hash function to locate a row in a hash cluster; no I/O is required. As a result, a minimum of one I/O operation is necessary to read or write a row in a hash cluster.

See Also: Chapter 17, "Managing Space for Schema Objects" is recommended reading before attempting tasks described in this chapter.

When to Use Hash Clusters

This section helps you decide when to use hash clusters by contrasting situations where hashing is most useful against situations where there is no advantage. If you find your decision is to use indexing rather than hashing, then you should consider whether to store a table individually or as part of a cluster.

Note: Even if you decide to use hashing, a table can still have separate indexes on any columns, including the cluster key.

Situations Where Hashing Is Useful

Hashing is useful when you have the following conditions:

- Most queries are equality queries on the cluster key:

  ```
  SELECT ... WHERE cluster_key = ...;
  ```

  In such cases, the cluster key in the equality condition is hashed, and the corresponding hash key is usually found with a single read. In comparison, for an indexed table the key value must first be found in the index (usually several reads), and then the row is read from the table (another read).

- The tables in the hash cluster are primarily static in size so that you can determine the number of rows and amount of space required for the tables in the cluster. If tables in a hash cluster require more space than the initial allocation for the cluster, performance degradation can be substantial because overflow blocks are required.

Situations Where Hashing Is Not Advantageous

Hashing is not advantageous in the following situations:

- Most queries on the table retrieve rows over a range of cluster key values. For example, in full table scans or queries such as the following, a hash function cannot be used to determine the location of specific hash keys. Instead, the equivalent of a full table scan must be done to fetch the rows for the query.

  ```
  SELECT . . . WHERE cluster_key < . . . ;
  ```

  With an index, key values are ordered in the index, so cluster key values that satisfy the `WHERE` clause of a query can be found with relatively few I/Os.

- The table is not static, but instead is continually growing. If a table grows without limit, the space required over the life of the table (its cluster) cannot be predetermined.

- Applications frequently perform full-table scans on the table and the table is sparsely populated. A full-table scan in this situation takes longer under hashing.

- You cannot afford to preallocate the space that the hash cluster will eventually need.

Creating Hash Clusters

A hash cluster is created using a `CREATE CLUSTER` statement, but you specify a `HASHKEYS` clause. The following example contains a statement to create a cluster named `trial_cluster` that stores the `trial` table, clustered by the `trialno` column (the cluster key); and another statement creating a table in the cluster.

```
CREATE CLUSTER trial_cluster (trialno NUMBER(5,0))
    TABLESPACE users
    STORAGE (INITIAL 250K     NEXT 50K
      MINEXTENTS 1     MAXEXTENTS 3
      PCTINCREASE 0)
    HASH IS trialno HASHKEYS 150;

CREATE TABLE trial (
    trialno NUMBER(5,0) PRIMARY KEY,
    ...)
    CLUSTER trial_cluster (trialno);
```

As with index clusters, the key of a hash cluster can be a single column or a composite key (multiple column key). In this example, it is a single column.

The `HASHKEYS` value, in this case 150, specifies and limits the number of unique hash values that can be generated by the hash function used by the cluster. The database rounds the number specified to the nearest prime number.

If no `HASH IS` clause is specified, the database uses an internal hash function. If the cluster key is already a unique identifier that is uniformly distributed over its range, you can bypass the internal hash function and specify the cluster key as the hash value, as is the case in the preceding example. You can also use the `HASH IS` clause to specify a user-defined hash function.

You cannot create a cluster index on a hash cluster, and you need not create an index on a hash cluster key.

For additional information about creating tables in a cluster, guidelines for setting parameters of the `CREATE CLUSTER` statement common to index and hash clusters, and the privileges required to create any cluster, see Chapter 20, "Managing Clusters". The following sections explain and provide guidelines for setting the parameters of the `CREATE CLUSTER` statement specific to hash clusters:

- Creating a Sorted Hash Cluster
- Creating Single-Table Hash Clusters
- Controlling Space Use Within a Hash Cluster
- Estimating Size Required by Hash Clusters

Creating a Sorted Hash Cluster

In a **sorted hash cluster**, the rows corresponding to each value of the hash function are sorted on a specified set of columns in ascending order, which can improve response time during subsequent operations on the clustered data.

For example, a telecommunications company needs to store detailed call records for a fixed number of originating telephone numbers through a telecommunications switch. From each originating telephone number there can be an unlimited number of telephone calls.

Calls are stored as they are made and processed later in first-in, first-out order (FIFO) when bills are generated for each originating telephone number. Each call has a detailed call record that is identified by a timestamp. The data that is gathered is similar to the following:

Originating Telephone Numbers	Call Records Identified by Timestamp
650-555-1212	t0, t1, t2, t3, t4, ...

Originating Telephone Numbers	Call Records Identified by Timestamp
650-555-1213	t0, t1, t2, t3, t4, ...
650-555-1214	t0, t1, t2, t3, t4, ...
...	...

In the following SQL statements, the `telephone_number` column is the hash key. The hash cluster is sorted on the `call_timestamp` and `call_duration` columns. The number of hash keys is based on 10-digit telephone numbers.

```
CREATE CLUSTER call_detail_cluster (
   telephone_number NUMBER,
   call_timestamp NUMBER SORT,
   call_duration NUMBER SORT )
  HASHKEYS 10000 HASH IS telephone_number
  SIZE 256;

CREATE TABLE call_detail (
   telephone_number     NUMBER,
   call_timestamp       NUMBER   SORT,
   call_duration        NUMBER   SORT,
   other_info           VARCHAR2(30) )
  CLUSTER call_detail_cluster (
   telephone_number, call_timestamp, call_duration );
```

Given the sort order of the data, the following query would return the call records for a specified hash key by oldest record first.

```
SELECT * WHERE telephone_number = 6505551212;
```

Creating Single-Table Hash Clusters

You can also create a **single-table hash cluster**, which provides fast access to rows in a table. However, this table must be the only table in the hash cluster. Essentially, there must be a one-to-one mapping between hash keys and data rows. The following statement creates a single-table hash cluster named `peanut` with the cluster key `variety`:

```
CREATE CLUSTER peanut (variety NUMBER)
   SIZE 512 SINGLE TABLE HASHKEYS 500;
```

The database rounds the `HASHKEYS` value up to the nearest prime number, so this cluster has a maximum of 503 hash key values, each of size 512 bytes. The `SINGLE TABLE` clause is valid only for hash clusters. `HASHKEYS` must also be specified.

See Also: *Oracle Database SQL Language Reference* for the syntax of the `CREATE CLUSTER` statement

Controlling Space Use Within a Hash Cluster

When creating a hash cluster, it is important to choose the cluster key correctly and set the `HASH IS`, `SIZE`, and `HASHKEYS` parameters so that performance and space use are optimal. The following guidelines describe how to set these parameters.

Choosing the Key

Choosing the correct cluster key is dependent on the most common types of queries issued against the clustered tables. For example, consider the `emp` table in a hash cluster. If queries often select rows by employee number, the `empno` column should be the cluster key. If queries often select rows by department number, the `deptno` column should be the cluster key. For hash clusters that contain a single table, the cluster key is typically the entire primary key of the contained table.

The key of a hash cluster, like that of an index cluster, can be a single column or a composite key (multiple column key). A hash cluster with a composite key must use the internal hash function of the database.

Setting HASH IS

Specify the `HASH IS` parameter only if the cluster key is a single column of the `NUMBER` datatype, and contains uniformly distributed integers. If these conditions apply, you can distribute rows in the cluster so that each unique cluster key value hashes, with no collisions (two cluster key values having the same hash value), to a unique hash value. If these conditions do not apply, omit this clause so that you use the internal hash function.

Setting SIZE

`SIZE` should be set to the average amount of space required to hold all rows for any given hash key. Therefore, to properly determine `SIZE`, you must be aware of the characteristics of your data:

- If the hash cluster is to contain only a single table and the hash key values of the rows in that table are unique (one row for each value), `SIZE` can be set to the average row size in the cluster.
- If the hash cluster is to contain multiple tables, `SIZE` can be set to the average amount of space required to hold all rows associated with a representative hash value.

Further, once you have determined a (preliminary) value for `SIZE`, consider the following. If the `SIZE` value is small (more than four hash keys can be assigned for each data block) you can use this value for `SIZE` in the `CREATE CLUSTER` statement. However, if the value of `SIZE` is large (four or fewer hash keys can be assigned for each data block), then you should also consider the expected frequency of collisions and whether performance of data retrieval or efficiency of space usage is more important to you.

- If the hash cluster does not use the internal hash function (if you specified `HASH IS`) and you expect few or no collisions, you can use your preliminary value of `SIZE`. No collisions occur and space is used as efficiently as possible.
- If you expect frequent collisions on inserts, the likelihood of overflow blocks being allocated to store rows is high. To reduce the possibility of overflow blocks and maximize performance when collisions are frequent, you should adjust `SIZE` as shown in the following chart.

Available Space for each Block / Calculated SIZE	Setting for SIZE
1	`SIZE`
2	`SIZE` + 15%
3	`SIZE` + 12%
4	`SIZE` + 8%
>4	`SIZE`

Overestimating the value of `SIZE` increases the amount of unused space in the cluster. If space efficiency is more important than the performance of data retrieval, disregard the adjustments shown in the preceding table and use the original value for `SIZE`.

Setting HASHKEYS

For maximum distribution of rows in a hash cluster, the database rounds the `HASHKEYS` value up to the nearest prime number.

Controlling Space in Hash Clusters

The following examples show how to correctly choose the cluster key and set the `HASH IS`, `SIZE`, and `HASHKEYS` parameters. For all examples, assume that the data block size is 2K and that on average, 1950 bytes of each block is available data space (block size minus overhead).

Controlling Space in Hash Clusters: Example 1 You decide to load the `emp` table into a hash cluster. Most queries retrieve employee records by their employee number. You estimate that the maximum number of rows in the `emp` table at any given time is 10000 and that the average row size is 55 bytes.

In this case, `empno` should be the cluster key. Because this column contains integers that are unique, the internal hash function can be bypassed. `SIZE` can be set to the average row size, 55 bytes. Note that 34 hash keys are assigned for each data block. `HASHKEYS` can be set to the number of rows in the table, 10000. The database rounds this value up to the next highest prime number: 10007.

```
CREATE CLUSTER emp_cluster (empno
NUMBER)
. . .
SIZE 55
HASH IS empno HASHKEYS 10000;
```

Controlling Space in Hash Clusters: Example 2 Conditions similar to the previous example exist. In this case, however, rows are usually retrieved by department number. At most, there are 1000 departments with an average of 10 employees for each department. Department numbers increment by 10 (0, 10, 20, 30, . . .).

In this case, `deptno` should be the cluster key. Since this column contains integers that are uniformly distributed, the internal hash function can be bypassed. A preliminary value of `SIZE` (the average amount of space required to hold all rows for each department) is 55 bytes * 10, or 550 bytes. Using this value for `SIZE`, only three hash keys can be assigned for each data block. If you expect some collisions and want maximum performance of data retrieval, slightly alter your estimated `SIZE` to prevent collisions from requiring overflow blocks. By adjusting `SIZE` by 12%, to 620 bytes (refer to "Setting SIZE" on page 21-5), there is more space for rows from expected collisions.

`HASHKEYS` can be set to the number of unique department numbers, 1000. The database rounds this value up to the next highest prime number: 1009.

```
CREATE CLUSTER emp_cluster (deptno NUMBER)
. . .
SIZE 620
HASH IS deptno HASHKEYS 1000;
```

Estimating Size Required by Hash Clusters

As with index clusters, it is important to estimate the storage required for the data in a hash cluster.

Oracle Database guarantees that the initial allocation of space is sufficient to store the hash table according to the settings `SIZE` and `HASHKEYS`. If settings for the storage parameters `INITIAL`, `NEXT`, and `MINEXTENTS` do not account for the hash table size, incremental (additional) extents are allocated until at least `SIZE*HASHKEYS` is reached. For example, assume that the data block size is 2K, the available data space for each block is approximately 1900 bytes (data block size minus overhead), and that the `STORAGE` and `HASH` parameters are specified in the `CREATE CLUSTER` statement as follows:

```
STORAGE (INITIAL 100K
    NEXT 150K
    MINEXTENTS 1
    PCTINCREASE 0)
SIZE 1500
HASHKEYS 100
```

In this example, only one hash key can be assigned for each data block. Therefore, the initial space required for the hash cluster is at least 100*2K or 200K. The settings for the storage parameters do not account for this requirement. Therefore, an initial extent of 100K and a second extent of 150K are allocated to the hash cluster.

Alternatively, assume the `HASH` parameters are specified as follows:

```
SIZE 500 HASHKEYS 100
```

In this case, three hash keys are assigned to each data block. Therefore, the initial space required for the hash cluster is at least 34*2K or 68K. The initial settings for the storage parameters are sufficient for this requirement (an initial extent of 100K is allocated to the hash cluster).

Altering Hash Clusters

You can alter a hash cluster with the `ALTER CLUSTER` statement:

```
ALTER CLUSTER emp_dept . . . ;
```

The implications for altering a hash cluster are identical to those for altering an index cluster, described in "Altering Clusters" on page 20-6. However, the `SIZE`, `HASHKEYS`, and `HASH IS` parameters cannot be specified in an `ALTER CLUSTER` statement. To change these parameters, you must re-create the cluster, then copy the data from the original cluster.

Dropping Hash Clusters

You can drop a hash cluster using the `DROP CLUSTER` statement:

```
DROP CLUSTER emp_dept;
```

A table in a hash cluster is dropped using the `DROP TABLE` statement. The implications of dropping hash clusters and tables in hash clusters are the same as those for dropping index clusters.

See Also: "Dropping Clusters" on page 20-7

Hash Clusters Data Dictionary Views

The following views display information about hash clusters:

View	Description

`DBA_CLUSTERS`
`ALL_CLUSTERS`
`USER_CLUSTERS`
	`DBA` view describes all clusters (including hash clusters) in the database. `ALL` view describes all clusters accessible to the user. `USER` view is restricted to clusters owned by the user. Some columns in these views contain statistics that are generated by the `DBMS_STATS` package or `ANALYZE` statement.

`DBA_CLU_COLUMNS` `USER_CLU_COLUMNS`	These views map table columns to cluster columns.

`DBA_CLUSTER_HASH_EXPRESSIONS`
`ALL_CLUSTER_HASH_EXPRESSIONS`
`USER_CLUSTER_HASH_EXPRESSIONS`
	These views list hash functions for hash clusters.

See Also: *Oracle Database Reference* for complete descriptions of these views

22

Managing Views, Sequences, and Synonyms

This chapter describes the management of views, sequences, and synonyms and contains the following topics:

Managing Views

This section describes aspects of managing views, and contains the following topics:

About Views

A **view** is a logical representation of another table or combination of tables. A view derives its data from the tables on which it is based. These tables are called **base tables**. Base tables might in turn be actual tables or might be views themselves. All operations performed on a view actually affect the base table of the view. You can use views in almost the same way as tables. You can query, update, insert into, and delete from views, just as you can standard tables.

Views can provide a different representation (such as subsets or supersets) of the data that resides within other tables and views. Views are very powerful because they allow you to tailor the presentation of data to different types of users.

> **See Also:** *Oracle Database Concepts* for a more complete description of views

Creating Views

To create a view, you must meet the following requirements:

- To create a view in your schema, you must have the `CREATE VIEW` privilege. To create a view in another user's schema, you must have the `CREATE ANY VIEW` system privilege. You can acquire these privileges explicitly or through a role.
- The owner of the view (whether it is you or another user) must have been explicitly granted privileges to access all objects referenced in the view definition. The owner *cannot* have obtained these privileges through roles. Also, the functionality of the view depends on the privileges of the view owner. For example, if the owner of the view has only the `INSERT` privilege for Scott's `emp` table, then the view can be used only to insert new rows into the `emp` table, not to `SELECT`, `UPDATE`, or `DELETE` rows.
- If the owner of the view intends to grant access to the view to other users, the owner must have received the object privileges to the base objects with the `GRANT OPTION` or the system privileges with the `ADMIN OPTION`.

You can create views using the `CREATE VIEW` statement. Each view is defined by a query that references tables, materialized views, or other views. As with all subqueries, the query that defines a view cannot contain the `FOR UPDATE` clause.

The following statement creates a view on a subset of data in the `emp` table:

```
CREATE VIEW sales_staff AS
      SELECT empno, ename, deptno
      FROM emp
      WHERE deptno = 10
    WITH CHECK OPTION CONSTRAINT sales_staff_cnst;
```

The query that defines the `sales_staff` view references only rows in department 10. Furthermore, the `CHECK OPTION` creates the view with the constraint (named `sales_staff_cnst`) that `INSERT` and `UPDATE` statements issued against the view cannot result in rows that the view cannot select. For example, the following `INSERT` statement successfully inserts a row into the `emp` table by means of the `sales_staff` view, which contains all rows with department number 10:

```
INSERT INTO sales_staff VALUES (7584, 'OSTER', 10);
```

However, the following `INSERT` statement returns an error because it attempts to insert a row for department number 30, which cannot be selected using the `sales_staff` view:

```
INSERT INTO sales_staff VALUES (7591, 'WILLIAMS', 30);
```

The view could have been constructed specifying the `WITH READ ONLY` clause, which prevents any updates, inserts, or deletes from being done to the base table through the view. If no `WITH` clause is specified, the view, with some restrictions, is inherently updatable.

> **See Also:** *Oracle Database SQL Language Reference* for syntax and semantics of the `CREATE VIEW` statement

Join Views

You can also create views that specify more than one base table or view in the `FROM` clause. These are called **join views**. The following statement creates the `division1_staff` view that joins data from the `emp` and `dept` tables:

```
CREATE VIEW division1_staff AS
      SELECT ename, empno, job, dname
      FROM emp, dept
      WHERE emp.deptno IN (10, 30)
```

```
        AND emp.deptno = dept.deptno;
```

An **updatable join view** is a join view where UPDATE, INSERT, and DELETE operations are allowed. See "Updating a Join View" on page 22-5 for further discussion.

Expansion of Defining Queries at View Creation Time

When a view is created, Oracle Database expands any wildcard (*) in a top-level view query into a column list. The resulting query is stored in the data dictionary; any subqueries are left intact. The column names in an expanded column list are enclosed in quote marks to account for the possibility that the columns of the base object were originally entered with quotes and require them for the query to be syntactically correct.

As an example, assume that the dept view is created as follows:

```
CREATE VIEW dept AS SELECT * FROM scott.dept;
```

The database stores the defining query of the dept view as:

```
SELECT "DEPTNO", "DNAME", "LOC" FROM scott.dept;
```

Views created with errors do not have wildcards expanded. However, if the view is eventually compiled without errors, wildcards in the defining query are expanded.

Creating Views with Errors

If there are no syntax errors in a CREATE VIEW statement, the database can create the view even if the defining query of the view cannot be executed. In this case, the view is considered "created with errors." For example, when a view is created that refers to a nonexistent table or an invalid column of an existing table, or when the view owner does not have the required privileges, the view can be created anyway and entered into the data dictionary. However, the view is not yet usable.

To create a view with errors, you must include the FORCE clause of the CREATE VIEW statement.

```
CREATE FORCE VIEW AS ...;
```

By default, views with errors are created as INVALID. When you try to create such a view, the database returns a message indicating the view was created with errors. If conditions later change so that the query of an invalid view can be executed, the view can be recompiled and be made valid (usable). For information changing conditions and their impact on views, see "Managing Object Dependencies" on page 16-17.

Replacing Views

To replace a view, you must have all of the privileges required to drop and create a view. If the definition of a view must change, the view must be replaced; you cannot use an ALTER VIEW statement to change the definition of a view. You can replace views in the following ways:

- You can drop and re-create the view.

Caution: When a view is dropped, all grants of corresponding object privileges are revoked from roles and users. After the view is re-created, privileges must be regranted.

- You can redefine the view with a `CREATE VIEW` statement that contains the `OR REPLACE` clause. The `OR REPLACE` clause replaces the current definition of a view and preserves the current security authorizations. For example, assume that you created the `sales_staff` view as shown earlier, and, in addition, you granted several object privileges to roles and other users. However, now you need to redefine the `sales_staff` view to change the department number specified in the `WHERE` clause. You can replace the current version of the `sales_staff` view with the following statement:

  ```
  CREATE OR REPLACE VIEW sales_staff AS
       SELECT empno, ename, deptno
       FROM emp
       WHERE deptno = 30
       WITH CHECK OPTION CONSTRAINT sales_staff_cnst;
  ```

Before replacing a view, consider the following effects:

- Replacing a view replaces the view definition in the data dictionary. All underlying objects referenced by the view are not affected.
- If a constraint in the `CHECK OPTION` was previously defined but not included in the new view definition, the constraint is dropped.
- All views dependent on a replaced view become invalid (not usable). In addition, dependent PL/SQL program units may become invalid, depending on what was changed in the new version of the view. For example, if only the `WHERE` clause of the view changes, dependent PL/SQL program units remain valid. However, if any changes are made to the number of view columns or to the view column names or data types, dependent PL/SQL program units are invalidated. See "Managing Object Dependencies" on page 16-17 for more information on how the database manages such dependencies.

Using Views in Queries

To issue a query or an `INSERT, UPDATE`, or `DELETE` statement against a view, you must have the `SELECT, INSERT, UPDATE,` or `DELETE` object privilege for the view, respectively, either explicitly or through a role.

Views can be queried in the same manner as tables. For example, to query the `Division1_staff` view, enter a valid `SELECT` statement that references the view:

```
SELECT * FROM Division1_staff;

ENAME        EMPNO       JOB             DNAME
------------------------------------------------------
CLARK         7782       MANAGER         ACCOUNTING
KING          7839       PRESIDENT       ACCOUNTING
MILLER        7934       CLERK           ACCOUNTING
ALLEN         7499       SALESMAN        SALES
WARD          7521       SALESMAN        SALES
JAMES         7900       CLERK           SALES
TURNER        7844       SALESMAN        SALES
MARTIN        7654       SALESMAN        SALES
BLAKE         7698       MANAGER         SALES
```

With some restrictions, rows can be inserted into, updated in, or deleted from a base table using a view. The following statement inserts a new row into the `emp` table using the `sales_staff` view:

```
INSERT INTO sales_staff
    VALUES (7954, 'OSTER', 30);
```

Restrictions on DML operations for views use the following criteria in the order listed:

1. If a view is defined by a query that contains SET or DISTINCT operators, a GROUP BY clause, or a group function, then rows cannot be inserted into, updated in, or deleted from the base tables using the view.
2. If a view is defined with WITH CHECK OPTION, a row cannot be inserted into, or updated in, the base table (using the view), if the view cannot select the row from the base table.
3. If a NOT NULL column that does not have a DEFAULT clause is omitted from the view, then a row cannot be inserted into the base table using the view.
4. If the view was created by using an expression, such as DECODE(deptno, 10, "SALES", ...), then rows cannot be inserted into or updated in the base table using the view.

The constraint created by WITH CHECK OPTION of the sales_staff view only allows rows that have a department number of 30 to be inserted into, or updated in, the emp table. Alternatively, assume that the sales_staff view is defined by the following statement (that is, excluding the deptno column):

```
CREATE VIEW sales_staff AS
    SELECT empno, ename
    FROM emp
    WHERE deptno = 10
    WITH CHECK OPTION CONSTRAINT sales_staff_cnst;
```

Considering this view definition, you can update the empno or ename fields of existing records, but you cannot insert rows into the emp table through the sales_staff view because the view does not let you alter the deptno field. If you had defined a DEFAULT value of 10 on the deptno field, then you could perform inserts.

When a user attempts to reference an invalid view, the database returns an error message to the user:

```
ORA-04063: view 'view_name' has errors
```

This error message is returned when a view exists but is unusable due to errors in its query (whether it had errors when originally created or it was created successfully but became unusable later because underlying objects were altered or dropped).

Updating a Join View

An updatable join view (also referred to as a **modifiable join view**) is a view that contains more than one table in the top-level FROM clause of the SELECT statement, and is not restricted by the WITH READ ONLY clause.

The rules for updatable join views are shown in the following table. Views that meet these criteria are said to be inherently updatable.

Rule	Description
General Rule	Any INSERT, UPDATE, or DELETE operation on a join view can modify only one underlying base table at a time.

Rule	Description
UPDATE Rule	All updatable columns of a join view must map to columns of a **key-preserved table**. See "Key-Preserved Tables" on page 22-7 for a discussion of key-preserved tables. If the view is defined with the WITH CHECK OPTION clause, then all join columns and all columns of repeated tables are not updatable.
DELETE Rule	Rows from a join view can be deleted as long as there is exactly one key-preserved table in the join. The key preserved table can be repeated in the FROM clause. If the view is defined with the WITH CHECK OPTION clause and the key preserved table is repeated, then the rows cannot be deleted from the view.
INSERT Rule	An INSERT statement must not explicitly or implicitly refer to the columns of a **non-key-preserved table**. If the join view is defined with the WITH CHECK OPTION clause, INSERT statements are not permitted.

There are data dictionary views that indicate whether the columns in a join view are inherently updatable. See "Using the UPDATABLE_ COLUMNS Views" on page 22-11 for descriptions of these views.

Note: There are some additional restrictions and conditions that can affect whether a join view is inherently updatable. Specifics are listed in the description of the CREATE VIEW statement in the *Oracle Database SQL Language Reference.*

If a view is not inherently updatable, it can be made updatable by creating an INSTEAD OF trigger on it. See *Oracle Database PL/SQL Language Reference* for information about triggers.

Additionally, if a view is a join on other nested views, then the other nested views must be mergeable into the top level view. For a discussion of mergeable and unmergeable views, and more generally, how the optimizer optimizes statements that reference views, see the *Oracle Database Performance Tuning Guide.*

Examples illustrating the rules for inherently updatable join views, and a discussion of key-preserved tables, are presented in following sections. The examples in these sections work only if you explicitly define the primary and foreign keys in the tables, or define unique indexes. The following statements create the appropriately constrained table definitions for emp and dept.

```
CREATE TABLE dept (
      deptno        NUMBER(4) PRIMARY KEY,
      dname         VARCHAR2(14),
      loc           VARCHAR2(13));

CREATE TABLE emp (
      empno        NUMBER(4) PRIMARY KEY,
      ename        VARCHAR2(10),
      job          VARCHAR2(9),
      mgr          NUMBER(4),
      sal          NUMBER(7,2),
      comm         NUMBER(7,2),
      deptno       NUMBER(2),
      FOREIGN KEY (DEPTNO) REFERENCES DEPT(DEPTNO));
```

You could also omit the primary and foreign key constraints listed in the preceding example, and create a `UNIQUE INDEX` on `dept (deptno)` to make the following examples work.

The following statement created the `emp_dept` join view which is referenced in the examples:

```
CREATE VIEW emp_dept AS
      SELECT emp.empno, emp.ename, emp.deptno, emp.sal, dept.dname, dept.loc
      FROM emp, dept
      WHERE emp.deptno = dept.deptno
         AND dept.loc IN ('DALLAS', 'NEW YORK', 'BOSTON');
```

Key-Preserved Tables

The concept of a **key-preserved table** is fundamental to understanding the restrictions on modifying join views. A table is key-preserved if every key of the table can also be a key of the result of the join. So, a key-preserved table has its keys preserved through a join.

Note: It is not necessary that the key or keys of a table be selected for it to be key preserved. It is sufficient that if the key or keys were selected, then they would also be keys of the result of the join.

The key-preserving property of a table does not depend on the actual data in the table. It is, rather, a property of its schema. For example, if in the `emp` table there was at most one employee in each department, then `deptno` would be unique in the result of a join of `emp` and `dept`, but `dept` would still not be a key-preserved table.

If you select all rows from `emp_dept`, the results are:

```
EMPNO      ENAME      DEPTNO  DNAME          LOC
---------- ---------- ------- -------------- -----------
      7782 CLARK           10 ACCOUNTING     NEW YORK
      7839 KING            10 ACCOUNTING     NEW YORK
      7934 MILLER          10 ACCOUNTING     NEW YORK
      7369 SMITH           20 RESEARCH       DALLAS
      7876 ADAMS           20 RESEARCH       DALLAS
      7902 FORD            20 RESEARCH       DALLAS
      7788 SCOTT           20 RESEARCH       DALLAS
      7566 JONES           20 RESEARCH       DALLAS
8 rows selected.
```

In this view, `emp` is a key-preserved table, because `empno` is a key of the `emp` table, and also a key of the result of the join. `dept` is *not* a key-preserved table, because although `deptno` is a key of the `dept` table, it is not a key of the join.

DML Statements and Join Views

The general rule is that any `UPDATE`, `DELETE`, or `INSERT` statement on a join view can modify only one underlying base table. The following examples illustrate rules specific to `UPDATE`, `DELETE`, and `INSERT` statements.

UPDATE Statements The following example shows an `UPDATE` statement that successfully modifies the `emp_dept` view:

```
UPDATE emp_dept
     SET sal = sal * 1.10
     WHERE deptno = 10;
```

The following UPDATE statement would be disallowed on the emp_dept view:

```
UPDATE emp_dept
     SET loc = 'BOSTON'
     WHERE ename = 'SMITH';
```

This statement fails with an error (ORA-01779 cannot modify a column which maps to a non key-preserved table), because it attempts to modify the base dept table, and the dept table is not key-preserved in the emp_dept view.

In general, all updatable columns of a join view must map to columns of a key-preserved table. If the view is defined using the WITH CHECK OPTION clause, then all join columns and all columns taken from tables that are referenced more than once in the view are not modifiable.

So, for example, if the emp_dept view were defined using WITH CHECK OPTION, the following UPDATE statement would fail:

```
UPDATE emp_dept
     SET deptno = 10
     WHERE ename = 'SMITH';
```

The statement fails because it is trying to update a join column.

> **See Also:** *Oracle Database SQL Language Reference* for syntax and additional information about the UPDATE statement

DELETE Statements You can delete from a join view provided there is *one and only one* key-preserved table in the join. The key-preserved table can be repeated in the FROM clause.

The following DELETE statement works on the emp_dept view:

```
DELETE FROM emp_dept
     WHERE ename = 'SMITH';
```

This DELETE statement on the emp_dept view is legal because it can be translated to a DELETE operation on the base emp table, and because the emp table is the only key-preserved table in the join.

In the following view, a DELETE operation is permitted, because although there are two key-preserved tables, they are the same table. That is, the key-preserved table is repeated. In this case, the delete statement operates on the first table in the FROM list (e1, in this example):

```
CREATE VIEW emp_emp AS
     SELECT e1.ename, e2.empno, e2.deptno
     FROM emp e1, emp e2
     WHERE e1.empno = e2.empno;
```

If a view is defined using the WITH CHECK OPTION clause and the key-preserved table is repeated, rows cannot be deleted from such a view.

```
CREATE VIEW emp_mgr AS
     SELECT e1.ename, e2.ename mname
     FROM emp e1, emp e2
     WHERE e1.mgr = e2.empno
     WITH CHECK OPTION;
```

> **See Also:** *Oracle Database SQL Language Reference* for syntax and additional information about the DELETE statement

INSERT Statements The following INSERT statement on the emp_dept view succeeds:

```
INSERT INTO emp_dept (ename, empno, deptno)
   VALUES ('KURODA', 9010, 40);
```

This statement works because only one key-preserved base table is being modified (emp), and 40 is a valid deptno in the dept table (thus satisfying the FOREIGN KEY integrity constraint on the emp table).

An INSERT statement, such as the following, would fail for the same reason that such an UPDATE on the base emp table would fail: the FOREIGN KEY integrity constraint on the emp table is violated (because there is no deptno 77).

```
INSERT INTO emp_dept (ename, empno, deptno)
   VALUES ('KURODA', 9010, 77);
```

The following INSERT statement would fail with an error (ORA-01776 cannot modify more than one base table through a join view):

```
INSERT INTO emp_dept (empno, ename, loc)
   VALUES (9010, 'KURODA', 'BOSTON');
```

An INSERT cannot implicitly or explicitly refer to columns of a non-key-preserved table. If the join view is defined using the WITH CHECK OPTION clause, then you cannot perform an INSERT to it.

> **See Also:** *Oracle Database SQL Language Reference* for syntax and additional information about the INSERT statement

Updating Views That Involve Outer Joins

Views that involve outer joins are modifiable in some cases. For example:

```
CREATE VIEW emp_dept_oj1 AS
    SELECT empno, ename, e.deptno, dname, loc
    FROM emp e, dept d
    WHERE e.deptno = d.deptno (+);
```

The statement:

```
SELECT * FROM emp_dept_oj1;
```

Results in:

```
EMPNO   ENAME      DEPTNO  DNAME          LOC
------- ---------- ------- -------------- -------------
7369    SMITH      40      OPERATIONS     BOSTON
7499    ALLEN      30      SALES          CHICAGO
7566    JONES      20      RESEARCH       DALLAS
7654    MARTIN     30      SALES          CHICAGO
7698    BLAKE      30      SALES          CHICAGO
7782    CLARK      10      ACCOUNTING     NEW YORK
7788    SCOTT      20      RESEARCH       DALLAS
7839    KING       10      ACCOUNTING     NEW YORK
7844    TURNER     30      SALES          CHICAGO
7876    ADAMS      20      RESEARCH       DALLAS
7900    JAMES      30      SALES          CHICAGO
7902    FORD       20      RESEARCH       DALLAS
7934    MILLER     10      ACCOUNTING     NEW YORK
7521    WARD       30      SALES          CHICAGO
14 rows selected.
```

Columns in the base emp table of emp_dept_oj1 are modifiable through the view, because emp is a key-preserved table in the join.

The following view also contains an outer join:

```
CREATE VIEW emp_dept_oj2 AS
SELECT e.empno, e.ename, e.deptno, d.dname, d.loc
FROM emp e, dept d
WHERE e.deptno (+) = d.deptno;
```

The following statement:

```
SELECT * FROM emp_dept_oj2;
```

Results in:

```
EMPNO      ENAME      DEPTNO    DNAME          LOC
---------- ---------- --------- -------------- ----
7782       CLARK      10        ACCOUNTING     NEW YORK
7839       KING       10        ACCOUNTING     NEW YORK
7934       MILLER     10        ACCOUNTING     NEW YORK
7369       SMITH      20        RESEARCH       DALLAS
7876       ADAMS      20        RESEARCH       DALLAS
7902       FORD       20        RESEARCH       DALLAS
7788       SCOTT      20        RESEARCH       DALLAS
7566       JONES      20        RESEARCH       DALLAS
7499       ALLEN      30        SALES          CHICAGO
7698       BLAKE      30        SALES          CHICAGO
7654       MARTIN     30        SALES          CHICAGO
7900       JAMES      30        SALES          CHICAGO
7844       TURNER     30        SALES          CHICAGO
7521       WARD       30        SALES          CHICAGO
                                OPERATIONS     BOSTON
15 rows selected.
```

In this view, emp is no longer a key-preserved table, because the empno column in the result of the join can have nulls (the last row in the preceding SELECT statement). So, UPDATE, DELETE, and INSERT operations cannot be performed on this view.

In the case of views containing an outer join on other nested views, a table is key preserved if the view or views containing the table are merged into their outer views, all the way to the top. A view which is being outer-joined is currently merged only if it is "simple." For example:

```
SELECT col1, col2, ... FROM T;
```

The select list of the view has no expressions, and there is no WHERE clause.

Consider the following set of views:

```
CREATE VIEW emp_v AS
    SELECT empno, ename, deptno
        FROM emp;
CREATE VIEW emp_dept_oj1 AS
    SELECT e.*, Loc, d.dname
        FROM emp_v e, dept d
            WHERE e.deptno = d.deptno (+);
```

In these examples, emp_v is merged into emp_dept_oj1 because emp_v is a simple view, and so emp is a key-preserved table. But if emp_v is changed as follows:

```
CREATE VIEW emp_v_2 AS
    SELECT empno, ename, deptno
```

```
        FROM emp
            WHERE sal > 1000;
```

Then, because of the presence of the WHERE clause, emp_v_2 cannot be merged into emp_dept_oj1, and hence emp is no longer a key-preserved table.

If you are in doubt whether a view is modifiable, then you can select from the USER_UPDATABLE_COLUMNS view to see if it is. For example:

```
SELECT owner, table_name, column_name, updatable FROM USER_UPDATABLE_COLUMNS
     WHERE TABLE_NAME = 'EMP_DEPT_VIEW';
```

This returns output similar to the following:

```
OWNER       TABLE_NAME      COLUMN_NAM      UPD
----------  ----------      ----------      ---
SCOTT       EMP_DEPT_V      EMPNO           NO
SCOTT       EMP_DEPT_V      ENAME           NO
SCOTT       EMP_DEPT_V      DEPTNO          NO
SCOTT       EMP_DEPT_V      DNAME           NO
SCOTT       EMP_DEPT_V      LOC             NO
5 rows selected.
```

Using the UPDATABLE_ COLUMNS Views

The views described in the following table can assist you to identify inherently updatable join views.

View	Description
DBA_UPDATABLE_COLUMNS	Shows all columns in all tables and views that are modifiable.
ALL_UPDATABLE_COLUMNS	Shows all columns in all tables and views accessible to the user that are modifiable.
USER_UPDATABLE_COLUMNS	Shows all columns in all tables and views in the user's schema that are modifiable.

The updatable columns in view emp_dept are shown below.

```
SELECT COLUMN_NAME, UPDATABLE
      FROM USER_UPDATABLE_COLUMNS
      WHERE TABLE_NAME = 'EMP_DEPT';

COLUMN_NAME                    UPD
------------------------------ ---
EMPNO                          YES
ENAME                          YES
DEPTNO                         YES
SAL                            YES
DNAME                          NO
LOC                            NO

6 rows selected.
```

See Also: *Oracle Database Reference* for complete descriptions of the updatable column views

Altering Views

You use the `ALTER VIEW` statement only to explicitly recompile a view that is invalid. If you want to change the definition of a view, see "Replacing Views" on page 22-3.

The `ALTER VIEW` statement lets you locate recompilation errors before run time. To ensure that the alteration does not affect the view or other objects that depend on it, you can explicitly recompile a view after altering one of its base tables.

To use the `ALTER VIEW` statement, the view must be in your schema, or you must have the `ALTER ANY TABLE` system privilege.

> **See Also:** *Oracle Database SQL Language Reference* for syntax and additional information about the `ALTER VIEW` statement

Dropping Views

You can drop any view contained in your schema. To drop a view in another user's schema, you must have the `DROP ANY VIEW` system privilege. Drop a view using the `DROP VIEW` statement. For example, the following statement drops the `emp_dept` view:

```
DROP VIEW emp_dept;
```

> **See Also:** *Oracle Database SQL Language Reference* for syntax and additional information about the `DROP VIEW` statement

Managing Sequences

This section describes aspects of managing sequences, and contains the following topics:

- About Sequences
- Creating Sequences
- Altering Sequences
- Using Sequences
- Dropping Sequences

About Sequences

Sequences are database objects from which multiple users can generate unique integers. The sequence generator generates sequential numbers, which can help to generate unique primary keys automatically, and to coordinate keys across multiple rows or tables.

Without sequences, sequential values can only be produced programmatically. A new primary key value can be obtained by selecting the most recently produced value and incrementing it. This method requires a lock during the transaction and causes multiple users to wait for the next value of the primary key; this waiting is known as **serialization**. If developers have such constructs in applications, then you should encourage the developers to replace them with access to sequences. Sequences eliminate serialization and improve the concurrency of an application.

> **See Also:** *Oracle Database Concepts* for a more complete description of sequences

Creating Sequences

To create a sequence in your schema, you must have the `CREATE SEQUENCE` system privilege. To create a sequence in another user's schema, you must have the `CREATE ANY SEQUENCE` privilege.

Create a sequence using the `CREATE SEQUENCE` statement. For example, the following statement creates a sequence used to generate employee numbers for the `empno` column of the `emp` table:

```
CREATE SEQUENCE emp_sequence
      INCREMENT BY 1
      START WITH 1
      NOMAXVALUE
      NOCYCLE
      CACHE 10;
```

Notice that several parameters can be specified to control the function of sequences. You can use these parameters to indicate whether the sequence is ascending or descending, the starting point of the sequence, the minimum and maximum values, and the interval between sequence values. The `NOCYCLE` option indicates that the sequence cannot generate more values after reaching its maximum or minimum value.

The `CACHE` clause preallocates a set of sequence numbers and keeps them in memory so that sequence numbers can be accessed faster. When the last of the sequence numbers in the cache has been used, the database reads another set of numbers into the cache.

The database might skip sequence numbers if you choose to cache a set of sequence numbers. For example, when an instance abnormally shuts down (for example, when an instance failure occurs or a `SHUTDOWN ABORT` statement is issued), sequence numbers that have been cached but not used are lost. Also, sequence numbers that have been used but not saved are lost as well. The database might also skip cached sequence numbers after an export and import. See *Oracle Database Utilities* for details.

See Also:

- *Oracle Database SQL Language Reference* for the `CREATE SEQUENCE` statement syntax
- *Oracle Real Application Clusters Deployment and Performance Guide* for information about how caching sequence numbers improves performance in an Oracle Real Application Clusters environment

Altering Sequences

To alter a sequence, your schema must contain the sequence, or you must have the `ALTER ANY SEQUENCE` system privilege. You can alter a sequence to change any of the parameters that define how it generates sequence numbers except the sequence starting number. To change the starting point of a sequence, drop the sequence and then re-create it.

Alter a sequence using the `ALTER SEQUENCE` statement. For example, the following statement alters the `emp_sequence`:

```
ALTER SEQUENCE emp_sequence
    INCREMENT BY 10
    MAXVALUE 10000
    CYCLE
    CACHE 20;
```

See Also: *Oracle Database SQL Language Reference* for syntax and additional information about the ALTER SEQUENCE statement

Using Sequences

To use a sequence, your schema must contain the sequence or you must have been granted the SELECT object privilege for another user's sequence. Once a sequence is defined, it can be accessed and incremented by multiple users (who have SELECT object privilege for the sequence containing the sequence) with no waiting. The database does not wait for a transaction that has incremented a sequence to complete before that sequence can be incremented again.

The examples outlined in the following sections show how sequences can be used in master/detail table relationships. Assume an order entry system is partially comprised of two tables, orders_tab (master table) and line_items_tab (detail table), that hold information about customer orders. A sequence named order_seq is defined by the following statement:

```
CREATE SEQUENCE Order_seq
    START WITH 1
    INCREMENT BY 1
    NOMAXVALUE
    NOCYCLE
    CACHE 20;
```

Referencing a Sequence

A sequence is referenced in SQL statements with the NEXTVAL and CURRVAL pseudocolumns; each new sequence number is generated by a reference to the sequence pseudocolumn NEXTVAL, while the current sequence number can be repeatedly referenced using the pseudo-column CURRVAL.

NEXTVAL and CURRVAL are not reserved words or keywords and can be used as pseudocolumn names in SQL statements such as SELECT, INSERT, or UPDATE.

Generating Sequence Numbers with NEXTVAL To generate and use a sequence number, reference *seq_name*.NEXTVAL. For example, assume a customer places an order. The sequence number can be referenced in a values list. For example:

```
INSERT INTO Orders_tab (Orderno, Custno)
    VALUES (Order_seq.NEXTVAL, 1032);
```

Or, the sequence number can be referenced in the SET clause of an UPDATE statement. For example:

```
UPDATE Orders_tab
    SET Orderno = Order_seq.NEXTVAL
    WHERE Orderno = 10112;
```

The sequence number can also be referenced outermost SELECT of a query or subquery. For example:

```
SELECT Order_seq.NEXTVAL FROM dual;
```

As defined, the first reference to order_seq.NEXTVAL returns the value 1. Each subsequent statement that references order_seq.NEXTVAL generates the next sequence number (2, 3, 4,. . .). The pseudo-column NEXTVAL can be used to generate as many new sequence numbers as necessary. However, only a single sequence number can be generated for each row. In other words, if NEXTVAL is referenced more than once in a single statement, then the first reference generates the next number, and all subsequent references in the statement return the same number.

Once a sequence number is generated, the sequence number is available only to the session that generated the number. Independent of transactions committing or rolling back, other users referencing `order_seq.NEXTVAL` obtain unique values. If two users are accessing the same sequence concurrently, then the sequence numbers each user receives might have gaps because sequence numbers are also being generated by the other user.

Using Sequence Numbers with CURRVAL To use or refer to the current sequence value of your session, reference *seq_name*.`CURRVAL`. `CURRVAL` can only be used if *seq_name*.`NEXTVAL` has been referenced in the current user session (in the current or a previous transaction). `CURRVAL` can be referenced as many times as necessary, including multiple times within the same statement. The next sequence number is not generated until `NEXTVAL` is referenced. Continuing with the previous example, you would finish placing the customer's order by inserting the line items for the order:

```
INSERT INTO Line_items_tab (Orderno, Partno, Quantity)
    VALUES (Order_seq.CURRVAL, 20321, 3);

INSERT INTO Line_items_tab (Orderno, Partno, Quantity)
    VALUES (Order_seq.CURRVAL, 29374, 1);
```

Assuming the `INSERT` statement given in the previous section generated a new sequence number of 347, both rows inserted by the statements in this section insert rows with order numbers of 347.

Uses and Restrictions of NEXTVAL and CURRVAL `CURRVAL` and `NEXTVAL` can be used in the following places:

- `VALUES` clause of `INSERT` statements
- The `SELECT` list of a `SELECT` statement
- The `SET` clause of an `UPDATE` statement

`CURRVAL` and `NEXTVAL` cannot be used in these places:

- A subquery
- A view query or materialized view query
- A `SELECT` statement with the `DISTINCT` operator
- A `SELECT` statement with a `GROUP BY` or `ORDER BY` clause
- A `SELECT` statement that is combined with another `SELECT` statement with the `UNION, INTERSECT`, or `MINUS` set operator
- The `WHERE` clause of a `SELECT` statement
- `DEFAULT` value of a column in a `CREATE TABLE` or `ALTER TABLE` statement
- The condition of a `CHECK` constraint

Caching Sequence Numbers

Sequence numbers can be kept in the sequence cache in the System Global Area (SGA). Sequence numbers can be accessed more quickly in the sequence cache than they can be read from disk.

The sequence cache consists of entries. Each entry can hold many sequence numbers for a single sequence.

Follow these guidelines for fast access to all sequence numbers:

- Be sure the sequence cache can hold all the sequences used concurrently by your applications.
- Increase the number of values for each sequence held in the sequence cache.

The Number of Entries in the Sequence Cache When an application accesses a sequence in the sequence cache, the sequence numbers are read quickly. However, if an application accesses a sequence that is not in the cache, then the sequence must be read from disk to the cache before the sequence numbers are used.

If your applications use many sequences concurrently, then your sequence cache might not be large enough to hold all the sequences. In this case, access to sequence numbers might often require disk reads. For fast access to all sequences, be sure your cache has enough entries to hold all the sequences used concurrently by your applications.

The Number of Values in Each Sequence Cache Entry When a sequence is read into the sequence cache, sequence values are generated and stored in a cache entry. These values can then be accessed quickly. The number of sequence values stored in the cache is determined by the `CACHE` parameter in the `CREATE SEQUENCE` statement. The default value for this parameter is 20.

This `CREATE SEQUENCE` statement creates the `seq2` sequence so that 50 values of the sequence are stored in the `SEQUENCE` cache:

```
CREATE SEQUENCE seq2
    CACHE 50;
```

The first 50 values of `seq2` can then be read from the cache. When the 51st value is accessed, the next 50 values will be read from disk.

Choosing a high value for `CACHE` lets you access more successive sequence numbers with fewer reads from disk to the sequence cache. However, if there is an instance failure, then all sequence values in the cache are lost. Cached sequence numbers also could be skipped after an export and import if transactions continue to access the sequence numbers while the export is running.

If you use the `NOCACHE` option in the `CREATE SEQUENCE` statement, then the values of the sequence are not stored in the sequence cache. In this case, every access to the sequence requires a disk read. Such disk reads slow access to the sequence. This `CREATE SEQUENCE` statement creates the `SEQ3` sequence so that its values are never stored in the cache:

```
CREATE SEQUENCE seq3
    NOCACHE;
```

Dropping Sequences

You can drop any sequence in your schema. To drop a sequence in another schema, you must have the `DROP ANY SEQUENCE` system privilege. If a sequence is no longer required, you can drop the sequence using the `DROP SEQUENCE` statement. For example, the following statement drops the `order_seq` sequence:

```
DROP SEQUENCE order_seq;
```

When a sequence is dropped, its definition is removed from the data dictionary. Any synonyms for the sequence remain, but return an error when referenced.

See Also: *Oracle Database SQL Language Reference* for syntax and additional information about the `DROP SEQUENCE` statement

Managing Synonyms

This section describes aspects of managing synonyms, and contains the following topics:

- About Synonyms
- Creating Synonyms
- Using Synonyms in DML Statements
- Dropping Synonyms

About Synonyms

A synonym is an alias for a schema object. Synonyms can provide a level of security by masking the name and owner of an object and by providing location transparency for remote objects of a distributed database. Also, they are convenient to use and reduce the complexity of SQL statements for database users.

Synonyms allow underlying objects to be renamed or moved, where only the synonym needs to be redefined and applications based on the synonym continue to function without modification.

You can create both public and private synonyms. A **public** synonym is owned by the special user group named `PUBLIC` and is accessible to every user in a database. A **private** synonym is contained in the schema of a specific user and available only to the user and to grantees for the underlying object.

Synonyms themselves are not securable. When you grant object privileges on a synonym, you are really granting privileges on the underlying object, and the synonym is acting only as an alias for the object in the `GRANT` statement.

See Also: *Oracle Database Concepts* for a more complete description of synonyms

Creating Synonyms

To create a private synonym in your own schema, you must have the `CREATE SYNONYM` privilege. To create a private synonym in another user's schema, you must have the `CREATE ANY SYNONYM` privilege. To create a public synonym, you must have the `CREATE PUBLIC SYNONYM` system privilege.

Create a synonym using the `CREATE SYNONYM` statement. The underlying schema object need not exist, nor do you need privileges to access the object for the `CREATE SYNONYM` statement to succeed. The following statement creates a public synonym named `public_emp` on the `emp` table contained in the schema of `jward`:

```
CREATE PUBLIC SYNONYM public_emp FOR jward.emp
```

When you create a synonym for a remote procedure or function, you must qualify the remote object with its schema name. Alternatively, you can create a local public synonym on the database where the remote object resides, in which case the database link must be included in all subsequent calls to the procedure or function.

See Also: *Oracle Database SQL Language Reference* for syntax and additional information about the `CREATE SYNONYM` statement

Using Synonyms in DML Statements

You can successfully use any private synonym contained in your schema or any public synonym, assuming that you have the necessary privileges to access the underlying object, either explicitly, from an enabled role, or from PUBLIC. You can also reference any private synonym contained in another schema if you have been granted the necessary object privileges for the underlying object.

You can reference another user's synonym using only the object privileges that you have been granted. For example, if you have only the SELECT privilege on the jward.emp table, and the synonym jward.employee is created for jward.emp, you can query the jward.employee synonym, but you cannot insert rows using the jward.employee synonym.

A synonym can be referenced in a DML statement the same way that the underlying object of the synonym can be referenced. For example, if a synonym named employee refers to a table or view, then the following statement is valid:

```
INSERT INTO employee (empno, ename, job)
    VALUES (emp_sequence.NEXTVAL, 'SMITH', 'CLERK');
```

If the synonym named fire_emp refers to a standalone procedure or package procedure, then you could execute it with the command

```
EXECUTE Fire_emp(7344);
```

Dropping Synonyms

You can drop any private synonym in your own schema. To drop a private synonym in another user's schema, you must have the DROP ANY SYNONYM system privilege. To drop a public synonym, you must have the DROP PUBLIC SYNONYM system privilege.

Drop a synonym that is no longer required using DROP SYNONYM statement. To drop a private synonym, omit the PUBLIC keyword. To drop a public synonym, include the PUBLIC keyword.

For example, the following statement drops the private synonym named emp:

```
DROP SYNONYM emp;
```

The following statement drops the public synonym named public_emp:

```
DROP PUBLIC SYNONYM public_emp;
```

When you drop a synonym, its definition is removed from the data dictionary. All objects that reference a dropped synonym remain. However, they become invalid (not usable). For more information about how dropping synonyms can affect other schema objects, see "Managing Object Dependencies".

> **See Also:** *Oracle Database SQL Language Reference* for syntax and additional information about the DROP SYNONYM statement

Views, Synonyms, and Sequences Data Dictionary Views

The following views display information about views, synonyms, and sequences:

View	Description

`DBA_VIEWS`
`ALL_VIEWS`
`USER_VIEWS`
	`DBA` view describes all views in the database. `ALL` view is restricted to views accessible to the current user. `USER` view is restricted to views owned by the current user.

`DBA_SYNONYMS`
`ALL_SYNONYMS`
`USER_SYNONYMS`
	These views describe synonyms.

`DBA_SEQUENCES`
`ALL_SEQUENCES`
`USER_SEQUENCES`
	These views describe sequences.

`DBA_UPDATABLE_COLUMNS`
`ALL_UPDATABLE_COLUMNS`
`USER_UPDATABLE_COLUMNS`
	These views describe all columns in join views that are updatable.

See Also: *Oracle Database Reference* for complete descriptions of these views

23 Repairing Corrupted Data

This chapter explains how to use the DBMS_REPAIR PL/SQL package to repair data block corruption in database schema objects. It contains the following topics:

- Options for Repairing Data Block Corruption
- About the DBMS_REPAIR Package
- Using the DBMS_REPAIR Package
- DBMS_REPAIR Examples

Note: If you are not familiar with the DBMS_REPAIR package, then it is recommended that you work with an Oracle Support Services analyst when performing any of the repair procedures included in this package.

Options for Repairing Data Block Corruption

Oracle Database provides different methods for detecting and correcting data block corruption. One method of correction is to drop and re-create an object after the corruption is detected. However, this is not always possible or desirable. If data block corruption is limited to a subset of rows, then another option is to rebuild the table by selecting all data except for the corrupt rows.

Another way to manage data block corruption is to use the DBMS_REPAIR package. You can use DBMS_REPAIR to detect and repair corrupt blocks in tables and indexes. You can continue to use objects while you attempt to rebuild or repair them.

Note: Any corruption that involves the loss of data requires analysis and understanding of how that data fits into the overall database system. Depending on the nature of the repair, you might lose data, and logical inconsistencies can be introduced. You must determine whether the repair approach provided by this package is the appropriate tool for each specific corruption problem.

About the DBMS_REPAIR Package

This section describes the procedures contained in the DBMS_REPAIR package and notes some limitations and restrictions on their use.

See Also: *Oracle Database PL/SQL Packages and Types Reference* for more information on the syntax, restrictions, and exceptions for the `DBMS_REPAIR` procedures

DBMS_REPAIR Procedures

The following table lists the procedures included in the `DBMS_REPAIR` package.

Procedure Name	Description
`ADMIN_TABLES`	Provides administrative functions (create, drop, purge) for repair or orphan key tables. **Note:** These tables are always created in the `SYS` schema.
`CHECK_OBJECT`	Detects and reports corruptions in a table or index
`DUMP_ORPHAN_KEYS`	Reports on index entries that point to rows in corrupt data blocks
`FIX_CORRUPT_BLOCKS`	Marks blocks as software corrupt that have been previously identified as corrupt by the `CHECK_OBJECT` procedure
`REBUILD_FREELISTS`	Rebuilds the free lists of the object
`SEGMENT_FIX_STATUS`	Provides the capability to fix the corrupted state of a bitmap entry when segment space management is `AUTO`
`SKIP_CORRUPT_BLOCKS`	When used, ignores blocks marked corrupt during table and index scans. If not used, you get error `ORA-1578` when encountering blocks marked corrupt.

These procedures are further described, with examples of their use, in "DBMS_REPAIR Examples" on page 23-5.

Limitations and Restrictions

`DBMS_REPAIR` procedures have the following limitations:

- Tables with LOB datatypes, nested tables, and varrays are supported, but the out of line columns are ignored.
- Clusters are supported in the `SKIP_CORRUPT_BLOCKS` and `REBUILD_FREELISTS` procedures, but not in the `CHECK_OBJECT` procedure.
- Index-organized tables and LOB indexes are not supported.
- The `DUMP_ORPHAN_KEYS` procedure does not operate on bitmap indexes or function-based indexes.
- The `DUMP_ORPHAN_KEYS` procedure processes keys that are no more than 3,950 bytes long.

Using the DBMS_REPAIR Package

The following approach is recommended when considering `DBMS_REPAIR` for addressing data block corruption:

- Task 1: Detect and Report Corruptions
- Task 2: Evaluate the Costs and Benefits of Using DBMS_REPAIR
- Task 3: Make Objects Usable
- Task 4: Repair Corruptions and Rebuild Lost Data

Task 1: Detect and Report Corruptions

The first task is the detection and reporting of corruptions. Reporting not only indicates what is wrong with a block, but also identifies the associated repair directive. There are several ways to detect corruptions. Table 23–1 describes the different detection methodologies.

Table 23–1 Comparison of Corruption Detection Methods

Detection Method	Description
`DBMS_REPAIR` PL/SQL package	Performs block checking for a specified table, partition, or index. It populates a repair table with results.
`DB_VERIFY` utility	Performs block checking on an offline database
`ANALYZE TABLE` SQL statement	Used with the `VALIDATE STRUCTURE` option, the `ANALYZE TABLE` statement verifies the integrity of the structure of an index, table, or cluster; checks or verifies that tables and indexes are synchronized.
`DB_BLOCK_CHECKING` initialization parameter	When `DB_BLOCK_CHECKING=TRUE`, corrupt blocks are identified before they are marked corrupt. Checks are performed when changes are made to a block.

DBMS_REPAIR: Using the CHECK_OBJECT and ADMIN_TABLES Procedures

The `CHECK_OBJECT` procedure checks and reports block corruptions for a specified object. Similar to the `ANALYZE...VALIDATE STRUCTURE` statement for indexes and tables, block checking is performed for index and data blocks.

Not only does `CHECK_OBJECT` report corruptions, but it also identifies any fixes that would occur if `FIX_CORRUPT_BLOCKS` is subsequently run on the object. This information is made available by populating a repair table, which must first be created by the `ADMIN_TABLES` procedure.

After you run the `CHECK_OBJECT` procedure, a simple query on the repair table shows the corruptions and repair directives for the object. With this information, you can assess how best to address the reported problems.

DB_VERIFY: Performing an Offline Database Check

Use `DB_VERIFY` as an offline diagnostic utility when you encounter data corruption.

See Also: *Oracle Database Utilities* for more information about `DB_VERIFY`

ANALYZE: Reporting Corruption

The `ANALYZE TABLE...VALIDATE STRUCTURE` statement validates the structure of the analyzed object. If the database encounters corruption in the structure of the object, then an error message is returned. In this case, drop and re-create the object.

You can use the `CASCADE` clause of the `ANALYZE TABLE` statement to check the structure of the table and all of its indexes in one operation. Because this operation can consume significant resources, there is a FAST option that performs a lightweight check. See "Validating Tables, Indexes, Clusters, and Materialized Views" on page 16-3 for details.

See Also:

- *Oracle Database SQL Language Reference* for more information about the `ANALYZE` statement

DB_BLOCK_CHECKING Initialization Parameter

You can enable database block checking by setting the `DB_BLOCK_CHECKING` initialization parameter to `TRUE`. This checks data and index blocks for internal consistency whenever they are modified. `DB_BLOCK_CHECKING` is a dynamic parameter, modifiable by the `ALTER SYSTEM SET` statement. Block checking is always enabled for the system tablespace.

> **See Also:** *Oracle Database Reference* for more information about the `DB_BLOCK_CHECKING` initialization parameter

Task 2: Evaluate the Costs and Benefits of Using DBMS_REPAIR

Before using `DBMS_REPAIR` you must weigh the benefits of its use in relation to the liabilities. You should also examine other options available for addressing corrupt objects. Begin by answering the following questions:

- What is the extent of the corruption?

  To determine if there are corruptions and repair actions, execute the `CHECK_OBJECT` procedure and query the repair table.

- What other options are available for addressing block corruptions? Consider the following:

  – If the data is available from another source, then drop, re-create, and repopulate the object.

  – Issue the `CREATE TABLE...AS SELECT` statement from the corrupt table to create a new one.

  – Ignore the corruption by excluding corrupt rows from `SELECT` statements.

  – Perform media recovery.

- What logical corruptions or side effects are introduced when you use `DBMS_REPAIR` to make an object usable? Can these be addressed? What is the effort required to do so?

  It is possible that you do not have access to rows in blocks marked corrupt. However, a block can be marked corrupt even if there are rows that you can validly access.

  It is also possible that referential integrity constraints are broken when blocks are marked corrupt. If this occurs, then disable and reenable the constraint; any inconsistencies are reported. After fixing all problems, you should be able to reenable the constraint.

  Logical corruption can occur when there are triggers defined on the table. For example, if rows are reinserted, should insert triggers be fired or not? You can address these issues only if you understand triggers and their use in your installation.

  If indexes and tables are not synchronized, then execute the `DUMP_ORPHAN_KEYS` procedure to obtain information from the keys that might be useful in rebuilding corrupted data. Then issue the `ALTER INDEX...REBUILD ONLINE` statement to synchronize the table with its indexes.

- If repair involves loss of data, can this data be retrieved?

  You can retrieve data from the index when a data block is marked corrupt. The `DUMP_ORPHAN_KEYS` procedure can help you retrieve this information.

Task 3: Make Objects Usable

DBMS_REPAIR makes the object usable by ignoring corruptions during table and index scans.

Corruption Repair: Using the FIX_CORRUPT_BLOCKS and SKIP_CORRUPT_BLOCKS Procedures

You can make a corrupt object usable by establishing an environment that skips corruptions that remain outside the scope of DBMS_REPAIR capabilities.

If corruptions involve a loss of data, such as a bad row in a data block, all such blocks are marked corrupt by the FIX_CORRUPT_BLOCKS procedure. Then you can run the SKIP_CORRUPT_BLOCKS procedure, which skips blocks that are marked as corrupt. When the SKIP_FLAG parameter in the procedure is set, table and index scans skip all blocks marked corrupt. This applies to both media and software corrupt blocks.

Implications when Skipping Corrupt Blocks

If an index and table are not synchronized, then a SET TRANSACTION READ ONLY transaction can be inconsistent in situations where one query probes only the index, and a subsequent query probes both the index and the table. If the table block is marked corrupt, then the two queries return different results, thereby breaking the rules of a read-only transaction. One way to approach this is not to skip corruptions in a SET TRANSACTION READ ONLY transaction.

A similar issue occurs when selecting rows that are chained. A query of the same row may or may not access the corruption, producing different results.

Task 4: Repair Corruptions and Rebuild Lost Data

After making an object usable, perform the following repair activities.

Recover Data Using the DUMP_ORPHAN_KEYS Procedures

The DUMP_ORPHAN_KEYS procedure reports on index entries that point to rows in corrupt data blocks. All such index entries are inserted into an orphan key table that stores the key and rowid of the corruption.

After the index entry information has been retrieved, you can rebuild the index using the ALTER INDEX...REBUILD ONLINE statement.

Fix Segment Bitmaps Using the SEGMENT_FIX_STATUS Procedure

Use this procedure if free space in segments is being managed by using bitmaps (SEGMENT SPACE MANAGEMENT AUTO).

This procedure recalculates the state of a bitmap entry based on the current contents of the corresponding block. Alternatively, you can specify that a bitmap entry be set to a specific value. Usually the state is recalculated correctly and there is no need to force a setting.

DBMS_REPAIR Examples

This section includes the following topics:

- Examples: Building a Repair Table or Orphan Key Table
- Example: Detecting Corruption
- Example: Fixing Corrupt Blocks

- Example: Finding Index Entries Pointing to Corrupt Data Blocks
- Example: Skipping Corrupt Blocks

Examples: Building a Repair Table or Orphan Key Table

The ADMIN_TABLE procedure is used to create, purge, or drop a repair table or an orphan key table.

A repair table provides information about the corruptions that were found by the CHECK_OBJECT procedure and how these will be addressed if the FIX_CORRUPT_BLOCKS procedure is run. Further, it is used to drive the execution of the FIX_CORRUPT_BLOCKS procedure.

An orphan key table is used when the DUMP_ORPHAN_KEYS procedure is executed and it discovers index entries that point to corrupt rows. The DUMP_ORPHAN_KEYS procedure populates the orphan key table by logging its activity and providing the index information in a usable manner.

Example: Creating a Repair Table

The following example creates a repair table for the users tablespace.

```
BEGIN
DBMS_REPAIR.ADMIN_TABLES (
     TABLE_NAME => 'REPAIR_TABLE',
     TABLE_TYPE => dbms_repair.repair_table,
     ACTION     => dbms_repair.create_action,
     TABLESPACE => 'USERS');
END;
/
```

For each repair or orphan key table, a view is also created that eliminates any rows that pertain to objects that no longer exist. The name of the view corresponds to the name of the repair or orphan key table and is prefixed by DBA_ (for example, DBA_REPAIR_TABLE or DBA_ORPHAN_KEY_TABLE).

The following query describes the repair table that was created for the users tablespace.

```
DESC REPAIR_TABLE

 Name                          Null?    Type
 ---------------------------- -------- --------------
 OBJECT_ID                     NOT NULL NUMBER
 TABLESPACE_ID                 NOT NULL NUMBER
 RELATIVE_FILE_ID              NOT NULL NUMBER
 BLOCK_ID                      NOT NULL NUMBER
 CORRUPT_TYPE                  NOT NULL NUMBER
 SCHEMA_NAME                   NOT NULL VARCHAR2(30)
 OBJECT_NAME                   NOT NULL VARCHAR2(30)
 BASEOBJECT_NAME                        VARCHAR2(30)
 PARTITION_NAME                         VARCHAR2(30)
 CORRUPT_DESCRIPTION                    VARCHAR2(2000)
 REPAIR_DESCRIPTION                     VARCHAR2(200)
 MARKED_CORRUPT                NOT NULL VARCHAR2(10)
 CHECK_TIMESTAMP               NOT NULL DATE
 FIX_TIMESTAMP                          DATE
 REFORMAT_TIMESTAMP                     DATE
```

Example: Creating an Orphan Key Table

This example illustrates the creation of an orphan key table for the `users` tablespace.

```
BEGIN
DBMS_REPAIR.ADMIN_TABLES (
     TABLE_NAME => 'ORPHAN_KEY_TABLE',
     TABLE_TYPE => dbms_repair.orphan_table,
     ACTION     => dbms_repair.create_action,
     TABLESPACE => 'USERS');
END;
/
```

The orphan key table is described in the following query:

```
DESC ORPHAN_KEY_TABLE

 Name                          Null?    Type
 ----------------------------- -------- -----------------
 SCHEMA_NAME                   NOT NULL VARCHAR2(30)
 INDEX_NAME                    NOT NULL VARCHAR2(30)
 IPART_NAME                             VARCHAR2(30)
 INDEX_ID                      NOT NULL NUMBER
 TABLE_NAME                    NOT NULL VARCHAR2(30)
 PART_NAME                              VARCHAR2(30)
 TABLE_ID                      NOT NULL NUMBER
 KEYROWID                      NOT NULL ROWID
 KEY                           NOT NULL ROWID
 DUMP_TIMESTAMP                NOT NULL DATE
```

Example: Detecting Corruption

The `CHECK_OBJECT` procedure checks the specified object, and populates the repair table with information about corruptions and repair directives. You can optionally specify a range, partition name, or subpartition name when you want to check a portion of an object.

Validation consists of checking all blocks in the object that have not previously been marked corrupt. For each block, the transaction and data layer portions are checked for self consistency. During `CHECK_OBJECT`, if a block is encountered that has a corrupt buffer cache header, then that block is skipped.

The following is an example of executing the `CHECK_OBJECT` procedure for the `scott.dept` table.

```
SET SERVEROUTPUT ON
DECLARE num_corrupt INT;
BEGIN
num_corrupt := 0;
DBMS_REPAIR.CHECK_OBJECT (
     SCHEMA_NAME => 'SCOTT',
     OBJECT_NAME => 'DEPT',
     REPAIR_TABLE_NAME => 'REPAIR_TABLE',
     CORRUPT_COUNT =>  num_corrupt);
DBMS_OUTPUT.PUT_LINE('number corrupt: ' || TO_CHAR (num_corrupt));
END;
/
```

SQL*Plus outputs the following line, indicating one corruption:

```
number corrupt: 1
```

Querying the repair table produces information describing the corruption and suggesting a repair action.

```
SELECT OBJECT_NAME, BLOCK_ID, CORRUPT_TYPE, MARKED_CORRUPT,
       CORRUPT_DESCRIPTION, REPAIR_DESCRIPTION
     FROM REPAIR_TABLE;

OBJECT_NAME                       BLOCK_ID CORRUPT_TYPE MARKED_COR
------------------------------ ---------- ------------ ----------
CORRUPT_DESCRIPTION
------------------------------------------------------------------------------
REPAIR_DESCRIPTION
------------------------------------------------------------------------------
DEPT                                     3            1 FALSE
kdbchk: row locked by non-existent transaction
        table=0   slot=0
        lockid=32   ktbbhitc=1
mark block software corrupt
```

The corrupted block has not yet been marked corrupt, so this is the time to extract any meaningful data. After the block is marked corrupt, the entire block must be skipped.

Example: Fixing Corrupt Blocks

Use the FIX_CORRUPT_BLOCKS procedure to fix the corrupt blocks in specified objects based on information in the repair table that was generated by the CHECK_OBJECT procedure. Before changing a block, the block is checked to ensure that the block is still corrupt. Corrupt blocks are repaired by marking the block software corrupt. When a repair is performed, the associated row in the repair table is updated with a timestamp.

This example fixes the corrupt block in table scott.dept that was reported by the CHECK_OBJECT procedure.

```
SET SERVEROUTPUT ON
DECLARE num_fix INT;
BEGIN
num_fix := 0;
DBMS_REPAIR.FIX_CORRUPT_BLOCKS (
     SCHEMA_NAME => 'SCOTT',
     OBJECT_NAME=> 'DEPT',
     OBJECT_TYPE => dbms_repair.table_object,
     REPAIR_TABLE_NAME => 'REPAIR_TABLE',
     FIX_COUNT=> num_fix);
DBMS_OUTPUT.PUT_LINE('num fix: ' || TO_CHAR(num_fix));
END;
/
```

SQL*Plus outputs the following line:

```
num fix: 1
```

The following query confirms that the repair was done.

```
SELECT OBJECT_NAME, BLOCK_ID, MARKED_CORRUPT
     FROM REPAIR_TABLE;

OBJECT_NAME                       BLOCK_ID MARKED_COR
------------------------------ ---------- ----------
DEPT                                     3 TRUE
```

Example: Finding Index Entries Pointing to Corrupt Data Blocks

The DUMP_ORPHAN_KEYS procedure reports on index entries that point to rows in corrupt data blocks. For each index entry, a row is inserted into the specified orphan key table. The orphan key table must have been previously created.

This information can be useful for rebuilding lost rows in the table and for diagnostic purposes.

Note: This should be run for every index associated with a table identified in the repair table.

In this example, pk_dept is an index on the scott.dept table. It is scanned to determine if there are any index entries pointing to rows in the corrupt data block.

```
SET SERVEROUTPUT ON
DECLARE num_orphans INT;
BEGIN
num_orphans := 0;
DBMS_REPAIR.DUMP_ORPHAN_KEYS (
     SCHEMA_NAME => 'SCOTT',
     OBJECT_NAME => 'PK_DEPT',
     OBJECT_TYPE => dbms_repair.index_object,
     REPAIR_TABLE_NAME => 'REPAIR_TABLE',
     ORPHAN_TABLE_NAME=> 'ORPHAN_KEY_TABLE',
     KEY_COUNT => num_orphans);
DBMS_OUTPUT.PUT_LINE('orphan key count: ' || TO_CHAR(num_orphans));
END;
/
```

The following output indicates that there are three orphan keys:

```
orphan key count: 3
```

Index entries in the orphan key table implies that the index should be rebuilt. This guarantees that a table probe and an index probe return the same result set.

Example: Skipping Corrupt Blocks

The SKIP_CORRUPT_BLOCKS procedure enables or disables the skipping of corrupt blocks during index and table scans of the specified object. When the object is a table, skipping applies to the table and its indexes. When the object is a cluster, it applies to all of the tables in the cluster, and their respective indexes.

The following example enables the skipping of software corrupt blocks for the scott.dept table:

```
BEGIN
DBMS_REPAIR.SKIP_CORRUPT_BLOCKS (
     SCHEMA_NAME => 'SCOTT',
     OBJECT_NAME => 'DEPT',
     OBJECT_TYPE => dbms_repair.table_object,
     FLAGS => dbms_repair.skip_flag);
END;
/
```

Querying scott's tables using the DBA_TABLES view shows that SKIP_CORRUPT is enabled for table scott.dept.

```
SELECT OWNER, TABLE_NAME, SKIP_CORRUPT FROM DBA_TABLES
```

```
    WHERE OWNER = 'SCOTT';

OWNER                          TABLE_NAME                     SKIP_COR
------------------------------ ------------------------------ --------
SCOTT                          ACCOUNT                        DISABLED
SCOTT                          BONUS                          DISABLED
SCOTT                          DEPT                           ENABLED
SCOTT                          DOCINDEX                       DISABLED
SCOTT                          EMP                            DISABLED
SCOTT                          RECEIPT                        DISABLED
SCOTT                          SALGRADE                       DISABLED
SCOTT                          SCOTT_EMP                      DISABLED
SCOTT                          SYS_IOT_OVER_12255             DISABLED
SCOTT                          WORK_AREA                      DISABLED

10 rows selected.
```

Part IV

Database Resource Management and Task Scheduling

Part VI discusses database resource management. It contains information about using the Oracle Database Resource Manager. Other chapters discuss Scheduler, a product with functionality designed to simplify your management of tasks, but also to provide a rich set of scheduling functionality to suit many needs.

This part contains the following chapters:

24 Managing Automated Database Maintenance Tasks

Oracle Database has automated a number of common maintenance tasks typically performed by database administrators. These automated maintenance tasks are performed when the system load is expected to be light. You can enable and disable individual maintenance tasks, and can configure when these tasks run and what resource allocations they are allotted.

This chapter consists of the following sections:

Note: This chapter explains how to administer automated maintenance tasks using PL/SQL packages. An easier way is to use the graphical interface of Enterprise Manager.

To manage automatic maintenance tasks with Enterprise Manager:

1. Access the Database Home Page.

   See *Oracle Database 2 Day DBA* or the Oracle Enterprise Manager Grid Control online help for instructions.
2. On the Database Home Page, click **Server** to display the Server page.
3. Under the Oracle Scheduler section, click **Automated Maintenance Tasks** to configure maintenance tasks, or **Windows** to configure maintenance windows.

About Automated Maintenance Tasks

Automated maintenance tasks are tasks that are started automatically at regular intervals to perform maintenance operations on the database. An example is a task that gathers statistics on schema objects for the query optimizer. Automated maintenance tasks run in *maintenance windows*, which are predefined time intervals that are intended to occur during a period of low system load. You can customize maintenance windows based on the resource usage patterns of your database, or disable certain default windows from running. You can also create your own maintenance windows.

Oracle Database has three predefined automated maintenance tasks:

- **Automatic Optimizer Statistics Collection—**Collects optimizer statistics for all schema objects in the database for which there are no statistics or only stale statistics. The statistics gathered by this task are used by the SQL query optimizer to improve the performance of SQL execution.

  See Also: *Oracle Database Performance Tuning Guide* for more information on automatic statistics collection

- **Automatic Segment Advisor**—Identifies segments that have space available for reclamation, and makes recommendations on how to defragment those segments.

  You can also run the Segment Advisor manually to obtain more up-to-the-minute recommendations or to obtain recommendations on segments that the Automatic Segment Advisor did not examine for possible space reclamation.

  See Also: "Using the Segment Advisor" on page 17-16 for more information.

- **Automatic SQL Tuning Advisor—**Examines the performance of high-load SQL statements, and makes recommendations on how to tune those statements. You can configure this advisor to automatically implement SQL profile recommendations.

  See Also: *Oracle Database Performance Tuning Guide* for more information on SQL Tuning Advisor

By default, all three automated maintenance tasks are configured to run in all maintenance windows.

About Maintenance Windows

A **maintenance window** is a contiguous time interval during which automated maintenance tasks are run. Maintenance windows are Oracle Scheduler windows that belong to the window group named `MAINTENANCE_WINDOW_GROUP`. A Scheduler window can be a simple repeating interval (such as "between midnight and 6 a.m., every Saturday"), or a more complex interval (such as "between midnight and 6 a.m., on the last workday of every month, excluding company holidays").

When a maintenance window opens, Oracle Database creates an Oracle Scheduler job for each maintenance task that is scheduled to run in that window. Each job is assigned a job name that is generated at runtime. All automated maintenance task job names begin with `ORA$AT`. For example, the job for the Automatic Segment Advisor might be called `ORA$AT_SA_SPC_SY_26`. When an automated maintenance task job finishes, it is deleted from the Oracle Scheduler job system. However, the job can still be found in the Scheduler job history.

Note: To view job history, you must log in as the `SYS` user.

In the case of a very long maintenance window, all automated maintenance tasks except Automatic SQL Tuning Advisor are restarted every four hours. This feature ensures that maintenance tasks are run regularly, regardless of window size.

The framework of automated maintenance tasks relies on maintenance windows being defined in the database. Table 24–1 on page 24-7 lists the maintenance windows that are automatically defined with each new Oracle Database installation.

See Also:

- Chapter 27, "Scheduling Jobs with Oracle Scheduler" for more information on windows and window groups.

Configuring Automated Maintenance Tasks

To enable or disable specific maintenance tasks in any subset of maintenance windows, you can use the DBMS_AUTO_TASK_ADMIN PL/SQL package.

This section contains the following topics:

- Enabling and Disabling Maintenance Tasks for all Maintenance Windows
- Enabling and Disabling Maintenance Tasks for Specific Maintenance Windows

Enabling and Disabling Maintenance Tasks for all Maintenance Windows

You can disable a particular automated maintenance tasks for all maintenance windows with a single operation. You do so by calling the DISABLE procedure of the DBMS_AUTO_TASK_ADMIN PL/SQL package without supplying the window_name argument. For example, you can completely disable the Automatic SQL Tuning Advisor task as follows:

```
BEGIN
dbms_auto_task_admin.disable(
    client_name => 'sql tuning advisor',
    operation   => NULL,
    window_name => NULL);
END;
```

To enable this maintenance task again, use the ENABLE procedure, as follows:

```
BEGIN
dbms_auto_task_admin.enable(
    client_name => 'sql tuning advisor',
    operation   => NULL,
    window_name => NULL);
END;
```

The task names to use for the client_name argument are listed in the DBA_AUTOTASK_CLIENT database dictionary view.

To enable or disable all automated maintenance tasks for all windows, call the ENABLE or DISABLE procedure with no arguments.

```
EXECUTE DBMS_AUTO_TASK_ADMIN.DISABLE;
```

See Also:

- "Automated Maintenance Tasks Database Dictionary Views" on page 24-7
- *Oracle Database PL/SQL Packages and Types Reference* for more information on the DBMS_AUTO_TASK_ADMIN PL/SQL package.

Enabling and Disabling Maintenance Tasks for Specific Maintenance Windows

By default, all maintenance tasks run in all predefined maintenance windows. You can disable a maintenance task for a specific window. The following example disables the Automatic SQL Tuning Advisor from running in the window `MONDAY_WINDOW`:

```
BEGIN
dbms_auto_task_admin.disable(
    client_name => 'sql tuning advisor',
    operation   => NULL,
    window_name => 'MONDAY_WINDOW');
END;
```

Configuring Maintenance Windows

You may want to adjust the predefined maintenance windows to a time suitable to your database environment or create a new maintenance window. You can customize maintenance windows using the `DBMS_SCHEDULER` PL/SQL package.

This section contains the following topics:

- Modifying a Maintenance Window
- Creating a New Maintenance Window
- Removing a Maintenance Window

Modifying a Maintenance Window

The `DBMS_SCHEDULER` PL/SQL package includes a `SET_ATTRIBUTE` procedure for modifying the attributes of a window. For example, the following script changes the duration of the maintenance window `SATURDAY_WINDOW` to 4 hours:

```
BEGIN
dbms_scheduler.disable(
    name  => 'SATURDAY_WINDOW');
dbms_scheduler.set_attribute(
    name      => 'SATURDAY_WINDOW',
    attribute => 'DURATION',
    value     => numtodsinterval(4, 'hour'));
dbms_scheduler.enable(
    name => 'SATURDAY_WINDOW');
END;
```

Note that you must use the `DBMS_SCHEDULER.DISABLE` subprogram to disable the window before making changes to it, and then re-enable the window with `DBMS_SCHEDULER.ENABLE` when you are finished. If you change a window when it is currently open, the change does not take effect until the next time the window opens.

See Also: "Using Windows" on page 27-22 for more information about modifying windows.

Creating a New Maintenance Window

The `DBMS_SCHEDULER` PL/SQL package provides the `ADD_WINDOW_GROUP_MEMBER` subprogram, which adds a window to a window group. To create a maintenance window, you must create a Scheduler window and then add it to the window group `MAINTENANCE_WINDOW_GROUP`.

The following example uses the DBMS_SCHEDULER package to create a maintenance window called EARLY_MORNING_WINDOW. This window runs for one hour daily between 5 a.m. and 6 a.m.

```
BEGIN
dbms_scheduler.create_window(
    window_name     => 'EARLY_MORNING_WINDOW',
    duration        =>  numtodsinterval(1, 'hour'),
    resource_plan   => 'DEFAULT_MAINTENANCE_PLAN',
    repeat_interval => 'FREQ=DAILY;BYHOUR=5;BYMINUTE=0;BYSECOND=0');
dbms_scheduler.add_window_group_member(
    group_name  => 'MAINTENANCE_WINDOW_GROUP',
    window_list => 'EARLY_MORNING_WINDOW');
END;
```

See Also:

- "Creating Windows" on page 27-23
- *Oracle Database PL/SQL Packages and Types Reference* for information on the DBMS_SCHEDULER package

Removing a Maintenance Window

To remove an existing maintenance window, remove it from the MAINTENANCE_WINDOW_GROUP window group. The window continues to exist but no longer runs automated maintenance tasks. Any other Scheduler jobs assigned to this window continue to run as usual.

The following example removes EARLY_MORNING_WINDOW from the window group:

```
BEGIN
DBMS_SCHEDULER.REMOVE_WINDOW_GROUP_MEMBER(
    group_name  => 'MAINTENANCE_WINDOW_GROUP',
    window_list => 'EARLY_MORNING_WINDOW');
END;
```

See Also:

- "Dropping a Member from a Window Group" on page 27-32
- "Dropping Windows" on page 27-26
- *Oracle Database PL/SQL Packages and Types Reference* for information on the DBMS_SCHEDULER package

Configuring Resource Allocations for Automated Maintenance Tasks

This section contains the following topics on resource allocation for maintenance windows:

- About Resource Allocations for Automated Maintenance Tasks
- Changing Resource Allocations for Automated Maintenance Tasks

See Also: Chapter 25, "Managing Resource Allocation with Oracle Database Resource Manager"

About Resource Allocations for Automated Maintenance Tasks

By default, all predefined maintenance windows use the resource plan DEFAULT_MAINTENANCE_PLAN. Automated maintenance tasks run under its subplan

ORA$AUTOTASK_SUB_PLAN. This subplan divides its portion of total resource allocation equally among the maintenance tasks.

DEFAULT_MAINTENANCE_PLAN defines the following resource allocations:

Consumer Group/subplan	Level 1	Level 2
ORA$AUTOTASK_SUB_PLAN	-	25%
ORA$DIAGNOSTICS	-	5%
OTHER_GROUPS	-	70%
SYS_GROUP	100%	-

In this plan, any sessions in the SYS_GROUP consumer group get priority. (Sessions in this group are sessions created by user accounts SYS and SYSTEM.) Any resource allocation that is unused by sessions in SYS_GROUP is then shared by sessions belonging to the other consumer groups and subplans in the plan. Of that allocation, 25% goes to maintenance tasks, 5% goes to background processes performing diagnostic operations, and 70% goes to user sessions. To reduce or increase resource allocation to the automated maintenance tasks, you make adjustments to DEFAULT_MAINTENANCE_PLAN. See "Changing Resource Allocations for Automated Maintenance Tasks" on page 24-6 for more information.

Note that as with any resource plan, the portion of an allocation that is not used by a consumer group or subplan is available for other consumer groups or subplans. Note also that the Database Resource Manager does not begin to limit resource allocations according to resource plans until 100% of CPU is being used.

Note: Although DEFAULT_MAINTENANCE_PLAN is the default, you can assign any resource plan to any maintenance window.

See Also: Chapter 25, "Managing Resource Allocation with Oracle Database Resource Manager" for more information on resource plans.

Changing Resource Allocations for Automated Maintenance Tasks

To change the resource allocation for automated maintenance tasks within a maintenance window, you must change the percentage of resources allocated to the subplan ORA$AUTOTASK_SUB_PLAN in the resource plan for that window. (By default, the resource plan for each predefined maintenance window is DEFAULT_MAINTENANCE_PLAN.) You must also adjust the resource allocation for one or more other subplans or consumer groups in the window's resource plan such that the resource allocation at the top level of the plan adds up to 100%. For information on changing resource allocations, see Chapter 25, "Managing Resource Allocation with Oracle Database Resource Manager".

Automated Maintenance Tasks Reference

This section contains the following reference topics for automated maintenance tasks:

- Predefined Maintenance Windows
- Automated Maintenance Tasks Database Dictionary Views

Predefined Maintenance Windows

By default there are seven predefined maintenance windows, each one representing a day of the week. The weekend maintenance windows, `SATURDAY_WINDOW` and `SUNDAY_WINDOW`, are longer in duration than the weekday maintenance windows. The window group `MAINTENANCE_WINDOW_GROUP` consists of these seven windows. The list of predefined maintenance windows is given in Table 24–1.

Table 24–1 Predefined Maintenance Windows

Window Name	Description
`MONDAY_WINDOW`	Starts at 10 p.m. on Monday and ends at 2 a.m.
`TUESDAY_WINDOW`	Starts at 10 p.m. on Tuesday and ends at 2 a.m.
`WEDNESDAY_WINDOW`	Starts at 10 p.m. on Wednesday and ends at 2 a.m.
`THURSDAY_WINDOW`	Starts at 10 p.m. on Thursday and ends at 2 a.m.
`FRIDAY_WINDOW`	Starts at 10 p.m. on Friday and ends at 2 a.m.
`SATURDAY_WINDOW`	Starts at 6 a.m. on Saturday and is 20 hours long.
`SUNDAY_WINDOW`	Starts at 6 a.m. on Sunday and is 20 hours long.

Automated Maintenance Tasks Database Dictionary Views

Table 24–2 displays information about database dictionary views for automated maintenance tasks:

Table 24–2 Automated Maintenance Tasks Database Dictionary Views

View Name	Description
`DBA_AUTOTASK_CLIENT_JOB`	Contains information about currently running Scheduler jobs created for automated maintenance tasks. It provides information about some objects targeted by those jobs, as well as some additional statistics from previous instantiations of the same task. Some of this additional data is taken from generic Scheduler views.
`DBA_AUTOTASK_CLIENT`	Provides statistical data for each automated maintenance task over 7-day and 30-day periods.
`DBA_AUTOTASK_JOB_HISTORY`	Lists the history of automated maintenance task job runs. Jobs are added to this view after they finish executing.
`DBA_AUTOTASK_WINDOW_CLIENTS`	Lists the windows that belong to `MAINTENANCE_WINDOW_GROUP`, along with the Enabled or Disabled status for the window for each maintenance task. Primarily used by Enterprise Manager.
`DBA_AUTOTASK_CLIENT_HISTORY`	Provides per-window history of job execution counts for each automated maintenance task. This information is viewable in the Job History page of Enterprise Manager.

See Also: "Resource Manager Data Dictionary Views" on page 25-45 for column descriptions for views.

25 Managing Resource Allocation with Oracle Database Resource Manager

Oracle Database Resource Manager (the Resource Manager) enables you to configure your database for optimal resource allocation among the many concurrent user sessions. This chapter provides background information and instructions for using the Resource Manager. It includes the following topics:

Note: This chapter discusses using PL/SQL package procedures to administer the Resource Manager. An easier way to administer the Resource Manager is with the graphical user interface of Enterprise Manager.

To administer the Resource Manager in Enterprise Manager:

1. Access the Database Home page.

   See *Oracle Database 2 Day DBA* for instructions.
2. At the top of the page, click **Server** to display the Server page.
3. In the Resource Manager section, click **Getting Started**.

About Oracle Database Resource Manager

The main goal of Oracle Database Resource Manager (the Resource Manager) is to give administrators more control over how hardware resources are used by different types of users. The following sections provide an overview of the Resource Manager:

What Problems Does the Resource Manager Address?

When database resource allocation decisions are left to the operating system, you may encounter the following problems:

- Excessive overhead

  Excessive overhead results from operating system context switching between Oracle Database server processes when the number of server processes is high.

- Inefficient scheduling

  The operating system deschedules database servers while they hold latches, which is inefficient.

- Inappropriate allocation of resources

  The operating system distributes resources equally among all active processes and is unable to prioritize one task over another.

- Inability to manage database-specific resources, such as parallel execution servers and active sessions

How Does the Resource Manager Address These Problems?

The Resource Manager helps to overcome these problems by allowing the database more control over how hardware resources are allocated. In an environment with multiple concurrent users sessions that run jobs with differing priorities, all sessions should not be treated equally. The Resource Manager enables you to classify sessions into groups based on session attributes, and to then allocate resources to those groups in a way that optimizes hardware utilization for your application environment.

With the Resource Manager, you can:

- Guarantee certain sessions a minimum amount of processing resources regardless of the load on the system and the number of users.
- Distribute available processing resources by allocating percentages of CPU time to different users and applications. In a data warehouse, a higher percentage can be given to ROLAP (relational online analytical processing) applications than to batch jobs.
- Limit the degree of parallelism of any operation performed by members of a group of users.
- Create an active session pool. An **active session pool** consists of a specified maximum number of user sessions allowed to be concurrently active within a group of users. Additional sessions beyond the maximum are queued for execution, but you can specify a timeout period, after which queued jobs will terminate. The active session pool limits the total number of sessions actively competing for resources, thereby enabling active sessions to make faster progress.

- Manage runaway sessions or calls by detecting when they consume more than a specified amount of CPU or I/O. Such sessions can be automatically terminated or switched into a different (lower priority) group.
- Prevent the execution of operations that the optimizer estimates will run for a longer time than a specified limit.
- Limit the amount of time that a session can be idle. This can be further defined to mean only sessions that are blocking other sessions.
- Configure an instance to use a particular scheme for allocating resources. You can dynamically change the scheme, for example, from a daytime scheme to a nighttime scheme, without having to shut down and restart the instance. You can also schedule a scheme change with Oracle Scheduler. See Chapter 26, "Oracle Scheduler Concepts" for more information.

Elements of the Resource Manager

The elements of the Resource Manager are described in the following table.

Element	Description
Resource consumer group	A group of sessions that are grouped together based on resource requirements. The Resource Manager allocates resources to resource consumer groups, not to individual sessions.
Resource plan	A container for directives that specify how resources are allocated to resource consumer groups. You specify how the database allocates resources by activating a specific resource plan.
Resource plan directive	Associates a resource consumer group with a particular plan and specifies how resources are to be allocated to that resource consumer group.

You use the `DBMS_RESOURCE_MANAGER` PL/SQL package to create and maintain these elements. The elements are stored in tables in the data dictionary. You can view information about them with data dictionary views.

See Also: "Resource Manager Data Dictionary Views" on page 25-45

About Resource Consumer Groups

A resource consumer group (consumer group) is a collection of user sessions that are grouped together based on their processing needs. When a session is created, it is automatically mapped to a consumer group based on mapping rules that you set up. As a database administrator (DBA), you can manually switch a session to a different consumer group. Similarly, an application can run a PL/SQL package procedure that switches its session to a particular consumer group.

Because the Resource Manager allocates resources (such as CPU) only to consumer groups, when a session becomes a member of a consumer group, its resource allocation is then determined by the allocation for the consumer group. By default, each session in a consumer group shares the resources allocated to that group with other sessions in the group in a round robin fashion.

There are three special consumer groups that are always present in the data dictionary. They cannot be modified or deleted. They are:

- SYS_GROUP

  This is the initial consumer group for all sessions created by user accounts SYS or SYSTEM. This initial consumer group can be overridden by session-to–consumer group mapping rules.

- DEFAULT_CONSUMER_GROUP

  This is the initial consumer group for all sessions started by user accounts other than SYS and SYSTEM. This initial consumer group can be overridden by session-to–consumer group mapping rules. DEFAULT_CONSUMER_GROUP cannot be named in a resource plan directive.

- OTHER_GROUPS

  This group applies collectively to all sessions that belong to a consumer group that is not part of the currently active plan, including sessions that belong to DEFAULT_CONSUMER_GROUP. OTHER_GROUPS must have a resource plan directive specified in every plan. It cannot be explicitly assigned to sessions through mapping rules.

  See Also:

  - Table 25–2, " Predefined Resource Consumer Groups" on page 25-43
  - "Specifying Session-to–Consumer Group Mapping Rules" on page 25-24

About Resource Plan Directives

The Resource Manager allocates resources to consumer groups according to the set of resource plan directives (directives) that belong to the currently active resource plan. There is a parent-child relationship between a resource plan and its resource plan directives. Each directive references one consumer group, and no two directives for the currently active plan can reference the same consumer group.

A directive has a number of ways in which it can limit resource allocation for a consumer group. For example, it can control how much CPU the consumer group gets as a percentage of total CPU, and it can limit the total number of sessions that can be active in the consumer group. See "About Resource Allocation Methods" on page 25-6 for more information.

About Resource Plans

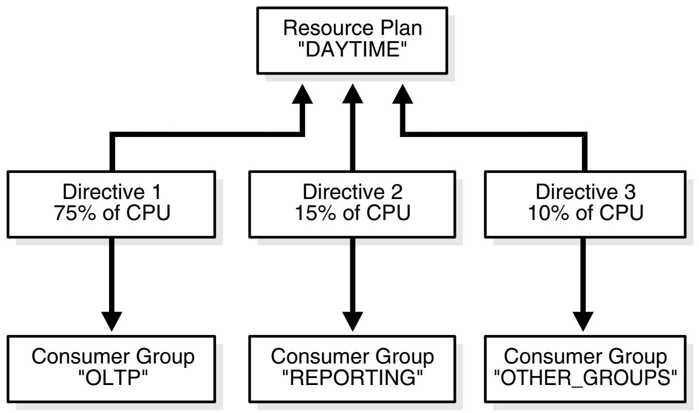
In addition to the resource plans that are predefined for each Oracle database, you can create any number of resource plans. However, only one resource plan is active at a time. When a resource plan is active, each of its child resource plan directives controls resource allocation for a different consumer group. Each plan must include a directive that allocates resources to the consumer group named OTHER_GROUPS. OTHER_GROUPS applies to all sessions that belong to a consumer group that is not part of the currently active plan.

Note: Although the term "resource plan" (or just "plan") denotes one element of the Resource Manager, in this chapter it is also used to refer to a complete *resource plan schema*, which includes the resource plan element itself, its resource plan directives, and the consumer groups that the directives reference. For example, when this chapter refers to the `DAYTIME` resource plan, it could mean either the resource plan element named `DAYTIME`, or the particular resource allocation schema that the `DAYTIME` resource plan and its directives define. Thus, for brevity, it is acceptable to say, "the `DAYTIME` plan favors interactive applications over batch applications."

Example: A Simple Resource Plan

Figure 25–1 shows a simple resource plan for an organization that runs online transaction processing (OLTP) applications and reporting applications simultaneously during the daytime. The currently active plan, `DAYTIME`, allocates CPU resources among three resource consumer groups. Specifically, `OLTP` is allotted 75% of the CPU time, `REPORTS` is allotted 15%, and `OTHER_GROUPS` receives the remaining 10%.

Figure 25–1 A Simple Resource Plan



Oracle Database provides a procedure (`CREATE_SIMPLE_PLAN`) that enables you to quickly create a simple resource plan. This procedure is discussed in "Creating a Simple Resource Plan" on page 25-9.

Note: The currently active resource plan does not enforce allocation limits until CPU usage is at 100%. If the CPU usage is below 100%, the database is not CPU-bound and hence there is no need to enforce limits to ensure that all sessions get their designated resource allocation.

In addition, when limits are enforced, unused allocation by any consumer group can be used by other consumer groups. In the previous example, if the `OLTP` group does not use all of its allocation, the Resource Manager permits the `REPORTS` group or `OTHER_GROUPS` group to use the unused allocation.

About Subplans

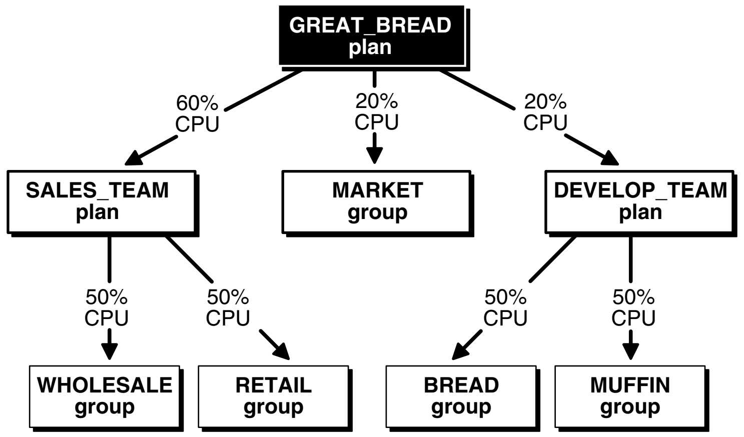
Instead of referencing a consumer group, a resource plan directive (directive) can reference another resource plan. In this case, the plan is referred to as a subplan. The subplan itself has directives that allocate resources to consumer groups and other subplans. The resource allocation scheme then works like this: The *top* resource plan (the currently active plan) divides resources among consumer groups and subplans. Each subplan allocates its portion of the total resource allocation among its consumer groups and subplans. You can create hierarchical plans with any number of subplans.

You create a resource subplan in the same way that you create a resource plan. There is no difference between a plan and a subplan. A plan becomes a subplan only because you use it as such.

Example: A Resource Plan with Subplans

In this example, the Great Bread Company allocates the CPU resource as shown in Figure 25–2. The figure illustrates a top plan (GREAT_BREAD) and all of its descendents. For simplicity, the requirement to include the OTHER_GROUPS consumer group is ignored, and resource plan directives are not shown, even though they are part of the plan. Rather, the CPU percentages that the directives allocate are shown along the connecting lines between plans, subplans, and consumer groups.

Figure 25–2 A Resource Plan With Subplans



The GREAT_BREAD plan allocates resources as follows:

- 20% of CPU resources to the consumer group MARKET
- 60% of CPU resources to subplan SALES_TEAM, which in turn divides its share equally between the WHOLESALE and RETAIL consumer groups
- 20% of CPU resources to subplan DEVELOP_TEAM, which in turn divides its resources equally between the BREAD and MUFFIN consumer groups.

It is possible for a subplan or consumer group to have more than one parent. An example would be if the MARKET group were included in the SALES_TEAM subplan. However, a plan cannot contain any loops. For example, the SALES_TEAM subplan cannot have a directive that references the GREAT_BREAD plan.

> **See Also:** "Putting It All Together: Oracle Database Resource Manager Examples" on page 25-31 for an example of a more complex resource plan.

About Resource Allocation Methods

Resource plan directives specify how resources are allocated to resource consumer groups or subplans. Each directive can specify a number of different methods for allocating resources to its consumer group or subplan. The following sections summarize these resource allocation methods:

- CPU
- Active Session Pool with Queuing
- Degree of Parallelism Limit
- Automatic Consumer Group Switching
- Canceling SQL and Terminating Sessions
- Execution Time Limit
- Undo Pool
- Idle Time Limit

CPU

This method enables you to specify how CPU resources are to be allocated among consumer groups and subplans. Multiple levels of CPU resource allocation (up to eight levels) provide a means of prioritizing CPU usage within a plan. Consumer groups and subplans at level 2 get resources that were not allocated at level 1 or were not consumed by a consumer group or subplan at level 1. Similarly, resource consumers at level 3 are allocated resources only when some allocation remains from levels 1 and 2. The same rules apply to levels 4 through 8. Multiple levels not only provide a way of prioritizing, but they provide a way of explicitly specifying how all primary and leftover resources are to be used.

See Figure 25–3 on page 25-33 for an example of a multilevel plan schema.

Note: When there is only one level, unused allocation by any consumer group or subplan can be used by other consumer groups or subplans in the level.

Active Session Pool with Queuing

You can control the maximum number of concurrently active sessions allowed within a consumer group. This maximum defines the active session pool. An **active session** is a session that is in a call. It is considered active even if it is blocked, for example waiting for an I/O request to complete. When the active session pool is full, a session that is trying to process a call is placed into a queue. When an active session completes, the first session in the queue can then be removed from the queue and scheduled for execution. You can also specify a period after which a session in the execution queue times out, causing the call to terminate with an error.

An entire parallel execution session is counted as one active session.

This feature is useful if you want to limit the number of sessions in a consumer group that are competing for resources. For example, if a consumer group is used for processing long-running, parallel queries for reporting, you may decide to limit the number of active sessions to one to allow one report to complete as quickly as possible, without competing with other reports for CPU or for parallel query slaves.

Degree of Parallelism Limit

You can limit the maximum degree of parallelism for any operation within a consumer group. This limit applies to one operation within a consumer group; it does not limit the total degree of parallelism across all operations within the consumer group.

However, you can combine both the degree of parallelism limit and the active session pool features to achieve the desired control.

Automatic Consumer Group Switching

This method enables you to control resource allocation by specifying criteria that, if met, causes the automatic switching of a session to a specified consumer group. Typically, this method is used to switch a session from a high-priority consumer group—one that receives a high proportion of system resources—to a lower priority consumer group because that session exceeded the expected resource consumption for a typical session in the group.

See "Specifying Automatic Switching by Setting Resource Limits" on page 25-22 for more information.

Canceling SQL and Terminating Sessions

You can also specify directives to cancel long-running SQL queries or to terminate long-running sessions based on the amount of system resources consumed. See "Specifying Automatic Switching by Setting Resource Limits" on page 25-22 for more information.

Execution Time Limit

You can specify a maximum execution time allowed for an operation. If the database estimates that an operation will run longer than the specified maximum execution time, the operation is terminated with an error. This error can be trapped and the operation rescheduled.

Undo Pool

You can specify an undo pool for each consumer group. An undo pool controls the total amount of undo for uncommitted transactions that can be generated by a consumer group. When the total undo generated by a consumer group exceeds its undo limit, the current DML statement generating the undo is terminated. No other members of the consumer group can perform further data manipulation until undo space is freed from the pool.

Idle Time Limit

You can specify an amount of time that a session can be idle, after which it is terminated. You can also specify a more stringent idle time limit that applies to sessions that are idle and blocking other sessions.

About Resource Manager Administration Privileges

You must have the system privilege `ADMINISTER_RESOURCE_MANAGER` to administer the Resource Manager. This privilege (with the `ADMIN` option) is granted to database administrators through the `DBA` role.

Being an administrator for the Resource Manager enables you to execute all of the procedures in the `DBMS_RESOURCE_MANAGER` PL/SQL package.

You may, as an administrator with the `ADMIN` option, choose to grant the administrative privilege to other users or roles. This is possible using the `DBMS_RESOURCE_MANAGER_PRIVS` PL/SQL package. The relevant package procedures are listed in the following table.

Procedure	Description
GRANT_SYSTEM_PRIVILEGE	Grants the ADMINISTER_RESOURCE_MANAGER system privilege to a user or role.
REVOKE_SYSTEM_PRIVILEGE	Revokes the ADMINISTER_RESOURCE_MANAGER system privilege from a user or role.

The following PL/SQL block grants the administrative privilege to user SCOTT, but does not grant SCOTT the ADMIN option. Therefore, SCOTT can execute all of the procedures in the DBMS_RESOURCE_MANAGER package, but SCOTT cannot use the GRANT_SYSTEM_PRIVILEGE procedure to grant the administrative privilege to others.

```
BEGIN
DBMS_RESOURCE_MANAGER_PRIVS.GRANT_SYSTEM_PRIVILEGE(
   GRANTEE_NAME   => 'SCOTT',
   PRIVILEGE_NAME => 'ADMINISTER_RESOURCE_MANAGER',
   ADMIN_OPTION   => FALSE);
END;
```

You can revoke this privilege using the REVOKE_SYSTEM_PRVILEGE procedure.

Note: The ADMINISTER_RESOURCE_MANAGER system privilege can only be granted or revoked using the DBMS_RESOURCE_MANAGER_PRIVS package. It cannot be granted or revoked through the SQL GRANT or REVOKE statements.

See Also: *Oracle Database PL/SQL Packages and Types Reference.* contains detailed information about the Resource Manager packages:

- DBMS_RESOURCE_MANAGER
- DBMS_RESOURCE_MANAGER_PRIVS

Creating a Simple Resource Plan

You can quickly create a simple resource plan that is adequate for many situations using the CREATE_SIMPLE_PLAN procedure. This procedure enables you to both create consumer groups and allocate resources to them by executing a single procedure call. Using this procedure, you are not required to invoke the procedures that are described in succeeding sections for creating a pending area, creating each consumer group individually, specifying resource plan directives, and so on.

You specify the following arguments for the CREATE_SIMPLE_PLAN procedure:

Parameter	Description
SIMPLE_PLAN	Name of the plan
CONSUMER_GROUP1	Consumer group name for first group
GROUP1_PERCENT	CPU resource allocated to this group
CONSUMER_GROUP2	Consumer group name for second group
GROUP2_PERCENT	CPU resource allocated to this group
CONSUMER_GROUP3	Consumer group name for third group

Parameter	Description
GROUP3_PERCENT	CPU resource allocated to this group
CONSUMER_GROUP4	Consumer group name for fourth group
GROUP4_PERCENT	CPU resource allocated to this group
CONSUMER_GROUP5	Consumer group name for fifth group
GROUP5_PERCENT	CPU resource allocated to this group
CONSUMER_GROUP6	Consumer group name for sixth group
GROUP6_PERCENT	CPU resource allocated to this group
CONSUMER_GROUP7	Consumer group name for seventh group
GROUP7_PERCENT	CPU resource allocated to this group
CONSUMER_GROUP8	Consumer group name for eighth group
GROUP8_PERCENT	CPU resource allocated to this group

You can specify up to eight consumer groups with this procedure. The only resource allocation method supported is CPU. The plan uses the `EMPHASIS` CPU allocation policy (the default) and each consumer group uses the `ROUND_ROBIN` scheduling policy (also the default). Each consumer group specified in the plan is allocated its CPU percentage at level 2. Also implicitly included in the plan are `SYS_GROUP` (a system-defined group that is the initial consumer group for the users `SYS` and `SYSTEM`) and `OTHER_GROUPS`. The `SYS_GROUP` consumer group is allocated 100% of the CPU at level 1, and `OTHER_GROUPS` is allocated 100% of the CPU at level 3.

Example: Creating a Simple Plan with the CREATE_SIMPLE_PLAN Procedure

The following PL/SQL block creates a simple resource plan with two user-specified consumer groups:

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_SIMPLE_PLAN(SIMPLE_PLAN => 'SIMPLE_PLAN1',
   CONSUMER_GROUP1 => 'MYGROUP1', GROUP1_PERCENT => 80,
   CONSUMER_GROUP2 => 'MYGROUP2', GROUP2_PERCENT => 20);
END;
```

Executing the preceding statements creates the following plan:

Consumer Group	Level 1	Level 2	Level 3
SYS_GROUP	100%	-	-
MYGROUP1	-	80%	-
MYGROUP2	-	20%	-
OTHER_GROUPS	-	-	100%

See Also:

- "Creating a Resource Plan" on page 25-13 for more information on the `EMPHASIS` CPU allocation policy
- "Creating Resource Consumer Groups" on page 25-12 for more information on the `ROUND_ROBIN` scheduling policy
- "Elements of the Resource Manager" on page 25-3

Creating a Complex Resource Plan

When your situation calls for a more complex resource plan, you must create the plan, with its directives and consumer groups, in a staging area called the pending area, and then validate the plan before storing it in the data dictionary.

The following is a summary of the steps required to create a complex resource plan.

Note: A complex resource plan is any resource plan that is not created with the `DBMS_RESOURCE_MANAGER.CREATE_SIMPLE_PLAN` procedure.

Step 1: Create a pending area.

Step 2: Create, modify, or delete consumer groups.

Step 3: Create the resource plan.

Step 4: Create resource plan directives.

Step 5: Validate the pending area.

Step 6: Submit the pending area.

You use procedures in the `DBMS_RESOURCE_MANAGER` PL/SQL package to complete these steps. The following sections provide details:

- About the Pending Area
- Creating a Pending Area
- Creating Resource Consumer Groups
- Creating a Resource Plan
- Creating Resource Plan Directives
- Validating the Pending Area
- Submitting the Pending Area
- Clearing the Pending Area

See Also:

- DBMS_RESOURCE_MANAGER Package Procedures Summary on page 25-44
- *Oracle Database PL/SQL Packages and Types Reference* for details on the `DBMS_RESOURCE_MANAGER` PL/SQL package.
- "Elements of the Resource Manager" on page 25-3

About the Pending Area

The **pending area** is a staging area where you can create a new resource plan, update an existing plan, or delete a plan without affecting currently running applications. When you create a pending area, the database initializes it and then copies existing plans into the pending area so that they can be updated.

Tip: After you create the pending area, if you list all plans by querying the DBA_RSRC_PLANS data dictionary view, you see two copies of each plan: one with the PENDING status, and one without. The plans with the PENDING status reflect any changes you made to the plans since creating the pending area. Pending changes can also be viewed for consumer groups using DBA_RSRC_CONSUMER_GROUPS and for resource plan directives using DBA_RSRC_PLAN_DIRECTIVES. See Resource Manager Data Dictionary Views on page 25-45 for more information.

After you make changes in the pending area, you validate the pending area and then submit it. Upon submission, all pending changes are applied to the data dictionary, and the pending area is cleared and deactivated.

If you attempt to create, update, or delete a plan (or create, update, or delete consumer groups or resource plan directives) without first creating the pending area, you receive an error message.

Submitting the pending area does not activate any new plan that you create; it just stores new or updated plan information in the data dictionary. However, if you modify a plan that is currently active, the plan is reactivated with the new plan definition. See "Enabling Oracle Database Resource Manager and Switching Plans" on page 25-30 for information about activating a resource plan.

When you create a pending area, no other users can create one until you submit or clear the pending area or log out.

Creating a Pending Area

You create a pending area with the CREATE_PENDING_AREA procedure.

Example: Creating a pending area:

The following PL/SQL block creates and initializes a pending area:

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_PENDING_AREA();
END;
```

Creating Resource Consumer Groups

You create a resource consumer group using the CREATE_CONSUMER_GROUP procedure. You can specify the following parameters:

Parameter	Description
CONSUMER_GROUP	Name to assign to the consumer group.
COMMENT	Any comment.
CPU_MTH	Deprecated. Use MGMT_MTH.
MGMT_MTH	The resource allocation method for distributing CPU among sessions in the consumer group. The default is 'ROUND-ROBIN', which uses a round-robin scheduler to ensure that sessions are fairly executed. 'RUN-TO-COMPLETION' specifies that long-running sessions are scheduled ahead of other sessions. This setting helps long-running sessions (such as batch processes) complete sooner.

Example: Creating a Resource Consumer Group

The following PL/SQL block creates a consumer group called OLTP with the default (ROUND-ROBIN) method of allocating resources to sessions in the group:

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP (
   CONSUMER_GROUP => 'OLTP',
   COMMENT        => 'OLTP applications');
END;
```

See Also:

- "Updating a Consumer Group" on page 25-36
- "Deleting a Consumer Group" on page 25-36

Creating a Resource Plan

You create a resource plan with the CREATE_PLAN procedure. You can specify the parameters shown in the following table. The first two parameters are required. The remainder are optional.

Parameter	Description
PLAN	Name to assign to the plan.
COMMENT	Any descriptive comment.
CPU_MTH	Deprecated. Use MGMT_MTH.
ACTIVE_SESS_POOL_MTH	Active session pool resource allocation method. ACTIVE_SESS_POOL_ABSOLUTE is the default and only method available.
PARALLEL_DEGREE_LIMIT_MTH	Resource allocation method for specifying a limit on the degree of parallelism of any operation. PARALLEL_DEGREE_LIMIT_ABSOLUTE is the default and only method available.
QUEUEING_MTH	Queuing resource allocation method. Controls the order in which queued inactive sessions are removed from the queue and added to the active session pool. FIFO_TIMEOUT is the default and only method available.
MGMT_MTH	Resource allocation method for specifying how much CPU each consumer group or subplan gets. 'EMPHASIS', the default method, is for single-level or multilevel plans that use percentages to specify how CPU is distributed among consumer groups. 'RATIO' is for single-level plans that use ratios to specify how CPU is distributed.
SUB_PLAN	If TRUE, the plan cannot be used as the top plan; it can be used as a subplan only. Default is FALSE.

Example: Creating a Resource Plan

The following PL/SQL block creates a resource plan named DAYTIME:

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_PLAN(
   PLAN    => 'DAYTIME',
   COMMENT => 'More resources for OLTP applications');
END;
```

About the RATIO CPU Allocation Method

The RATIO method is an alternate CPU allocation method intended for simple plans that have only a single level of CPU allocation. Instead of percentages, you specify numbers corresponding to the ratio of CPU that you want to give to each consumer group. To use the RATIO method, you set the MGMT_MTH argument for the CREATE_PLAN procedure to 'RATIO'. See "Creating Resource Plan Directives" on page 25-14 for an example of a plan that uses this method.

See Also:

- "Updating a Plan" on page 25-36
- "Deleting a Plan" on page 25-36

Creating Resource Plan Directives

You use the CREATE_PLAN_DIRECTIVE procedure to create resource plan directives. You can specify the following parameters:

Parameter	Description
PLAN	Name of the resource plan to which the directive belongs.
GROUP_OR_SUBPLAN	Name of the consumer group or subplan to which to allocate resources.
COMMENT	Any comment.
CPU_P1	Deprecated. Use MGMT_P1.
CPU_P2	Deprecated. Use MGMT_P2.
CPU_P3	Deprecated. Use MGMT_P3.
CPU_P4	Deprecated. Use MGMT_P4.
CPU_P5	Deprecated. Use MGMT_P5.
CPU_P6	Deprecated. Use MGMT_P6.
CPU_P7	Deprecated. Use MGMT_P7.
CPU_P8	Deprecated. Use MGMT_P8.
ACTIVE_SESS_POOL_P1	Specifies the maximum number of concurrently active sessions for a consumer group. Other sessions await execution in an inactive session queue. Default is UNLIMITED.
QUEUEING_P1	Specifies time (in seconds) after which a session in an inactive session queue (waiting for execution) times out and the call is aborted. Default is UNLIMITED.
PARALLEL_DEGREE_LIMIT_P1	Specifies a limit on the degree of parallelism for any operation. Default is UNLIMITED.

Parameter	Description
SWITCH_GROUP	Specifies the consumer group to which a session is switched if switch criteria are met. If the group name is 'CANCEL_SQL', then the current call is canceled when switch criteria are met. If the group name is 'KILL_SESSION', then the session is killed when switch criteria are met. Default is NULL.
SWITCH_TIME	Specifies the time (in CPU seconds) that a call can execute before an action is taken. Default is UNLIMITED. The action is specified by SWITCH_GROUP.
SWITCH_ESTIMATE	If TRUE, the database estimates the execution time of each call, and if estimated execution time exceeds SWITCH_TIME, the session is switched to the SWITCH_GROUP before beginning the call. Default is FALSE. The execution time estimate is obtained from the optimizer. The accuracy of the estimate is dependent on many factors, especially the quality of the optimizer statistics. In general, you should expect statistics to be no more accurate than ± 10 minutes.
MAX_EST_EXEC_TIME	Specifies the maximum execution time (in CPU seconds) allowed for a call. If the optimizer estimates that a call will take longer than MAX_EST_EXEC_TIME, the call is not allowed to proceed and ORA-07455 is issued. If the optimizer does not provide an estimate, this directive has no effect. Default is UNLIMITED. The accuracy of the estimate is dependent on many factors, especially the quality of the optimizer statistics. In general, you should expect statistics to be no more accurate than ± 10 minutes.
UNDO_POOL	Sets a maximum in kilobytes (K) on the total amount of undo for uncommitted transactions that can be generated by a consumer group. Default is UNLIMITED.
MAX_IDLE_TIME	Indicates the maximum session idle time, in seconds. Default is NULL, which implies unlimited.
MAX_IDLE_BLOCKER_TIME	Indicates the maximum session idle time of a blocking session, in seconds. Default is NULL, which implies unlimited.
SWITCH_TIME_IN_CALL	Deprecated. Use SWITCH_FOR_CALL.
MGMT_P1	For a plan with the MGMT_MTH parameter set to EMPHASIS, specifies the CPU percentage to allocate at the first level. For MGMT_MTH set to RATIO, specifies the weight of CPU usage. Default is NULL for all MGMT_P*n* parameters.
MGMT_P2	For EMPHASIS, specifies CPU percentage to allocate at the second level. Not applicable for RATIO.
MGMT_P3	For EMPHASIS, specifies CPU percentage to allocate at the third level. Not applicable for RATIO.

Parameter	Description
MGMT_P4	For EMPHASIS, specifies CPU percentage to allocate at the fourth level. Not applicable for RATIO.
MGMT_P5	For EMPHASIS, specifies CPU percentage to allocate at the fifth level. Not applicable for RATIO.
MGMT_P6	For EMPHASIS, specifies CPU percentage to allocate at the sixth level. Not applicable for RATIO.
MGMT_P7	For EMPHASIS, specifies CPU percentage to allocate at the seventh level. Not applicable for RATIO.
MGMT_P8	For EMPHASIS, specifies CPU percentage to allocate at the eighth level. Not applicable for RATIO.
SWITCH_IO_MEGABYTES	Specifies the number of megabytes of I/O that a session can transfer (read and write) before an action is taken. Default is UNLIMITED. The action is specified by SWITCH_GROUP.
SWITCH_IO_REQS	Specifies the number of I/O requests that a session can execute before an action is taken. Default is UNLIMITED. The action is specified by SWITCH_GROUP.
SWITCH_FOR_CALL	If TRUE, a session that was automatically switched to another consumer group (according to SWITCH_TIME, SWITCH_IO_MEGABYTES, or SWITCH_IO_REQS) is returned to its original consumer group when the top level call completes. Default is NULL.

Example 1:

The following PL/SQL block creates a resource plan directive for plan DAYTIME. (Assumes that the DAYTIME plan and OLTP consumer group are already created in the pending area.)

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE (
   PLAN             => 'DAYTIME',
   GROUP_OR_SUBPLAN => 'OLTP',
   COMMENT          => 'OLTP group',
   MGMT_P1          => 75);
END;
```

This directive assigns 75% of CPU resources to the OLTP consumer group at level 1.

To complete the plan shown in Figure 25–1 on page 25-5, create the REPORTING consumer group, and then execute the following PL/SQL block:

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE (
   PLAN                     => 'DAYTIME',
   GROUP_OR_SUBPLAN         => 'REPORTING',
   COMMENT                  => 'Reporting group',
   MGMT_P1                  => 15,
   PARALLEL_DEGREE_LIMIT_P1 => 8,
   ACTIVE_SESS_POOL_P1      => 4);
```

```
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE (
   PLAN                     => 'DAYTIME',
   GROUP_OR_SUBPLAN         => 'OTHER_GROUPS',
   COMMENT                  => 'This one is required',
   MGMT_P1                  => 10);
END;
```

In this plan, consumer group `REPORTING` has a maximum degree of parallelism of 8 for any operation, while none of the other consumer groups are limited in their degree of parallelism. In addition, the `REPORTING` group has a maximum of 4 concurrently active sessions.

Example 2:

This example uses the `RATIO` method to allocate CPU, which uses ratios instead of percentages. Suppose your application suite offers three service levels to clients: Gold, Silver, and Bronze. You create three consumer groups named `GOLD_CG`, `SILVER_CG`, and `BRONZE_CG`, and you create the following resource plan:

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_PLAN
   (PLAN             => 'SERVICE_LEVEL_PLAN',
    MGMT_MTH         => 'RATIO',
    COMMENT          => 'Plan that supports three service levels');

DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE
   (PLAN             => 'SERVICE_LEVEL_PLAN',
    GROUP_OR_SUBPLAN => 'GOLD_CG',
    COMMENT          => 'Gold service level customers',
    MGMT_P1          => 10);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE
   (PLAN             => 'SERVICE_LEVEL_PLAN',
    GROUP_OR_SUBPLAN => 'SILVER_CG',
    COMMENT          => 'Silver service level customers',
    MGMT_P1          => 5);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE
   (PLAN             => 'SERVICE_LEVEL_PLAN',
    GROUP_OR_SUBPLAN => 'BRONZE_CG',
    COMMENT          => 'Bronze service level customers',
    MGMT_P1          => 2);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE
    (PLAN            => 'SERVICE_LEVEL_PLAN',
    GROUP_OR_SUBPLAN => 'OTHER_GROUPS',
    COMMENT          => 'Lowest priority sessions',
    MGMT_P1          => 1);
END;
```

The ratio of CPU allocation is 10:5:2:1 for the `GOLD_CG`, `SILVER_CG`, `BRONZE_CG`, and `OTHER_GROUPS` consumer groups, respectively.

If sessions exist only in the `GOLD_CG` and `SILVER_CG` consumer groups, the ratio of CPU allocation is 10:5 between the two groups.

How Resource Plan Directives Interact

You may have occasion to reference the same consumer group from the top plan and any number of subplans. In this case, there are multiple resource plan directives that refer to the same consumer group, and the following rules apply:

- The parallel degree limit for the consumer group will be the *minimum* of all the incoming values.
- The active session pool for the consumer group will be the *sum* of all the incoming values and the queue timeout will be the *minimum* of all incoming timeout values.
- The undo pool for the consumer group will be the *sum* of all the incoming values.
- If there is more than one `SWITCH_TIME`, `SWITCH_IO_MEGABYTES`, or `SWITCH_IO_REQS`, Oracle Database Resource Manager (the Resource Manager) chooses the *most restrictive* of all incoming values. Specifically:
  - `SWITCH_TIME` = *`min`* (all incoming `SWITCH_TIME` values)
  - `SWITCH_IO_MEGABYTES` = *`min`* (all incoming `SWITCH_IO_MEGABYTES` values)
  - `SWITCH_IO_REQS` = *`min`* (all incoming `SWITCH_IO_REQS` values)
  - `SWITCH_ESTIMATE = TRUE` overrides `SWITCH_ESTIMATE = FALSE`

  Note: If both plan directives specify the same switch time, but different switch groups, then the choice as to which group to switch to is statically but arbitrarily decided by the Resource Manager.

- `SWITCH_FOR_CALL` is `TRUE` if any of the incoming values are `TRUE`.
- The maximum estimated execution time will be the *most restrictive* of all incoming values. Specifically:

  `MAX_EST_EXEC_TIME` = *`min`* (all incoming `MAX_EST_EXEC_TIME` values)
- The maximum idle time is the *minimum* of all incoming values.
- The maximum idle blocker time is the *minimum* of all incoming values.

See Also:

- "Updating a Resource Plan Directive" on page 25-37
- "Deleting a Resource Plan Directive" on page 25-37

Validating the Pending Area

At any time when you are making changes in the pending area, you can call `VALIDATE_PENDING_AREA` to ensure that the pending area is valid so far.

The following rules must be adhered to, and are checked by the validate procedure:

- No plan can contain any loops. A loop occurs when a subplan contains a directive that references a plan that is above the subplan in the plan hierarchy. For example, a subplan cannot reference the top plan.
- All plans and resource consumer groups referred to by plan directives must exist.
- All plans must have plan directives that point to either plans or resource consumer groups.
- All percentages in any given level must not add up to greater than 100.
- A plan that is currently being used as a top plan by an active instance cannot be deleted.

- The following parameters can appear only in plan directives that refer to resource consumer groups, not other resource plans:
  - `PARALLEL_DEGREE_LIMIT_P1`
  - `ACTIVE_SESS_POOL_P1`
  - `QUEUEING_P1`
  - `SWITCH_GROUP`
  - `SWITCH_TIME`
  - `SWITCH_ESTIMATE`
  - `SWITCH_IO_REQS`
  - `SWITCH_IO_MEGABYTES`
  - `MAX_EST_EXEC_TIME`
  - `UNDO_POOL`
  - `MAX_IDLE_TIME`
  - `MAX_IDLE_BLOCKER_TIME`
  - `SWITCH_FOR_CALL`
- There can be no more than 31 resource consumer groups in any active plan. Also, at most, a plan can have 31 children.
- Plans and resource consumer groups cannot have the same name.
- There must be a plan directive for `OTHER_GROUPS` somewhere in any active plan. This ensures that a session that is not part of any of the consumer groups included in the currently active plan is allocated resources (as specified by the directive for `OTHER_GROUPS`).

`VALIDATE_PENDING_AREA` raises an error if any of the preceding rules are violated. You can then make changes to fix any problems and call the procedure again.

It is possible to create "orphan" consumer groups that have no plan directives referring to them. This allows the creation of consumer groups that will not currently be used, but might be part of some plan to be implemented in the future.

Example: Validating the Pending Area:

The following PL/SQL block validates the pending area.

```
BEGIN
DBMS_RESOURCE_MANAGER.VALIDATE_PENDING_AREA();
END;
```

See Also: "About the Pending Area" on page 25-11

Submitting the Pending Area

After you have validated your changes, call the `SUBMIT_PENDING_AREA` procedure to make your changes active.

The submit procedure also performs validation, so you do not necessarily need to make separate calls to the validate procedure. However, if you are making major changes to plans, debugging problems is often easier if you incrementally validate your changes. No changes are submitted (made active) until validation is successful on all of the changes in the pending area.

The `SUBMIT_PENDING_AREA` procedure clears (deactivates) the pending area after successfully validating and committing the changes.

Note: A call to `SUBMIT_PENDING_AREA` might fail even if `VALIDATE_PENDING_AREA` succeeds. This can happen if, for example, a plan being deleted is loaded by an instance after a call to `VALIDATE_PENDING_AREA`, but before a call to `SUBMIT_PENDING_AREA`.

Example: Submitting the Pending Area:

The following PL/SQL block submits the pending area:

```
BEGIN
DBMS_RESOURCE_MANAGER.SUBMIT_PENDING_AREA();
END;
```

See Also: "About the Pending Area" on page 25-11

Clearing the Pending Area

There is also a procedure for clearing the pending area at any time. This PL/SQL block causes all of your changes to be cleared from the pending area and deactivates the pending area:

```
BEGIN
DBMS_RESOURCE_MANAGER.CLEAR_PENDING_AREA();
END;
```

After calling `CLEAR_PENDING_AREA`, you must call the `CREATE_PENDING_AREA` procedure before you can again attempt to make changes.

See Also: "About the Pending Area" on page 25-11

Assigning Sessions to Resource Consumer Groups

This section describes the automatic and manual methods that database administrators, users, and applications can use to assign sessions to resource consumer groups. When a session is assigned to a resource consumer group, Oracle Database Resource Manager (the Resource Manager) can manage resource allocation for it.

Note: Sessions that are not explicitly assigned an initial consumer group are placed in the consumer group `DEFAULT_CONSUMER_GROUP`.

This section includes the following topics:

- Overview of Assigning Sessions to Resource Consumer Groups
- Assigning an Initial Resource Consumer Group
- Manually Switching Resource Consumer Groups
- Specifying Automatic Resource Consumer Group Switching
- Specifying Session-to–Consumer Group Mapping Rules
- Enabling Users or Applications to Manually Switch Consumer Groups
- Granting and Revoking the Switch Privilege

Overview of Assigning Sessions to Resource Consumer Groups

Before you enable the Resource Manager, you must specify how user sessions are assigned to resource consumer groups. You do this by creating *mapping rules* that enable the Resource Manager to automatically assign each session to a consumer group upon session startup, based upon session attributes. After a session is assigned to its initial consumer group and is running, you can call a procedure to manually switch the session to a different consumer group. You would typically do this if the session is using excessive resources and must be moved to a consumer group that is more limited in its resource allocation. You can also grant the *switch privilege* to users and to applications so that they can switch their sessions from one consumer group to another.

The database can also automatically switch a session from one consumer group to another (typically lower priority) consumer group when there are changes in session attributes or when a session exceeds designated resource consumption limits.

Assigning an Initial Resource Consumer Group

The initial consumer group of a session is determined by the mapping rules that you configure. For information on how to configure mapping rules, see "Specifying Session-to–Consumer Group Mapping Rules" on page 25-24. If no mapping rule applies for a new session, the default consumer group for the session is specified by the `INITIAL_RSRC_CONSUMER_GROUP` attribute of the user who started the session. You can view the value of this attribute by viewing the `INITIAL_RSRC_CONSUMER_GROUP` column in the `*_USER` views.

Manually Switching Resource Consumer Groups

The `DBMS_RESOURCE_MANAGER` PL/SQL package provides two procedures that enable you to change the resource consumer group of running sessions. Both of these procedures can also change the consumer group of any parallel execution server sessions associated with the coordinator session. The changes made by these procedures pertain to current sessions only; they are not persistent. They also do not change the initial consumer groups for users.

Instead of killing (terminating) a session of a user who is using excessive CPU, you can change that user's consumer group to one that is allocated fewer resources.

Switching a Single Session

The `SWITCH_CONSUMER_GROUP_FOR_SESS` procedure causes the specified session to immediately be moved into the specified resource consumer group. In effect, this procedure can raise or lower priority of the session.

The following PL/SQL block switches a specific session to a new consumer group. The session identifier (`SID`) is 17, the session serial number (`SERIAL#`) is 12345, and the new consumer group is the `HIGH_PRIORITY` consumer group.

```
BEGIN
DBMS_RESOURCE_MANAGER.SWITCH_CONSUMER_GROUP_FOR_SESS ('17', '12345',
   'HIGH_PRIORITY');
END;
```

The `SID`, session serial number, and current resource consumer group for a session are viewable using the `V$SESSION` view.

> **See Also:** *Oracle Database Reference* for details about the `V$SESSION` view.

Switching All Sessions for a User

The `SWITCH_CONSUMER_GROUP_FOR_USER` procedure changes the resource consumer group for all sessions pertaining to the specified user name. The following PL/SQL block switches all sessions that belong to user `SCOTT` to the `LOW_GROUP` consumer group:

```
BEGIN
DBMS_RESOURCE_MANAGER.SWITCH_CONSUMER_GROUP_FOR_USER ('SCOTT',
    'LOW_GROUP');
END;
```

Specifying Automatic Resource Consumer Group Switching

You can configure the Resource Manager to automatically switch a session to another consumer group when a certain condition is met. Automatic switching can occur when:

- A session attribute changes, causing a new mapping rule to take effect.
- A session exceeds the CPU or I/O resource consumption limits set by its consumer group.

The following sections provide details:

- Specifying Automatic Switching with Mapping Rules
- Specifying Automatic Switching by Setting Resource Limits

Specifying Automatic Switching with Mapping Rules

If a session attribute changes while the session is running, the session-to–consumer group mapping rules are reevaluated, and if a new rule takes effect, the session might be moved to a different consumer group. See "Specifying Session-to–Consumer Group Mapping Rules" on page 25-24 for more information.

Specifying Automatic Switching by Setting Resource Limits

When you create a resource plan directive for a consumer group, you can specify limits for CPU and I/O resource consumption for sessions in that group. You do so by specifying the action that is to be taken if any single call within a session exceeds one of these limits. The possible actions are the following:

- The session is dynamically switched to a designated consumer group.

  The target consumer group is typically one that has lower resource allocations. The session's user must have *switch privileges* on the new consumer group, otherwise the switch cannot occur. See "Granting and Revoking the Switch Privilege" on page 25-28 for more information.
- The session is killed (terminated).
- The session's current SQL statement is aborted.

The following are the resource plan directive attributes that are involved in this type of automatic session switching.

- `SWITCH_GROUP`
- `SWITCH_TIME`
- `SWITCH_ESTIMATE`
- `SWITCH_IO_MEGABYTES`

- `SWITCH_IO_REQS`
- `SWITCH_FOR_CALL`

See "Creating Resource Plan Directives" on page 25-14 for descriptions of these attributes.

Switches occur for sessions that are running and consuming resources, not waiting for user input or waiting for CPU cycles. The switched session is allowed to continue running even if the active session pool for the new group is full. Under these conditions, a consumer group can have more sessions running than specified by its active session pool.

`SWITCH_FOR_CALL` is useful for three-tier applications where the middle tier server is using session pooling. A **top call** in PL/SQL is an entire PL/SQL block treated as one call. A top call in SQL is an individual SQL statement.

The following are examples of automatic switching based on resource limits:

Example 1:

The following PL/SQL block creates a resource plan directive for the `OLTP` group that switches any session in that group to the `LOW_GROUP` consumer group if a call in the sessions exceeds 5 seconds of CPU time. This example prevents unexpectedly long queries from consuming too many resources. The switched-to consumer group is typically one with lower resource allocations.

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE (
   PLAN             => 'DAYTIME',
   GROUP_OR_SUBPLAN => 'OLTP',
   COMMENT          => 'OLTP group',
   MGMT_P1          => 75,
   SWITCH_GROUP     => 'LOW_GROUP',
   SWITCH_TIME      => 5);
END;
```

Example 2

The following PL/SQL block creates a resource plan directive for the `OLTP` group that temporarily switches any session in that group to the `LOW_GROUP` consumer group if the session exceeds 10,000 I/O requests or exceeds 2,500 Megabytes of data transferred. The session is returned to its original group after the offending top call is complete.

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE (
   PLAN                => 'DAYTIME',
   GROUP_OR_SUBPLAN    => 'OLTP',
   COMMENT             => 'OLTP group',
   MGMT_P1             => 75,
   SWITCH_GROUP        => 'LOW_GROUP',
   SWITCH_IO_REQS      => 10000,
   SWITCH_IO_MEGABYTES => 2500,
   SWITCH_FOR_CALL     => TRUE);
END;
```

Example 3:

The following PL/SQL block creates a resource plan directive for the `OLTP` group that kills (terminates) any session that exceeds 60 seconds of CPU time. This example prevents runaway queries from consuming too many resources.

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE (
   PLAN             => 'DAYTIME',
   GROUP_OR_SUBPLAN => 'OLTP',
   COMMENT          => 'OLTP group',
   MGMT_P1          => 75,
   SWITCH_GROUP     => 'KILL_SESSION',
   SWITCH_TIME      => 60);
END;
```

See Also: "Creating Resource Plan Directives" on page 25-14

Specifying Session-to–Consumer Group Mapping Rules

This section provides background information about session-to–consumer group mapping rules, and describes how to create and prioritize them. The following topics are covered:

- About Session-to–Consumer Group Mapping Rules
- Creating Consumer Group Mapping Rules
- Creating Mapping Rule Priorities

About Session-to–Consumer Group Mapping Rules

By creating session-to–consumer group mapping rules, you can:

- Specify the initial consumer group for a session based on session attributes.
- Enable the Resource Manager to dynamically switch a running session to another consumer group based on changing session attributes.

The mapping rules are based on session attributes such as the user name, the service that the session used to connect to the database, or the name of the client program.

To resolve conflicts among mapping rules, the Resource Manager orders the rules by priority. For example, suppose user `SCOTT` connects to the database with the `SALES` service. If one mapping rule states that user `SCOTT` starts in the `MED_PRIORITY` consumer group, and another states that sessions that connect with the `SALES` service start in the `HIGH_PRIORITY` consumer group, mapping rule priorities resolve this conflict.

There are two types of session attributes upon which mapping rules are based: login attributes and runtime attributes. The login attributes are meaningful only at session login time, when the Resource Manager determines the initial consumer group of the session. In contrast, a session that has already logged in can later be reassigned to another consumer group based on its changing run-time attributes.

You use the `SET_CONSUMER_GROUP_MAPPING` and `SET_CONSUMER_GROUP_MAPPING_PRI` procedures to configure the automatic assigning of sessions to consumer groups. You must use a pending area for these procedures. (You must create the pending area, run the procedures, optionally validate the pending area, and then submit the pending area. For examples of using the pending area, see "Creating a Complex Resource Plan" on page 25-11.)

A session is automatically switched to a consumer group through mapping rules at distinct points in time:

- When the session first logs in, the mapping rules are evaluated to determine the initial group of the session.

- If a session attribute is dynamically changed to a new value (which is only possible for runtime attributes), the mapping rules are reevaluated and the session might be switched to another consumer group.

Two things to note about the preceding rules are the following:

- If a runtime attribute for which a mapping rule is provided is set to the same value that it already has, no switching takes place.
- A session can be switched to the same consumer group it is already in. The effect of switching in this case is to initialize to zero the session statistics that are typically initialized during a switch to a different group. An example of such a statistic is the `ACTIVE_TIME_IN_GROUP` value of the session.

See Also:

- "Assigning an Initial Resource Consumer Group" on page 25-21
- "Specifying Automatic Switching with Mapping Rules" on page 25-22

Creating Consumer Group Mapping Rules

The mapping rules for a session consist of a set of attribute/consumer group pairs that determine how a session is matched to a consumer group. You use the `SET_CONSUMER_GROUP_MAPPING` procedure to map a single session attribute to a consumer group. The parameters for this procedure are the following:

Parameter	Description
`ATTRIBUTE`	The login or runtime session attribute type, specified as a package constant
`VALUE`	The value of the attribute being mapped
`CONSUMER_GROUP`	The consumer group to map to

`ATTRIBUTE` can be one of the following:

Attribute	Type	Description
`ORACLE_USER`	Login	The Oracle Database user name
`SERVICE_NAME`	Login	The service name used by the client to establish a connection
`CLIENT_OS_USER`	Login	The operating system user name of the client that is logging in
`CLIENT_PROGRAM`	Login	The name of the client program used to log in to the server
`CLIENT_MACHINE`	Login	The name of the computer from which the client is making the connection
`MODULE_NAME`	Runtime	The module name in the currently running application as set by the `DBMS_APPLICATION_INFO.SET_MODULE` procedure or the equivalent OCI attribute setting

Attribute	Type	Description
MODULE_NAME_ACTION	Runtime	A combination of the current module and the action being performed as set by either of the following procedures or their equivalent OCI attribute setting: ■ DBMS_APPLICATION_INFO.SET_MODULE ■ DBMS_APPLICATION_INFO.SET_ACTION The attribute is specified as the module name followed by a period (.), followed by the action name (*module_name.action_name*).
SERVICE_MODULE	Runtime	A combination of service and module names in this form: *service_name.module_name*
SERVICE_MODULE_ACTION	Runtime	A combination of service name, module name, and action name, in this form: *service_name.module_name.action_name*

For example, the following PL/SQL block causes user SCOTT to map to the DEV_GROUP consumer group every time that he logs in:

```
BEGIN
DBMS_RESOURCE_MANAGER.SET_CONSUMER_GROUP_MAPPING
     (DBMS_RESOURCE_MANAGER.ORACLE_USER, 'SCOTT', 'DEV_GROUP');
END;
```

Again, you must create a pending area before running the SET_CONSUMER_GROUP_MAPPING procedure.

Creating Mapping Rule Priorities

To resolve conflicting mapping rules, you can establish a priority ordering of the session attributes from most important to least important. You use the SET_CONSUMER_GROUP_MAPPING_PRI procedure to set the priority of each attribute to a unique integer from 1 (most important) to 10 (least important). The following example illustrates this setting of priorities:

```
BEGIN
DBMS_RESOURCE_MANAGER.SET_CONSUMER_GROUP_MAPPING_PRI(
    EXPLICIT => 1,
    SERVICE_MODULE_ACTION => 2,
    SERVICE_MODULE => 3,
    MODULE_NAME_ACTION => 4,
    MODULE_NAME => 5,
    SERVICE_NAME => 6,
    ORACLE_USER => 7,
    CLIENT_PROGRAM => 8,
    CLIENT_OS_USER => 9,
    CLIENT_MACHINE => 10);
END;
```

In this example, the priority of the database user name is set to 7 (less important), while the priority of the module name is set to 5 (more important).

Note: SET_CONSUMER_GROUP_MAPPING_PRI requires that you include the pseudo-attribute EXPLICIT as an argument. It must be set to 1. It indicates that explicit consumer group switches have the highest priority. You explicitly switch consumer groups with these package procedures, which are described in detail in *Oracle Database PL/SQL Packages and Types Reference*:

- DBMS_SESSION.SWITCH_CURRENT_CONSUMER_GROUP
- DBMS_RESOURCE_MANAGER.SWITCH_CONSUMER_GROUP_FOR_SESS
- DBMS_RESOURCE_MANAGER.SWITCH_CONSUMER_GROUP_FOR_USER

To illustrate how mapping rule priorities work, assume that in addition to the mapping of user SCOTT to the DEV_GROUP consumer group, there is also a module name mapping rule as follows:

```
BEGIN
DBMS_RESOURCE_MANAGER.SET_CONSUMER_GROUP_MAPPING
     (DBMS_RESOURCE_MANAGER.MODULE_NAME, 'BACKUP', 'LOW_PRIORITY');
END;
```

Now if user SCOTT's session sets its module name to BACKUP, the session is reassigned to the LOW_PRIORITY consumer group, because module name mapping has a higher priority than database user mapping.

You can query the view DBA_RSRC_MAPPING_PRIORITY to see the current priority ordering of session attributes.

To prevent unauthorized clients from setting their session attributes so that they map to higher priority consumer groups, user switch privileges for consumer groups are enforced. Thus, even though the attribute of a particular session matches a mapping pair, the mapping rule is ignored if the session does not have the switch privilege for the designated consumer group.

Enabling Users or Applications to Manually Switch Consumer Groups

You can grant a user the switch privilege so that he can switch his current consumer group using the SWITCH_CURRENT_CONSUMER_GROUP procedure in the DBMS_SESSION package. A user can run this procedure from an interactive session, for example from SQL*Plus, or an application can call this procedure to switch its session, effectively dynamically changing its priority.

The SWITCH_CURRENT_CONSUMER_GROUP procedure enables users to switch to only those consumer groups for which they have the switch privilege. If the caller is another procedure, then this procedure enables users to switch to a consumer group for which the owner of that procedure has switch privileges.

The parameters for this procedure are the following:

Parameter	Description
NEW_CONSUMER_GROUP	The consumer group to which the user is switching.
OLD_CONSUMER_GROUP	Returns the name of the consumer group from which the user switched. Can be used to switch back later.

Parameter	Description
INITIAL_GROUP_ON_ERROR	Controls behavior if a switching error occurs. If TRUE, in the event of an error, the user is switched to the initial consumer group. If FALSE, raises an error.

The following SQL*Plus session illustrates switching to a new consumer group. By printing the value of the output parameter old_group, the example illustrates how the old consumer group name is saved.

```
SET serveroutput on
DECLARE
    old_group varchar2(30);
BEGIN
DBMS_SESSION.SWITCH_CURRENT_CONSUMER_GROUP('OLTP', old_group, FALSE);
DBMS_OUTPUT.PUT_LINE('OLD GROUP = ' || old_group);
END;
/
```

The following line is output:

```
OLD GROUP = DEFAULT_CONSUMER_GROUP
```

Note that the Resource Manager considers a switch to have taken place even if the SWITCH_CURRENT_CONSUMER_GROUP procedure is called to switch the session to the consumer group that it is already in.

Note: The Resource Manager also works in environments where a generic database user name is used to log on to an application. The DBMS_SESSION package can be called to switch the consumer group assignment of a session at session startup, or as particular modules are called.

See Also: *Oracle Database PL/SQL Packages and Types Reference* for additional examples and more information about the DBMS_SESSION package

Granting and Revoking the Switch Privilege

Using the DBMS_RESOURCE_MANAGER_PRIVS PL/SQL package, you can grant or revoke the switch privilege to a user, role, or PUBLIC. The switch privilege enables a user or application to switch a session to a specified resource consumer group. It also enables the database to automatically switch a session to a consumer group specified in a session-to–consumer group mapping rule or specified in the SWITCH_GROUP parameter of a resource plan directive. The package also enables you to revoke the switch privilege. The relevant package procedures are listed in the following table.

Procedure	Description
GRANT_SWITCH_CONSUMER_GROUP	Grants permission to a user, role, or PUBLIC to switch to a specified resource consumer group.
REVOKE_SWITCH_CONSUMER_GROUP	Revokes permission for a user, role, or PUBLIC to switch to a specified resource consumer group.

DEFAULT_CONSUMER_GROUP has switch privileges granted to PUBLIC. Therefore, all users are automatically granted the switch privilege for this consumer group.

See Also:

- "Enabling Users or Applications to Manually Switch Consumer Groups" on page 25-27
- "Specifying Automatic Resource Consumer Group Switching" on page 25-22

Granting the Switch Privilege

The following example grants user SCOTT the privilege to switch to consumer group OLTP.

```
BEGIN
DBMS_RESOURCE_MANAGER_PRIVS.GRANT_SWITCH_CONSUMER_GROUP (
   GRANTEE_NAME   => 'SCOTT',
   CONSUMER_GROUP => 'OLTP',
   GRANT_OPTION   =>  TRUE);
END;
```

User SCOTT is also granted permission to grant switch privileges for OLTP to others.

If you grant permission to a role to switch to a particular resource consumer group, then any user who is granted that role and has enabled that role can switch his session to that consumer group.

If you grant PUBLIC the permission to switch to a particular consumer group, then any user can switch to that group.

If the GRANT_OPTION argument is TRUE, then users granted switch privilege for the consumer group can also grant switch privileges for that consumer group to others.

Revoking Switch Privileges

The following example revokes user SCOTT's privilege to switch to consumer group OLTP.

```
BEGIN
DBMS_RESOURCE_MANAGER_PRIVS.REVOKE_SWITCH_CONSUMER_GROUP (
   REVOKEE_NAME   => 'SCOTT',
   CONSUMER_GROUP => 'OLTP');
END;
```

If you revoke a user's switch privileges for a particular consumer group, any subsequent attempts by that user to switch to that consumer group fail. If you revoke the switch privilege for the initial consumer group from a user, that user is automatically assigned to the DEFAULT_CONSUMER_GROUP upon login.

If you revoke from a role the switch privileges to a consumer group, any users who had switch privileges for the consumer group only through that role are no longer able to switch to that consumer group.

If you revoke switch privileges to a consumer group from PUBLIC, any users other than those who are explicitly assigned switch privileges either directly or through a role are no longer able to switch to that consumer group.

Enabling Oracle Database Resource Manager and Switching Plans

You enable Oracle Database Resource Manager (the Resource Manager) by setting the `RESOURCE_MANAGER_PLAN` initialization parameter. This parameter specifies the top plan, identifying the plan to be used for the current instance. If no plan is specified with this parameter, the Resource Manager is not activated.

By default the Resource Manager is not enabled.

The following statement in a text initialization parameter file activates the Resource Manager upon database startup and sets the top plan as `mydb_plan`.

```
RESOURCE_MANAGER_PLAN = mydb_plan
```

You can also activate or deactivate the Resource Manager, or change the current top plan, using the `DBMS_RESOURCE_MANAGER.SWITCH_PLAN` package procedure or the `ALTER SYSTEM` statement.

The following SQL statement sets the top plan to `mydb_plan`, and activates the Resource Manager if it is not already active:

```
ALTER SYSTEM SET RESOURCE_MANAGER_PLAN = 'mydb_plan';
```

An error message is returned if the specified plan does not exist in the data dictionary.

Automatic Enabling of the Resource Manager by Oracle Scheduler Windows

The Resource Manager automatically activates if an Oracle Scheduler window that specifies a resource plan opens. When the Scheduler window closes, the resource plan associated with the window is disabled and the resource plan that was running before the Scheduler window opened is reenabled. (If no resource plan was enabled before the window opened, the Resource Manager is disabled again when the window closes.) In an Oracle Real Application Clusters environment, a Scheduler window applies to all instances, so the window's resource plan is enabled on every instance.

Note that by default a set of automated maintenance tasks run during **maintenance windows**, which are predefined Scheduler windows that are members of the `MAINTENANCE_WINDOW_GROUP` window group and which specify the `DEFAULT_MAINTENANCE_PLAN` resource plan. Thus, the Resource Manager activates by default during maintenance windows.

See Also:

- "Windows" on page 26-9
- Chapter 24, "Managing Automated Database Maintenance Tasks"

Disabling Plan Switches by Oracle Scheduler Windows

In some cases, the automatic change of Resource Manager plans at Scheduler window boundaries may be undesirable. For example, if you have an important task to finish, and if you set the Resource Manager plan to give your task priority, then you expect that the plan will remain the same until you change it. However, because a Scheduler window could activate after you have set your plan, the Resource Manager plan might change while your task is running.

To prevent this situation, you can set the `RESOURCE_MANAGER_PLAN` initialization parameter to the name of the plan that you want for the system and prepend "`FORCE:`" to the name, as shown in the following SQL statement:

```
ALTER SYSTEM SET RESOURCE_MANAGER_PLAN = 'FORCE:mydb_plan';
```

Using the prefix `FORCE:` indicates that the current resource plan can be changed only when the database administrator changes the value of the `RESOURCE_MANAGER_PLAN` initialization parameter. This restriction can be lifted by rerunning the command without preceding the plan name with "`FORCE:`".

The `DBMS_RESOURCE_MANAGER.SWITCH_PLAN` package procedure has a similar capability.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for more information on `DBMS_RESOURCE_MANAGER.SWITCH_PLAN`.

Disabling the Resource Manager

To disable the Resource Manager, complete the following steps:

1. Issue the following SQL statement:

   ```
   ALTER SYSTEM SET RESOURCE_MANAGER_PLAN = '';
   ```

2. Disassociate the Resource Manager from all Oracle Scheduler windows.

   To do so, for any Scheduler window that references a resource plan in its `resource_plan` attribute, use the `DBMS_SCHEDULER.SET_ATTRIBUTE` procedure to set `resource_plan` to the empty string (''). Qualify the window name with the `SYS` schema name if you are not logged in as user `SYS`. You can view Scheduler windows with the `DBA_SCHEDULER_WINDOWS` data dictionary view. See "Altering Windows" on page 27-25 and *Oracle Database PL/SQL Packages and Types Reference* for more information.

   > **Note:** By default, all maintenance windows reference the `DEFAULT_MAINTENANCE_PLAN` resource plan. If you want to completely disable the Resource Manager, you must alter all maintenance windows to remove this plan. However, use caution, because resource consumption by automated maintenance tasks will no longer be regulated, which may adversely affect the performance of your other sessions. See Chapter 24, "Managing Automated Database Maintenance Tasks" for more information on maintenance windows.

Putting It All Together: Oracle Database Resource Manager Examples

This section provides some examples of resource plans. The following examples are presented:

- Multilevel Plan Example
- Example of Using Several Resource Allocation Methods
- An Oracle-Supplied Mixed Workload Plan

Multilevel Plan Example

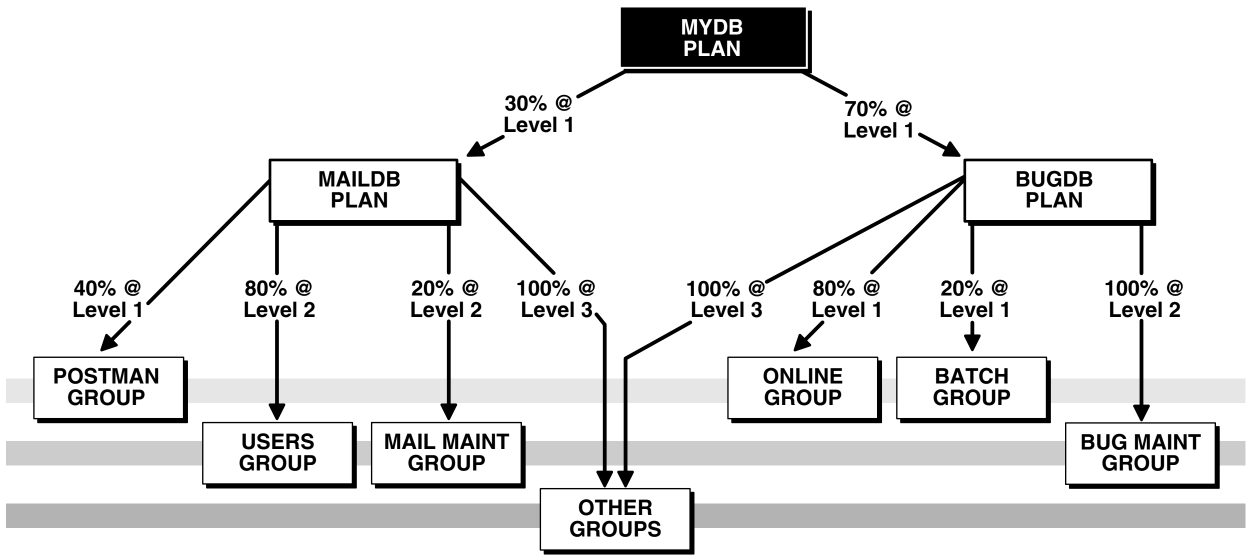
The following PL/SQL block creates a multilevel plan as illustrated in Figure 25–3 on page 25-33. Default resource allocation method settings are used for all plans and resource consumer groups.

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_PENDING_AREA();
DBMS_RESOURCE_MANAGER.CREATE_PLAN(PLAN => 'bugdb_plan',
   COMMENT => 'Resource plan/method for bug users sessions');
```

```
DBMS_RESOURCE_MANAGER.CREATE_PLAN(PLAN => 'maildb_plan',
   COMMENT => 'Resource plan/method for mail users sessions');
DBMS_RESOURCE_MANAGER.CREATE_PLAN(PLAN => 'mydb_plan',
   COMMENT => 'Resource plan/method for bug and mail users sessions');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'Online_group',
   COMMENT => 'Resource consumer group/method for online bug users sessions');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'Batch_group',
   COMMENT => 'Resource consumer group/method for batch job bug users sessions');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'Bug_Maint_group',
   COMMENT => 'Resource consumer group/method for users sessions for bug db maint');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'Users_group',
   COMMENT => 'Resource consumer group/method for mail users sessions');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'Postman_group',
   COMMENT => 'Resource consumer group/method for mail postman');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'Mail_Maint_group',
   COMMENT => 'Resource consumer group/method for users sessions for mail db maint');
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'bugdb_plan',
   GROUP_OR_SUBPLAN => 'Online_group',
   COMMENT => 'online bug users sessions at level 1', MGMT_P1 => 80, MGMT_P2=> 0);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'bugdb_plan',
   GROUP_OR_SUBPLAN => 'Batch_group',
   COMMENT => 'batch bug users sessions at level 1', MGMT_P1 => 20, MGMT_P2 => 0,
   PARALLEL_DEGREE_LIMIT_P1 => 8);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'bugdb_plan',
   GROUP_OR_SUBPLAN => 'Bug_Maint_group',
   COMMENT => 'bug maintenance users sessions at level 2', MGMT_P1 => 0, MGMT_P2 => 100);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'bugdb_plan',
   GROUP_OR_SUBPLAN => 'OTHER_GROUPS',
   COMMENT => 'all other users sessions at level 3', MGMT_P1 => 0, MGMT_P2 => 0,
   MGMT_P3 => 100);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'maildb_plan',
   GROUP_OR_SUBPLAN => 'Postman_group',
   COMMENT => 'mail postman at level 1', MGMT_P1 => 40, MGMT_P2 => 0);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'maildb_plan',
   GROUP_OR_SUBPLAN => 'Users_group',
   COMMENT => 'mail users sessions at level 2', MGMT_P1 => 0, MGMT_P2 => 80);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'maildb_plan',
   GROUP_OR_SUBPLAN => 'Mail_Maint_group',
   COMMENT => 'mail maintenance users sessions at level 2', MGMT_P1 => 0, MGMT_P2 => 20);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'maildb_plan',
   GROUP_OR_SUBPLAN => 'OTHER_GROUPS',
   COMMENT => 'all other users sessions at level 3', MGMT_P1 => 0, MGMT_P2 => 0,
   MGMT_P3 => 100);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'mydb_plan',
   GROUP_OR_SUBPLAN => 'maildb_plan',
   COMMENT=> 'all mail users sessions at level 1', MGMT_P1 => 30);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'mydb_plan',
   GROUP_OR_SUBPLAN => 'bugdb_plan',
   COMMENT => 'all bug users sessions at level 1', MGMT_P1 => 70);
DBMS_RESOURCE_MANAGER.VALIDATE_PENDING_AREA();
DBMS_RESOURCE_MANAGER.SUBMIT_PENDING_AREA();
END;
```

The preceding call to `VALIDATE_PENDING_AREA` is optional because the validation is implicitly performed in `SUBMIT_PENDING_AREA`.

Figure 25–3 Multilevel Plan Schema



In this plan schema, CPU resources are allocated as follows:

- Under `mydb_plan`, 30% of CPU is allocated to the `maildb_plan` subplan, and 70% is allocated to the `bugdb_plan` subplan. Both subplans are at level 1. Because `mydb_plan` itself has no levels below level 1, any resource allocations that are unused by either subplan at level 1 can be used by its sibling subplan. Thus, if `maildb_plan` uses only 20% of CPU, then 80% of CPU is available to `bugdb_plan`.
- `maildb_plan` defines allocations at levels 1, 2, and 3, and `bugdb_plan` defines allocations at levels 1 and 2. The levels in these subplans are independent of levels in their parent plan, `mydb_plan`. That is, all plans and subplans in a plan schema have their own level 1, level 2, level 3, and so on.
- Of the 30% of CPU allocated to `maildb_plan`, 40% of that amount (effectively 12% of total CPU) is allocated to `Postman_group` at level 1. Because `Postman_group` has no siblings at level 1, there is an implied 60% remaining at level 1. This 60% is then shared by `Users_group` and `Mail_Maint_group` at level 2, at 80% and 20%, respectively. In addition to this 60%, `Users_group` and `Mail_Maint_group` can also use any of the 40% not used by `Postman_group` at level 1.
- CPU resources not used by either `Users_group` or `Mail_Maint_group` at level 2 are allocated to `OTHER_GROUPS`, because in multilevel plans, unused resources are reallocated to consumer groups or subplans at the next lower level, not to siblings at the same level. Thus, if `Users_group` uses only 70% instead of 80%, the remaining 10% cannot be used by `Mail_Maint_group`. That 10% is available only to `OTHER_GROUPS` at level 3.

Example of Using Several Resource Allocation Methods

The example presented here could represent a plan for a database supporting a packaged ERP (Enterprise Resource Planning) or CRM (Customer Relationship Management) application. The work in such an environment can be highly varied. There may be a mix of short transactions and quick queries, in combination with longer running batch jobs that include large parallel queries. The goal is to give good response time to OLTP (Online Transaction Processing), while allowing batch jobs to run in parallel.

The plan is summarized in the following table.

Group	CPU Resource Allocation %	Active Session Pool Parameters	Automatic Consumer Group Switching	Maximum Estimated Execution Time	Undo Pool
`oltp`	Level 1: 80%		Switch to group: `batch` Switch time: 3 secs		200K
`batch`	Level 2: 100%	Pool size: 5 Timeout: 600 secs	--	3600 secs	--
`OTHER_GROUPS`	Level 3: 100%	--	--		--

By assigning only 80% of the CPU to `oltp` at level 1, `batch` is guaranteed to get at least 20%, plus any of `oltp`'s unused CPU resources. `OTHER_GROUPS`, however, is not guaranteed any CPU resources. It gets CPU resources only if `batch` is unable to consume all of its allocation. A similar-looking plan would give `oltp` 80% and `batch` 20%, both at level 1, and `OTHER_GROUPS` 100% at level 2. With this plan, `oltp`'s unused CPU allocation would be given to `OTHER_GROUPS`, not `batch`.

The following statements create the preceding plan, which is named `erp_plan`:

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_PENDING_AREA();
DBMS_RESOURCE_MANAGER.CREATE_PLAN(PLAN => 'erp_plan',
  COMMENT => 'Resource plan/method for ERP Database');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'oltp',
  COMMENT => 'Resource consumer group/method for OLTP jobs');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'batch',
  COMMENT => 'Resource consumer group/method for BATCH jobs');
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'erp_plan',
  GROUP_OR_SUBPLAN => 'oltp', COMMENT => 'OLTP sessions', MGMT_P1 => 80,
  SWITCH_GROUP => 'batch', SWITCH_TIME => 3, UNDO_POOL => 200);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'erp_plan',
  GROUP_OR_SUBPLAN => 'batch', COMMENT => 'BATCH sessions', MGMT_P2 => 100,
  ACTIVE_SESS_POOL_P1 => 5, QUEUEING_P1 => 600, MAX_EST_EXEC_TIME => 3600);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'erp_plan',
  GROUP_OR_SUBPLAN => 'OTHER_GROUPS', COMMENT => 'mandatory', MGMT_P3 => 100);
DBMS_RESOURCE_MANAGER.VALIDATE_PENDING_AREA();
DBMS_RESOURCE_MANAGER.SUBMIT_PENDING_AREA();
END;
```

An Oracle-Supplied Mixed Workload Plan

Oracle Database includes a predefined resource plan, `MIXED_WORKLOAD_PLAN`, that prioritizes interactive operations over batch operations, and includes the required subplans and consumer groups recommended by Oracle. `MIXED_WORKLOAD_PLAN` is defined as follows:

	CPU Resource Allocation				
Group or Subplan	Level 1	Level 2	Level 3	Automatic Consumer Group Switching	Max Degree of Parallelism
`BATCH_GROUP`			100%		

Group or Subplan	CPU Resource Allocation				
	Level 1	Level 2	Level 3	Automatic Consumer Group Switching	Max Degree of Parallelism
INTERACTIVE_GROUP		85%		Switch to group: BATCH_GROUP Switch time: 60 seconds Switch for call: TRUE	1
ORA$AUTOTASK_SUB_PLAN		5%			
ORA$DIAGNOSTICS		5%			
OTHER_GROUPS		5%			
SYS_GROUP	100%				

In this plan, because INTERACTIVE_GROUP is intended for short transactions, any call that lasts longer than 60 seconds is automatically switched to BATCH_GROUP, which is intended for longer batch operations.

You can use this predefined plan if it is appropriate for your environment. (You can modify the plan, or delete it if you do not intend to use it.) Note that there is nothing special about the names BATCH_GROUP and INTERACTIVE_GROUP. The names reflect only the intended purposes of the groups, and it is up to you to map application sessions to these groups and adjust CPU resource allocation percentages accordingly so that you achieve proper resource management for your interactive and batch applications. For example, to ensure that your interactive applications run under the INTERACTIVE_GROUP consumer group, you must map your interactive applications' user sessions to this consumer group based on user name, service name, program name, module name, or action, as described in "Specifying Session-to–Consumer Group Mapping Rules" on page 25-24. You must map your batch applications to the BATCH_GROUP in the same way. Finally, you must enable this plan as described in "Enabling Oracle Database Resource Manager and Switching Plans" on page 25-30.

See Table 25–1 on page 25-43 and Table 25–2 on page 25-43 for explanations of the other resource consumer groups and subplans in this plan.

Maintaining Consumer Groups, Plans, and Directives

This section provides instructions for maintaining consumer groups, resource plans, and resource plan directives for Oracle Database Resource Manager (the Resource Manager). You perform maintenance tasks using the DBMS_RESOURCE_MANAGER PL/SQL package. The following topics are covered:

- Updating a Consumer Group
- Deleting a Consumer Group
- Updating a Plan
- Deleting a Plan
- Updating a Resource Plan Directive
- Deleting a Resource Plan Directive

See Also:

- DBMS_RESOURCE_MANAGER Package Procedures Summary on page 25-44
- *Oracle Database PL/SQL Packages and Types Reference* for details on the `DBMS_RESOURCE_MANAGER` PL/SQL package.

Updating a Consumer Group

You use the `UPDATE_CONSUMER_GROUP` procedure to update consumer group information. The pending area must be created first, and then submitted after the consumer group is updated. If you do not specify the arguments for the `UPDATE_CONSUMER_GROUP` procedure, they remain unchanged in the data dictionary.

Deleting a Consumer Group

The `DELETE_CONSUMER_GROUP` procedure deletes the specified consumer group. The pending area must be created first, and then submitted after the consumer group is deleted. Upon deletion of a consumer group, all users having the deleted group as their initial consumer group are assigned the `DEFAULT_CONSUMER_GROUP` as their initial consumer group. All currently running sessions belonging to a deleted consumer group are assigned to a new consumer group, based on the consumer group mapping rules. If no consumer group is found for a session through mapping, the session is switched to the `DEFAULT_CONSUMER_GROUP`.

You cannot delete a consumer group if it is referenced by a resource plan directive.

Updating a Plan

You use the `UPDATE_PLAN` procedure to update plan information. The pending area must be created first, and then submitted after the plan is updated. If you do not specify the arguments for the `UPDATE_PLAN` procedure, they remain unchanged in the data dictionary. The following PL/SQL block updates the `COMMENT` parameter.

```
BEGIN
DBMS_RESOURCE_MANAGER.UPDATE_PLAN(
   PLAN => 'DAYTIME',
   NEW_COMMENT => '50% more resources for OLTP applications');
END;
```

Deleting a Plan

The `DELETE_PLAN` procedure deletes the specified plan as well as all the plan directives associated with it. The pending area must be created first, and then submitted after the plan is deleted.

The following PL/SQL block deletes the `great_bread` plan and its directives.

```
BEGIN
DBMS_RESOURCE_MANAGER.DELETE_PLAN(PLAN => 'great_bread');
END;
```

The resource consumer groups referenced by the deleted directives are not deleted, but they are no longer associated with the `great_bread` plan.

The `DELETE_PLAN_CASCADE` procedure deletes the specified plan as well as all its descendants: plan directives and those subplans and resource consumer groups that are not marked by the database as mandatory. If `DELETE_PLAN_CASCADE` encounters an error, it rolls back, leaving the plan unchanged.

You cannot delete the currently active plan.

Updating a Resource Plan Directive

Use the UPDATE_PLAN_DIRECTIVE procedure to update plan directives. The pending area must be created first, and then submitted after the resource plan directive is updated. If you do not specify the arguments for the UPDATE_PLAN_DIRECTIVE procedure, they remain unchanged in the data dictionary.

Deleting a Resource Plan Directive

To delete a resource plan directive, use the DELETE_PLAN_DIRECTIVE procedure. The pending area must be created first, and then submitted after the resource plan directive is deleted.

Viewing Database Resource Manager Configuration and Status

You can use a number of static data dictionary views and dynamic performance views to view the current configuration and status of Oracle Database Resource Manager (the Resource Manager). This section provides the following examples:

- Viewing Consumer Groups Granted to Users or Roles
- Viewing Plan Information
- Viewing Current Consumer Groups for Sessions
- Viewing the Currently Active Plans

See Also: *Oracle Database Reference* for details on all static data dictionary views and dynamic performance views

Viewing Consumer Groups Granted to Users or Roles

The DBA_RSRC_CONSUMER_GROUP_PRIVS view displays the consumer groups granted to users or roles. Specifically, it displays the groups to which a user or role is allowed to belong or be switched. For example, in the view shown below, user SCOTT always starts in the SALES consumer group, can switch to the MARKETING group through a specific grant, and can switch to the DEFAULT_CONSUMER_GROUP and LOW_GROUP groups because they are granted to PUBLIC. SCOTT also has the ability to grant the SALES group but not the MARKETING group to other users.

```
SQL> SELECT * FROM DBA_RSRC_CONSUMER_GROUP_PRIVS;

GRANTEE            GRANTED_GROUP                 GRANT_OPTION INITIAL_GROUP
------------------ ----------------------------- ------------ -------------
PUBLIC             DEFAULT_CONSUMER_GROUP        YES          YES
PUBLIC             LOW_GROUP                     NO           NO
SCOTT              MARKETING                     NO           NO
SCOTT              SALES                         YES          YES
SYSTEM             SYS_GROUP                     NO           YES
```

SCOTT was granted the ability to switch to these groups using the DBMS_RESOURCE_MANAGER_PRIVS package.

Viewing Plan Information

This example uses the DBA_RSRC_PLANS view to display all of the resource plans defined in the database. All plans have a NULL status, meaning that they are not in the pending area.

Note: Plans in the pending area have a status of PENDING.

```
SQL> SELECT PLAN,COMMENTS,STATUS FROM DBA_RSRC_PLANS;

PLAN                        COMMENTS                                     STATUS
--------------------------  -------------------------------------------  ------
MIXED_WORKLOAD_PLAN         Example plan for a mixed workload that prio
ORA$AUTOTASK_SUB_PLAN       Default sub-plan for automated maintenance
ORA$AUTOTASK_HIGH_SUB_PLAN  Default sub-plan for high-priority, automat
ERP_PLAN                    Resource plan/method for ERP Database
DEFAULT_PLAN                Default, basic, pre-defined plan that prior
INTERNAL_QUIESCE            Plan for quiescing the database.  This plan
INTERNAL_PLAN               Internally-used plan for disabling the reso
DEFAULT_MAINTENANCE_PLAN    Default plan for maintenance windows that p
```

Viewing Current Consumer Groups for Sessions

You can use the V$SESSION view to display the consumer groups that are currently assigned to sessions.

```
SQL> SELECT SID,SERIAL#,USERNAME,RESOURCE_CONSUMER_GROUP FROM V$SESSION;

SID    SERIAL#  USERNAME                  RESOURCE_CONSUMER_GROUP
-----  -------  ------------------------  --------------------------------
.
.
.
   11       136 SYS                       SYS_GROUP
   13     16570 SCOTT                     SALES
```

Viewing the Currently Active Plans

This example sets mydb_plan, as created by the example shown earlier in "Multilevel Plan Example" on page 25-31, as the top level plan. It then queries the V$RSRC_PLAN view to display the currently active plans. The view displays the current top level plan and all of its descendent subplans.

```
SQL> ALTER SYSTEM SET RESOURCE_MANAGER_PLAN = mydb_plan;

System altered.

SQL> SELECT NAME, IS_TOP_PLAN FROM V$RSRC_PLAN;

NAME             IS_TOP_PLAN
----------------------------
MYDB_PLAN        TRUE
MAILDB_PLAN      FALSE
BUGDB_PLAN       FALSE
```

Monitoring Oracle Database Resource Manager

Use the following dynamic performance views to help you monitor the results of your Oracle Database Resource Manager settings:

- V$RSRC_PLAN
- V$RSRC_CONSUMER_GROUP
- V$RSRC_SESSION_INFO
- V$RSRC_PLAN_HISTORY
- V$RSRC_CONS_GROUP_HISTORY

These views provide:

- Current status information
- History of resource plan activations
- Current and historical statistics on resource consumption and CPU waits by both resource consumer group and session

In addition, historical statistics are available through the `DBA_HIST_RSRC_PLAN` and `DBA_HIST_RSRC_CONSUMER_GROUP` views, which contain Automatic Workload Repository (AWR) snapshots of the `V$RSRC_PLAN_HISTORY` and `V$RSRC_CONS_GROUP_HISTORY`, respectively.

For assistance with tuning, the views `V$RSRCMGRMETRIC` and `V$RSRCMGRMETRIC_HISTORY` show how much time was spent waiting for CPU and how much CPU was consumed per minute for every consumer group for the past hour. These metrics can be viewed graphically with Enterprise Manager, on the Resource Manager Statistics page.

V$RSRC_PLAN This view displays the currently active resource plan and its subplans.

```
SELECT name, is_top_plan FROM v$rsrc_plan;

NAME                             IS_TOP_PLAN
-------------------------------- -----------
DEFAULT_PLAN                     TRUE
ORA$AUTOTASK_SUB_PLAN            FALSE
ORA$AUTOTASK_HIGH_SUB_PLAN       FALSE
```

The plan for which `IS_TOP_PLAN` is `TRUE` is the currently active (top) plan, and the other plans are subplans of either the top plan or of other subplans in the list.

V$RSRC_CONSUMER_GROUP Use the `V$RSRC_CONSUMER_GROUP` view to monitor CPU usage and CPU waits. It provides the cumulative amount of CPU time consumed, cumulative amount of time waiting for CPU, and cumulative number of CPU waits by all sessions in each consumer group. It also provides a number of other measures helpful for tuning.

```
SQL> SELECT name, active_sessions, queue_length,
  consumed_cpu_time, cpu_waits, cpu_wait_time
  FROM v$rsrc_consumer_group;

NAME               ACTIVE_SESSIONS QUEUE_LENGTH CONSUMED_CPU_TIME  CPU_WAITS CPU_WAIT_TIME
------------------ --------------- ------------ ----------------- ---------- -------------
OLTP_ORDER_ENTRY                 1            0             29690        467          6709
OTHER_GROUPS                     0            0           5982366       4089         60425
```

```
SYS_GROUP                         1           0           2420704        914          19540
DSS_QUERIES                       4           2           4594660       3004          55700
```

In the preceding query results, the `DSS_QUERIES` consumer group has four sessions in its active session pool and two more sessions queued for activation.

A key measure in this view is `CPU_WAIT_TIME`. This indicates the total time that sessions in the consumer group waited for CPU because of resource management. Not included in this measure are waits due to latch or enqueue contention, I/O waits, and so on.

V$RSRC_SESSION_INFO Use this view to monitor the status of one or more sessions. The view shows how the session has been affected by the Resource Manager. It provides information such as:

- The consumer group that the session currently belongs to.
- The consumer group that the session originally belonged to.
- The session attribute that was used to map the session to the consumer group.
- Session state (`RUNNING`, `WAIT_FOR_CPU`, `QUEUED`, and so on).
- Current and cumulative statistics for metrics, such as CPU consumed, wait times, and queued time. Current statistics reflect statistics for the session since it joined its current consumer group. Cumulative statistics reflect statistics for the session in all consumer groups to which it has belonged since it was created.

```
SQL> SELECT se.sid sess_id, co.name consumer_group,
 se.state, se.consumed_cpu_time cpu_time, se.cpu_wait_time, se.queued_time
 FROM v$rsrc_session_info se, v$rsrc_consumer_group co
 WHERE se.current_consumer_group_id = co.id;

SESS_ID CONSUMER_GROUP     STATE     CPU_TIME CPU_WAIT_TIME QUEUED_TIME
------- ------------------ -------- --------- ------------- -----------
    113 OLTP_ORDER_ENTRY   WAITING     137947         28846           0
    135 OTHER_GROUPS       IDLE        785669         11126           0
    124 OTHER_GROUPS       WAITING      50401         14326           0
    114 SYS_GROUP          RUNNING        495             0           0
    102 SYS_GROUP          IDLE         88054            80           0
    147 DSS_QUERIES        WAITING     460910        512154           0
```

`CPU_WAIT_TIME` in this view has the same meaning as in the `V$RSRC_CONSUMER_GROUP` view, but applied to an individual session.

V$RSRC_PLAN_HISTORY This view shows when resource plans were enabled or disabled on the instance. Each resource plan activation or deactivation is assigned a sequence number. For each entry in the view, the `V$RSRC_CONS_GROUP_HISTORY` view has a corresponding entry for each consumer group in the plan that shows the cumulative statistics for the consumer group. The two views are joined by the `SEQUENCE#` column in each.

```
SQL> SELECT sequence# seq, name plan_name,
to_char(start_time, 'DD-MON-YY HH24:MM') start_time,
to_char(end_time, 'DD-MON-YY HH24:MM') end_time, window_name
FROM v$rsrc_plan_history;

 SEQ PLAN_NAME                  START_TIME      END_TIME        WINDOW_NAME
---- -------------------------- --------------- --------------- ----------------
   1                            29-MAY-07 23:05 29-MAY-07 23:05
   2 DEFAULT_MAINTENANCE_PLAN   29-MAY-07 23:05 30-MAY-07 02:05 TUESDAY_WINDOW
   3                           30-MAY-07 02:05 30-MAY-07 22:05
   4 DEFAULT_MAINTENANCE_PLAN   30-MAY-07 22:05 31-MAY-07 02:05 WEDNESDAY_WINDOW
   5                           31-MAY-07 02:05 31-MAY-07 22:05
   6 DEFAULT_MAINTENANCE_PLAN   31-MAY-07 22:05                 THURSDAY_WINDOW
```

A null value under PLAN_NAME indicates that no plan was active.

AWR snapshots of this view are stored in the DBA_HIST_RSRC_PLAN view.

V$RSRC_CONS_GROUP_HISTORY This view helps you understand how resources were shared among the consumer groups over time. The sequence# column corresponds to the column of the same name in the V$RSRC_PLAN_HISTORY view. This enables you to determine the plan that was active for each row of consumer group statistics.

```
SQL> select sequence# seq, name, cpu_wait_time, cpu_waits,
consumed_cpu_time from V$RSRC_CONS_GROUP_HISTORY;

 SEQ NAME                       CPU_WAIT_TIME  CPU_WAITS CONSUMED_CPU_TIME
---- ------------------------- ------------- ---------- -----------------
   2 SYS_GROUP                          18133        691          33364431
   2 OTHER_GROUPS                       51252        825         181058333
   2 ORA$AUTOTASK_MEDIUM_GROUP             21          5           4019709
   2 ORA$AUTOTASK_URGENT_GROUP             35          1            198760
   2 ORA$AUTOTASK_STATS_GROUP               0          0                 0
   2 ORA$AUTOTASK_SPACE_GROUP               0          0                 0
   2 ORA$AUTOTASK_SQL_GROUP                 0          0                 0
   2 ORA$AUTOTASK_HEALTH_GROUP              0          0                 0
   2 ORA$DIAGNOSTICS                        0          0           1072678
   4 SYS_GROUP                          40344         85          42519265
   4 OTHER_GROUPS                      123295       1040         371481422
   4 ORA$AUTOTASK_MEDIUM_GROUP              1          4           7433002
   4 ORA$AUTOTASK_URGENT_GROUP          22959        158          19964703
   4 ORA$AUTOTASK_STATS_GROUP               0          0                 0
      .
      .
   6 ORA$DIAGNOSTICS                        0          0                 0
```

AWR snapshots of this view are stored in the DBA_HIST_RSRC_CONSUMER_GROUP view. Use DBA_HIST_RSRC_CONSUMER_GROUP with DBA_HIST_RSRC_PLAN to determine the plan that was active for each historical set of consumer group statistics.

See Also:

- *Oracle Database Reference* for information on these and other Resource Manager views.
- *Oracle Database Performance Tuning Guide* for information about the AWR.

Interacting with Operating-System Resource Control

Many operating systems provide tools for resource management. These tools often contain "workload manager" or "resource manager" in their names, and are intended to allow multiple applications to share the resources of a single server, using an administrator-defined policy. Oracle Database expects a static configuration and allocates internal resources, such as latches, from available resources detected at database startup. The database might not perform optimally and can become unstable if operating system resource configuration changes frequently.

Guidelines for Using Operating-System Resource Control

If you do choose to use Operating-system resource control with Oracle Database, then you must use it judiciously, according to the following guidelines:

1. In general, operating system resource control should not be used concurrently with Oracle Database Resource Manager (the Resource Manager), because neither of them are aware of each other's existence. As a result, both the operating system and the Resource Manager try to control resource allocation in a manner that causes unpredictable behavior and instability of Oracle Database.
   - If you want to control resource distribution within an instance, use the Resource Manager and turn off operating-system resource control.
   - If you have multiple instances on a node and you want to distribute resources among them, use operating-system resource control, not the Resource Manager.

   Note: Oracle Database currently does not support the use of both tools simultaneously. Future releases might allow for their interaction on a limited scale.

2. If you decide to use an operating system resource manager (such as Hewlett Packard's Process Resource Manager or Sun's Solaris Resource Manager) concurrently with Oracle Database Resource Manager (the Resource Manager), you must ensure that all of the following conditions are met:
   - Each database instance must be assigned to a dedicated operating-system resource manager group or managed entity.
   - The dedicated entity running all the instance's processes must run at one priority (or resource consumption) level.
   - The CPU resources assigned to the dedicated entity cannot be changed more frequently than once every few minutes.
   - Process priority management must not be enabled.

   Caution: Management of individual database processes at different priority levels (for example, using the `nice` command on UNIX platforms) is not supported. Severe consequences, including instance crashes, can result. You can expect similar undesirable results if operating-system resource control is permitted to manage the memory to which an Oracle Database instance is pinned.

3. If you decide to use operating system resource control only, ensure that you turn off the Resource Manager. See "Disabling the Resource Manager" on page 25-31 for instructions.

Oracle Database Resource Manager Reference

The following sections provide reference information for Oracle Database Resource Manager (the Resource Manager):

- Predefined Resource Plans and Consumer Groups
- DBMS_RESOURCE_MANAGER Package Procedures Summary

- Resource Manager Data Dictionary Views

Predefined Resource Plans and Consumer Groups

Table 25–1 lists the resource plans and Table 25–2 lists the resource consumer groups that are predefined for each Oracle database.

Table 25–1 Predefined Resource Plans

Resource Plan	Description
`DEFAULT_MAINTENANCE_PLAN`	Default plan for maintenance windows. See "About Resource Allocations for Automated Maintenance Tasks" on page 24-5 for details of this plan.
`DEFAULT_PLAN`	Basic default plan that prioritizes `SYS_GROUP` operations and allocates minimal resources for automated maintenance and diagnostics operations.
`INTERNAL_PLAN`	For disabling the resource manager. For internal use only.
`INTERNAL_QUIESCE`	For quiescing the database. This plan cannot be activated directly. To activate, use the `QUIESCE` command.
`MIXED_WORKLOAD_PLAN`	Example plan for a mixed workload that prioritizes interactive operations over batch operations. See "An Oracle-Supplied Mixed Workload Plan" on page 25-34 for details.
`ORA$AUTOTASK_HIGH_SUB_PLAN`	Default sub-plan for high-priority, automated maintenance tasks. This sub-plan is referenced by `ORA$AUTOTASK_SUB_PLAN` and should not be referenced directly. This plan is a sub-plan of `DEFAULT_MAINTENANCE_PLAN`.
`ORA$AUTOTASK_SUB_PLAN`	Default sub-plan for automated maintenance tasks. A directive to this sub-plan should be included in every top-level plan to manage the resources consumed by the automated maintenance tasks. This plan is a sub-plan of `DEFAULT_MAINTENANCE_PLAN`.

Table 25–2 Predefined Resource Consumer Groups

Resource Consumer Group	Description
`BATCH_GROUP`	Consumer group for batch operations.
`DEFAULT_CONSUMER_GROUP`	Initial consumer group for all sessions started by user accounts other than `SYS` and `SYSTEM`. This initial consumer group can be overridden by session-to–consumer group mapping rules. `DEFAULT_CONSUMER_GROUP` cannot be named in a resource plan directive.
`INTERACTIVE_GROUP`	Consumer group for interactive, OLTP operations.
`LOW_GROUP`	Consumer group for low-priority sessions.
`ORA$DIAGNOSTICS`	Consumer group used by database processes that create diagnostic dumps when critical errors occur.
`ORA$AUTOTASK_HEALTH_GROUP`	Reserved for future use. Included in `ORA$AUTOTASK_HIGH_SUB_PLAN`.
`ORA$AUTOTASK_MEDIUM_GROUP`	Consumer group for medium-priority maintenance tasks.
`ORA$AUTOTASK_SPACE_GROUP`	Consumer group for Automatic Segment Advisor maintenance task. Included in `ORA$AUTOTASK_HIGH_SUB_PLAN`.

Table 25–2 (Cont.) Predefined Resource Consumer Groups

Resource Consumer Group	Description
ORA$AUTOTASK_SQL_GROUP	Consumer group for Automatic SQL Tuning Advisor maintenance task. Included in ORA$AUTOTASK_HIGH_SUB_PLAN.
ORA$AUTOTASK_STATS_GROUP	Consumer group for optimizer statistics gathering maintenance task. Included in ORA$AUTOTASK_HIGH_SUB_PLAN.
ORA$AUTOTASK_URGENT_GROUP	Consumer group for urgent maintenance tasks.
OTHER_GROUPS	Consumer group that applies collectively to all sessions that belong to a consumer group that is not part of the currently active plan, including sessions that belong to DEFAULT_CONSUMER_GROUP. OTHER_GROUPS must have a resource plan directive specified in every plan. It cannot be explicitly assigned to sessions through mapping rules.
SYS_GROUP	Consumer group for system administrators. It is the initial consumer group for all sessions created by user accounts SYS or SYSTEM. This initial consumer group can be overridden by session-to–consumer group mapping rules.

DBMS_RESOURCE_MANAGER Package Procedures Summary

Table 25–3 summarizes the procedures in the `DBMS_RESOURCE_MANAGER` package. You must have the `ADMINISTER_RESOURCE_MANAGER` privilege to run these procedures.

Table 25–3 DBMS_RESOURCE_MANAGER Package Procedures

Procedure	Description
CREATE_SIMPLE_PLAN	Creates a simple resource plan, containing up to eight consumer groups, in one step. This is the quickest way to get started with Oracle Database Resource Manager.
CREATE_PLAN	Creates a resource plan and specifies its allocation methods.
UPDATE_PLAN	Updates a resource plan.
DELETE_PLAN	Deletes a resource plan and its directives.
DELETE_PLAN_CASCADE	Deletes a resource plan and all of its descendents.
CREATE_CONSUMER_GROUP	Creates a resource consumer group.
UPDATE_CONSUMER_GROUP	Updates a consumer group.
DELETE_CONSUMER_GROUP	Deletes a consumer group.
CREATE_PLAN_DIRECTIVE	Specifies the resource plan directives that allocate resources to resource consumer groups or subplans in a plan.
UPDATE_PLAN_DIRECTIVE	Updates plan directives
DELETE_PLAN_DIRECTIVE	Deletes plan directives
CREATE_PENDING_AREA	Creates a pending area (scratch area) within which changes can be made to a plan schema
VALIDATE_PENDING_AREA	Validates the pending changes to a plan schema
CLEAR_PENDING_AREA	Clears all pending changes from the pending area
SUBMIT_PENDING_AREA	Submits all changes for a plan schema

Table 25–3 (Cont.) DBMS_RESOURCE_MANAGER Package Procedures

Procedure	Description
`SET_INITIAL_CONSUMER_GROUP`	Sets the initial consumer group for a user. This procedure has been deprecated. Oracle recommends that you use the `SET_CONSUMER_GROUP_MAPPING` procedure to specify the initial consumer group for a user or session.
`SWITCH_CONSUMER_GROUP_FOR_SESS`	Switches the consumer group of a specific session
`SWITCH_CONSUMER_GROUP_FOR_USER`	Switches the consumer group of all sessions belonging to a specific user
`SWITCH_PLAN`	Sets the current resource manager plan.
`SET_CONSUMER_GROUP_MAPPING`	Maps sessions to consumer groups
`SET_CONSUMER_GROUP_MAPPING_PRI`	Establishes session attribute mapping priorities

See Also: *Oracle Database PL/SQL Packages and Types Reference* for details on the `DBMS_RESOURCE_MANAGER` PL/SQL package.

Resource Manager Data Dictionary Views

Table 25–4 lists views that are associated with the Resource Manager.

Table 25–4 Resource Manager Data Dictionary Views

View	Description
`DBA_RSRC_CONSUMER_GROUP_PRIVS` `USER_RSRC_CONSUMER_GROUP_PRIVS`	`DBA` view lists all resource consumer groups and the users and roles to which they have been granted. `USER` view lists all resource consumer groups granted to the user.
`DBA_RSRC_CONSUMER_GROUPS`	Lists all resource consumer groups that exist in the database.
`DBA_RSRC_MANAGER_SYSTEM_PRIVS` `USER_RSRC_MANAGER_SYSTEM_PRIVS`	`DBA` view lists all users and roles that have been granted Resource Manager system privileges. `USER` view lists all the users that are granted system privileges for the `DBMS_RESOURCE_MANAGER` package.
`DBA_RSRC_PLAN_DIRECTIVES`	Lists all resource plan directives that exist in the database.
`DBA_RSRC_PLANS`	Lists all resource plans that exist in the database.
`DBA_RSRC_GROUP_MAPPINGS`	Lists all of the various mapping pairs for all of the session attributes.
`DBA_RSRC_MAPPING_PRIORITY`	Lists the current mapping priority of each attribute.
`DBA_HIST_RSRC_PLAN`	Displays historical information about resource plan activation. This view contains AWR snapshots of `V$RSRC_PLAN_HISTORY`.
`DBA_HIST_RSRC_CONSUMER_GROUP`	Displays historical statistical information about consumer groups. This view contains AWR snapshots of `V$RSRC_CONS_GROUP_HISTORY`.
`DBA_USERS` `USERS_USERS`	`DBA` view contains information about all users of the database. It contains the initial resource consumer group for each user. `USER` view contains information about the current user. It contains the current user's initial resource consumer group.
`V$ACTIVE_SESS_POOL_MTH`	Displays all available active session pool resource allocation methods.
`V$PARALLEL_DEGREE_LIMIT_MTH`	Displays all available parallel degree limit resource allocation methods.

Table 25–4 (Cont.) Resource Manager Data Dictionary Views

View	Description
V$QUEUEING_MTH	Displays all available queuing resource allocation methods.
V$RSRC_CONS_GROUP_HISTORY	For each entry in the view V$RSRC_PLAN_HISTORY, contains an entry for each consumer group in the plan showing the cumulative statistics for the consumer group.
V$RSRC_CONSUMER_GROUP	Displays information about active resource consumer groups. This view can be used for tuning.
V$RSRC_CONSUMER_GROUP_CPU_MTH	Displays all available CPU resource allocation methods for resource consumer groups.
V$RSRCMGRMETRIC	Displays a history of resources consumed and cumulative CPU wait time (due to resource management) per consumer group for the past minute.
V$RSRCMGRMETRIC_HISTORY	Displays a history of resources consumed and cumulative CPU wait time (due to resource management) per consumer group for the past hour on a minute-by-minute basis. If a new resource plan is enabled, the history is cleared.
V$RSRC_PLAN	Displays the names of all currently active resource plans.
V$RSRC_PLAN_CPU_MTH	Displays all available CPU resource allocation methods for resource plans.
V$RSRC_PLAN_HISTORY	Shows when Resource Manager plans were enabled or disabled on the instance. It helps you understand how resources were shared among the consumer groups over time.
V$RSRC_SESSION_INFO	Displays Resource Manager statistics for each session. Shows how the session has been affected by the Resource Manager. Can be used for tuning.
V$SESSION	Lists session information for each current session. Specifically, lists the name of the resource consumer group of each current session.

See Also: *Oracle Database Reference* for detailed information about the contents of each of these views

26
Oracle Scheduler Concepts

Oracle Database provides advanced job scheduling capabilities through Oracle Scheduler (the Scheduler). This chapter introduces you to Scheduler concepts and includes the following topics:

- Overview of the Scheduler
- Basic Scheduler Concepts
- Advanced Scheduler Concepts
- Scheduler Architecture

Note: This chapter discusses the use of the Oracle-supplied `DBMS_SCHEDULER` package to administer scheduling capabilities. You can also use Oracle Enterprise Manager (EM) as an easy-to-use graphical interface for many of the same capabilities.

See the *Oracle Database PL/SQL Packages and Types Reference* for `DBMS_SCHEDULER` syntax and the Oracle Enterprise Manager documentation set for more information regarding EM.

Overview of the Scheduler

Organizations have too many tasks, and manually dealing with each one can be daunting. To help you simplify these management tasks, as well as offering a rich set of functionality for complex scheduling needs, Oracle provides a collection of functions and procedures in the `DBMS_SCHEDULER` package. Collectively, these functions are called the Scheduler, and they are callable from any PL/SQL program.

The Scheduler enables database administrators and application developers to control when and where various tasks take place in the database environment. These tasks can be time consuming and complicated, so using the Scheduler can help you to improve the management and planning of these tasks. In addition, by ensuring that many routine database tasks occur without manual intervention, you can lower operating costs, implement more reliable routines, minimize human error, and shorten the time windows needed.

Some typical examples of using the Scheduler are:

- Database administrators can schedule and monitor recurring database maintenance jobs such as backups or nightly data warehousing loads and extracts.
- Application developers can create programs and program libraries that end users can use to create or monitor their own jobs. In addition to typical database jobs, you can schedule and monitor jobs that run as part of an application suite.

What Can the Scheduler Do?

The Scheduler provides complex enterprise scheduling functionality, which you can use to:

- Schedule job execution based on time or events

  The most basic capability of a job scheduler is the ability to schedule a job to run at a particular date and time or when a particular event occurs. The Scheduler enables you to reduce your operating costs by enabling you to schedule execution of jobs. For example, consider the situation where a patch needs to be applied to a database that is in production. To minimize disruptions, this task will need to be performed during non-peak hours. This can be easily accomplished using the Scheduler. Instead of having IT personnel manually carry out this task during non-peak hours, you can instead create a job and schedule it to run at a specified time using the Scheduler.

  Scheduler jobs can be database jobs or external jobs. The typical Scheduler job is a database job (or just "job"), which runs PL/SQL code within the database. An external job runs an operating system executable such as a compiled C++ application or a shell script. External jobs can be run on the local host, or on a remote host with the help of a remote Scheduler agent.

  See "Creating Jobs" on page 27-2 for more information.

- Schedule job processing in a way that models your business requirements

  The Scheduler enables limited computing resources to be allocated appropriately among competing jobs, thus aligning job processing with your business needs. This is accomplished in the following ways:

  – Jobs that share common characteristics and behavior can be grouped into larger entities called job classes. You can prioritize among the classes by controlling the resources allocated to each class. This enables you to ensure that your critical jobs have priority and have enough resources to complete. For example, if you have a critical project to load a data warehouse, then you can combine all the data warehousing jobs into one class and give priority to it over other jobs by allocating it a high percentage of the available resources.

  – The Scheduler takes prioritization of jobs one step further, by providing you the ability to change the prioritization based on a schedule. Because your definition of a critical job can change over time, the Scheduler enables you to also change the priority among your jobs over that time frame. For example, you may consider the jobs to load a data warehouse to be critical jobs during non-peak hours but not during peak hours. In such a case, you can change the priority among the classes by changing the resource allocated to each class. See "Creating Job Classes" on page 27-22 and "Creating Windows" on page 27-23 for more information.

  – In addition to running jobs based on a time schedule, the Scheduler enables you to start jobs in response to system or business events. Your applications can detect events and then signal the Scheduler. Depending on the type of signal sent, the Scheduler starts a specific job. An example of using events to align your job processing with business needs is to prepare event-based jobs for when a transaction fails, such as someone trying to withdraw more money from a bank account than is available. In this case, you could run jobs that check for suspicious activity in this account.

- Manage and monitor jobs

There are multiple states that a job undergoes from its creation to its completion. Scheduler activity is logged and information such as the status of the job and the last run time of the job can be easily tracked. This information is stored in views and can be easily queried using Enterprise Manager or a SQL query. These views provide valuable information about jobs and their execution that can help you schedule and manage your jobs better. For example, a DBA can easily track all jobs that failed for user `scott`. See "Monitoring and Managing the Scheduler" on page 28-7.

- Execute and manage jobs in a clustered environment

  A cluster is a set of database instances that cooperates to perform the same task. Oracle Real Application Clusters (RAC) provides scalability and reliability without any change to your applications. The Scheduler fully supports execution of jobs in such a clustered environment. To balance the load on your system and for better performance, you can also specify the database service where you want a job to run. See "Using the Scheduler in Real Application Clusters Environments" on page 26-16 for more information.

Basic Scheduler Concepts

The Scheduler offers a modular approach for managing tasks within the Oracle environment. Advantages of modularity include easier management of your database environment and reusability of scheduler objects when creating new tasks that are similar to existing tasks.

In the Scheduler, most components are database objects like a table, which enables you to use normal Oracle privileges.

The basic elements of the Scheduler are:

- Programs
- Schedules
- Jobs
- Events
- Chains

See Also: "Advanced Scheduler Concepts" on page 26-8

Programs

A Scheduler program object is a collection of metadata about what will be run by the Scheduler. It includes information such as the name of the program object, program action (for example, a procedure or executable name), program type (for example, PL/SQL and Java stored procedures or PL/SQL anonymous blocks) and the number of arguments required for the program.

A program is a separate entity from a job. Jobs run at a certain time or because a certain event occurred, and invoke a certain program. Jobs can be created that point to existing program objects, which means that different jobs can use the same program and run the program at different times and with different settings. Given the right privileges, different users can thus use the same program without having to redefine it. This enables the creation of program libraries, where users can select from a list of existing programs.

Because a Scheduler program can invoke a stored procedure or other executable that requires arguments, a means is provided to store default values for those arguments as program attributes.

See "Creating Programs" on page 27-12 for more information about programs, and "Jobs" on page 26-4 for an overview of jobs.

Schedules

A schedule specifies when and how many times a job is executed. Jobs can be scheduled for processing at a later time or immediately. For jobs to be executed at a later time, the user can specify a date and time when the job should start. For jobs that repeat over a period of time, an end date and time can be specified, which indicates when the schedule expires.

A schedule can also specify that a job be executed when a certain event occurs, such as a badge swipe or inventory dropping below a threshold. For more information on events, see "Events" on page 26-6.

Similar to programs, schedules are objects that can be named and saved in the database. Users can then share named schedules. For example, the end of a business quarter may be a common time frame for many jobs. Instead having to define an end-of-quarter schedule each time a new job is defined, job creators can point to a named schedule.

Some examples of schedules you might use to control time-based jobs are:

- Run on Wednesday, December 26th, 2001 at 2pm
- Run every Monday, at 8am, starting on December 26th, 2001, and ending on January 31st, 2002
- Run on every working day

See "Creating Schedules" on page 27-16 for more information.

Jobs

A job is a user-defined task that is scheduled to run one or more times. It is a combination of what needs to be executed (the action) and when (the schedule). Users with the right privileges can create jobs either by:

- Specifying as job attributes both the action to perform (for example, an inline PL/SQL anonymous block) and the schedule by which to perform the action (for example, every day at noon, or when a certain event occurs)
- Specifying as job attributes the names of an existing program object and an existing schedule object

The Scheduler supports the following two job types:

- Regular jobs
- Lightweight jobs

Regular Jobs

Like programs and schedules, regular jobs are schema objects. In releases before Oracle Database 11*g* Release 1, regular jobs were the only job type supported by the Scheduler.

A regular job offers the maximum flexibility but does entail some overhead when it is created or dropped. Regular jobs can be created with a single procedure call. The user has fine-grained control of the privileges on the job, and the job can have as its action a program or a stored procedure owned by another user.

If a relatively small number of jobs that run infrequently need to be created, then regular jobs are preferred over lightweight jobs.

Lightweight Jobs

Lightweight jobs are based on a job template from which privileges and (in some cases) job metadata is inherited. Use lightweight jobs when you need to create and drop hundreds or thousands of jobs per second or when you have a library of programs that are available to be used as job templates.

Lightweight jobs have the following characteristics:

- They are not schema objects like regular jobs.
- They have a significant improvement in create and drop time over regular jobs because they do not have the overhead of creating a schema object.
- They have a significantly lower average session creation time than regular jobs.
- They have a small footprint on disk for job metadata and runtime data.

You cannot set privileges on lightweight jobs because these jobs inherit privileges from the parent job template. Because the use of a job template is mandatory, it is not possible to create a fully self-contained lightweight job.

See Also: "Creating Jobs" on page 27-2 and "Examples of Using the Scheduler" on page 28-19 for examples of creating lightweight jobs

Job Templates

A job template is a database object that provides the necessary metadata needed for running a job (other than a schedule) and provides a privilege infrastructure that can be inherited by any lightweight job.

A job template is created based on a Scheduler program.

Job Arguments

You can specify job arguments to customize a named program object. Job arguments override the default argument values in the program object, and provide values for those program arguments that have no default value. In addition, job arguments can provide argument values to an inline action (for example, a stored procedure) that the job specifies.

A job cannot be enabled until all required program argument values are defined, either as defaults in a referenced program object, or as job arguments.

A common example of a job is one that runs a set of nightly reports. If different departments require different reports, you can create a program for this task that can be shared among different users from different departments. The program action would be to run a reports script, and the program would have one argument: the department number. Each user can then create a job that points to this program, and can specify the department number as a job argument.

See "Creating Jobs" on page 27-2 for more information.

Job Instances

A job instance represents a specific run of a job. Jobs that are scheduled to run only once will have only one instance. Jobs that have a repeating schedule will have multiple instances, with each run of the job representing an instance. For example, a job that is scheduled to run on Tuesday, Oct. 8th 2002 will have one instance. A job that runs daily at noon for a week has seven instances, one for each time the job runs.

When a job is created, only one entry is added to the Scheduler's job table to represent the job. Each time the job runs, an entry is added to the job log. Therefore, if you create a job that has a repeating schedule, you will find one entry in the job views and multiple entries in the job log. Each job instance log entry provides information about a particular run, such as the job completion status and the start and end time. Each run of the job is assigned a unique log id which is used in both the job log and job run details views.

See "Scheduler Data Dictionary Views" on page 28-31 for more information.

Events

An event is a message sent by one application or system process to another to indicate that some action or occurrence has been detected. An event is **raised** (sent) by one application or process, and **consumed** (received) by one or more applications or processes.

There are two kinds of events in the Scheduler:

- Events raised by the Scheduler

  The Scheduler can raise an event to indicate state changes that occur within the Scheduler itself. For example, the Scheduler can raise an event when a job starts, when a job completes, when a job exceeds its allotted run time, and so on. The consumer of the event is an application that takes some action in response to the event.

  For example, if due to a high system load, a job is still not started 30 minutes after the scheduled start time, the Scheduler can raise an event that causes a handler application to send a notification e-mail to the database administrator.

- Events raised by an application

  An application can raise an event to be consumed by the Scheduler. The Scheduler reacts to the event by starting a job. You can create a schedule that references an event instead of containing date, time, and recurrence information. If a job is assigned to such a schedule (an **event schedule**), the job runs when the event is raised. You can also create a job that has no schedule assigned and that directly references an event as the means to start the job.

  For example, when an inventory tracking system notices that the inventory has gone below a certain threshold, it can raise an event that starts an inventory replenishment job.

The Scheduler uses Oracle Streams Advanced Queuing to raise and consume events. When raising a job state change event, the Scheduler enqueues a message onto a default event queue. Applications subscribe to this queue, dequeue event messages, and take appropriate action. When raising an event to notify the Scheduler to start a job, an application enqueues a message onto a queue that was specified when setting up the job.

See Also:

- *Oracle Streams Advanced Queuing User's Guide* for more information on Advanced Queuing
- "Using Events" on page 27-33 for more information on Events

Chains

A chain is a grouping of programs that are linked together for a single, combined objective. An example of a chain might be "run program A and then program B, but only run program C if programs A and B complete successfully, otherwise run program D." A Scheduler job can point to a chain instead of pointing to a single program object.

Each position within a chain of interdependent programs is referred to as a step. Typically, after an initial set of chain steps has started, the execution of successive steps depends on the completion of one or more previous steps. Each step can point to one of the following:

- A program
- Another chain (a nested chain)
- An event

  A step that points to an event waits until the specified event is raised. If the event occurs, the step completes successfully.

Multiple steps in the chain can invoke the same program or nested chain.

In a sense, a chain resembles a decision tree, with many possible paths for selecting which steps run and when. A list of rules is used to decide which actions to perform at any particular stage. An example of a rule is "If step 2 fails or step 3 fails, wait an hour and then start step 4."

While a job pointing to a chain is running, the current state of all steps of the running chain can be monitored.

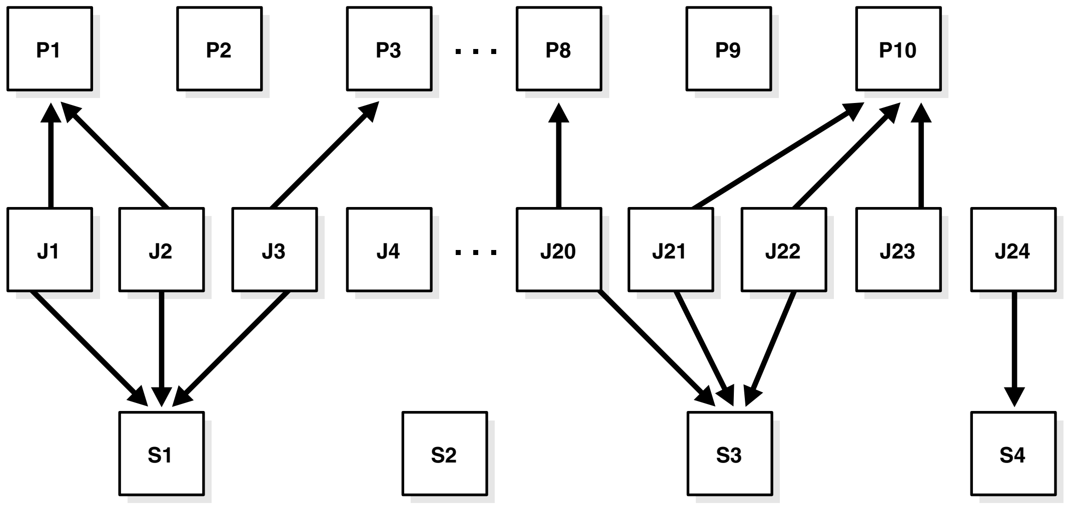
A typical situation where you might want to create a chain is to combine the different programs necessary for a successful financial transaction.

See "Using Chains" on page 27-40 for more information.

How Programs, Jobs, and Schedules are Related

To define what is executed and when, you assign relationships among programs, jobs, and schedules. Figure 26–1 illustrates examples of such relationships.

Figure 26–1 Relationships Among Programs, Jobs, and Schedules



To understand Figure 26–1, consider a situation where tables are being analyzed. In this example, `P1` would be a program to analyze a table using the `DBMS_STATS` package. The program has an input parameter for the table name. Two jobs, `J1` and `J2`, both point to the same program, but each supplies a different table name. Additionally, schedule `S1` could specify a run time of 2:00 a.m. every day. The end result would be that the two tables named in `J1` and `J2` are analyzed daily at 2:00 a.m.

Note that `J4` points to no other entity, so it is self-contained with all relevant information defined in the job itself. `P2`, `P9` and `S2` illustrate that you can leave a program or schedule unassigned if you want. You could, for example, create a program that calculates a year-end inventory and temporarily leave it unassigned to any job.

Advanced Scheduler Concepts

Many Scheduler capabilities enable database administrators to control more advanced aspects of scheduling. Typically, these topics are not as important for application developers.

This section discusses the following advanced topics:

- Job Classes
- Windows
- Window Groups
- External Jobs
- Scheduler Support for Oracle Data Guard

Job Classes

Job classes provide a way to:

- Assign the same set of attribute values to member jobs

  Each job class specifies a set of attributes, such as logging level. When you assign a job to a job class, the job inherits those attributes. For example, you can specify the same policy for purging log entries for all payroll jobs.

- Set service affinity for member jobs

  You can set the `service` attribute of a job class to a desired database service name. This determines the instances in a Real Application Clusters environment that run the member jobs, and optionally the system resources that are assigned to member jobs. See "Service Affinity when Using the Scheduler" on page 26-16 for more information.

- Set resource allocation for member jobs

  Job classes provide the link between the Database Resource Manager and the Scheduler, because each job class can specify a resource consumer group as an attribute. Member jobs then belong to the specified consumer group, and are assigned resources according to settings in the current resource plan.

  Alternatively, you can leave the `resource_consumer_group` attribute `NULL` and set the `service` attribute of a job class to a desired database service name. That service can in turn be mapped to a resource consumer group. If both the `resource_consumer_group` and `service` attributes are set, and the designated service maps to a resource consumer group, the resource consumer group named in the `resource_consumer_group` attribute takes precedence.

See Chapter 25, "Managing Resource Allocation with Oracle Database Resource Manager" for more information on mapping services to consumer groups.

- Group jobs for prioritization

  Within the same job class, you can assign priority values of 1-5 to individual jobs so that if two jobs in the class are scheduled to start at the same time, the one with the higher priority takes precedence. This ensures that you do not have a less important job preventing the timely completion of a more important one.

  If two jobs have the same assigned priority value, the job with the earlier start date takes precedence. If no priority is assigned to a job, its priority defaults to 3.

Note: Job priorities are used only to prioritize among jobs in the same class.

There is no guarantee that a high priority job in class A will be started before a low priority job in class B, even if they share the same schedule. Prioritizing among jobs of different classes depends on the current resource plan and on the designated resource consumer group or service name of each job class.

When defining job classes, you should try to classify jobs by functionality. Consider dividing jobs into groups that access similar data, such as marketing, production, sales, finance, and human resources.

Some of the restrictions to keep in mind are:

- A job must be part of exactly one class. When you create a job, you can specify which class the job is part of. If you do not specify a class, the job automatically becomes part of the class `DEFAULT_JOB_CLASS`.
- Dropping a class while there are still jobs in that class results in an error. You can force a class to be dropped even if there are still jobs that are members of that class, but all jobs referring to that class are then automatically disabled and assigned to the class `DEFAULT_JOB_CLASS`. Jobs belonging to the dropped class that are already running continue to run under class settings determined at the start of the job.

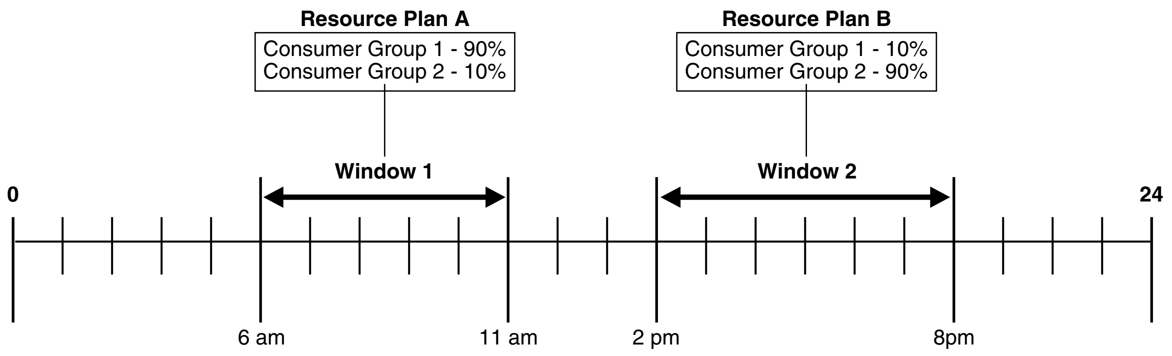
Windows

You create windows to automatically start jobs or to change resource allocation among jobs during various time periods of the day, week, and so on. A window is represented by an interval of time with a well-defined beginning and end, such as "from 12am-6am".

Windows work with job classes to control resource allocation. Each window specifies the resource plan to activate when the window **opens** (becomes active), and each job class specifies a resource consumer group or specifies a database service, which can map to a consumer group. A job that runs within a window therefore has resources allocated to it according to the consumer group of its job class and the resource plan of the window.

Figure 26–2 shows a workday that includes two windows. In this configuration, jobs that belong to the job class that links to `Consumer Group 1` get more resources in the morning than in the afternoon. The opposite is true for jobs in the job class that links to `Consumer Group 2`.

Figure 26–2 Windows help define the resources that are allocated to jobs



See Chapter 25, "Managing Resource Allocation with Oracle Database Resource Manager" for more information on resource plans and consumer groups.

You can assign a priority to each window. If windows overlap, the window with the highest priority is chosen over other windows with lower priorities. The Scheduler automatically opens and closes windows as window start times and end times come and go.

A job can name a window in its `schedule_name` attribute. The Scheduler then starts the job when the window opens. If a window is already open, and a new job is created that points to that window, the job is not started until the next time the window opens.

See "Creating Windows" on page 27-23 for examples of creating and using windows.

Note: If necessary, you can temporarily block windows from switching the current resource plan. For more information, see "Enabling Oracle Database Resource Manager and Switching Plans" on page 25-30, or the discussion of the `DBMS_RESOURCE_MANAGER.SWITCH_PLAN` package procedure in *Oracle Database PL/SQL Packages and Types Reference*.

Window Groups

You can group windows for ease of use in scheduling jobs. If a job must run during multiple time periods throughout the day, week, and so on, you can create a window for each time period, and then add the windows to a window group. You can then set the `schedule_name` attribute of the job to the name of this window group, and the job executes during all the time periods specified in the window group.

For example, if you had a window called "Weekends" and a window called "Weeknights," you could add these two windows to a window group called "Downtime." The data warehousing staff could then create a job to run queries according to this Downtime window group—on weeknights and weekends—when the queries could be assigned a high percentage of available resources.

If a window in a window group is already open, and a new job is created that points to that window group, the job is not started until the next window in the window group opens.

See "Creating Window Groups" on page 27-30 for examples of creating window groups.

External Jobs

This section discusses the Scheduler's support for external jobs.

An **external job** is an operating system executable that runs outside the database. For an external job, `job_type` is specified as `EXECUTABLE`. (If using named programs, the corresponding `program_type` would be `EXECUTABLE`.) The `job_action` (or corresponding `program_action` if using named programs) is the full operating system–dependent path of the desired external executable, excluding any command line arguments. An example might be `/usr/local/bin/perl` or `C:\perl\bin\perl`. The program or job arguments for type `EXECUTABLE` must be a string type such as `CHAR` or `VARCHAR2`. They are set with the `DBMS_SCHEDULER.SET_JOB_ARGUMENT_VALUE` procedure.

Most, but not all, platforms support external jobs. For platforms that do not support external jobs, creating or setting the attribute of a job or a program to type `EXECUTABLE` returns an error. See your operating system-specific documentation for more information. Note that a Windows batch file is not directly executable and must be run with `cmd.exe`.

Like any Scheduler job, you can assign a schema when you create the job. That schema then becomes the job owner. Note that although it is possible to create an external job in the `SYS` schema, Oracle recommends against this practice.

The `CREATE JOB` and `CREATE EXTERNAL JOB` privileges are both required for any schema that runs external jobs.

External jobs must run on the host computer as some operating system user. Thus, you must be able to assign operating system credentials to any external job that you create. You do so with a database object introduced in Oracle Database 11*g* Release 1 called a credential.

There are two types of external jobs: local external jobs and remote external jobs. Local external jobs run on the same computer as the database that schedules them. Remote external jobs run on a remote host—that is, on a host computer other than the computer running the database that schedules them.

Credentials, local external jobs, and remote external jobs are discussed in detail in the following sections:

- About Credentials
- About Local External Jobs
- About Remote External Jobs

About Credentials

A **credential** is a username and password pair stored in a dedicated database object. You set the `credential_name` attribute of an external job to designate a credential for that job. The job then runs under the username and password specified by that credential.

You use the `DBMS_SCHEDULER.CREATE_CREDENTIAL` procedure to create a credential. A credential can be used only by a job whose owner has `EXECUTE` privileges on the credential or whose owner is also the owner of the credential. Because a credential belongs to a schema like any other schema object, you use the `GRANT` SQL statement to grant privileges on a credential.

```
BEGIN
 DBMS_SCHEDULER.CREATE_CREDENTIAL('HRCREDENTIAL', 'HR', 'hr001515');
END;
```

```
GRANT EXECUTE ON SYSTEM.HRCREDENTIAL to HRJOBUSER;
```

You can query the `*_SCHEDULER_CREDENTIALS` views to see a list of credentials in the database. Credential passwords are stored obfuscated, and are not displayed in the `*_SCHEDULER_CREDENTIALS` views.

About Local External Jobs

A local external job runs on the same computer as the Oracle database that schedules it. For such a job, the `destination` job attribute is null or contains a value of `localhost`. You do not have to assign a credential to a local external job, although Oracle recommends that you do so. If you do not assign a credential by setting the `credential_name` job attribute, the job runs under default credentials. Table 26–1 defines the default credentials for different platforms and different job owners.

Table 26–1 Default Credentials for Remote External Jobs

Job in SYS Schema?	Platform	Default Credentials
Yes	All	User who installed Oracle Database
No	UNIX and Linux	Values of the `run-user` and `run-group` attributes specified in the *ORACLE_HOME*/rdbms/admin/externaljob.ora file
No	Windows	User that the `OracleJobScheduler` Windows service runs as

Note: Default credentials may be deprecated in a future release. It is therefore best to assign a credential to every local external job.

To disable the running of local external jobs that were not assigned credentials, remove the `run_user` attribute from the *`ORACLE_HOME`*`/rdbms/admin/externaljob.ora` file (UNIX and Linux) or stop the `OracleJobScheduler` service (Windows). Note that these steps do not disable the running of local external jobs in the `SYS` schema.

Some additional post-installation steps might be required to ensure that local external jobs are enabled. See your operating system-specific documentation for any post-installation configuration steps. For example, on Windows, you must set the username and password for the user account under which the `OracleJobScheduler` service is to run, and then enable the service.

About Remote External Jobs

A remote external job runs on a host computer other than the computer running the Oracle database that schedules it. For purposes of this discussion, the **database host** is the computer containing the database used to schedule a remote external job, and the **remote host** is the computer that the remote external job is to run on. The remote host may or may not have Oracle Database installed. However, in all cases, the remote host has a *Scheduler agent* that the database communicates with to start external jobs on the remote host. The agent is also involved in returning execution results to the database. The agent is an executable on a remote host that is installed separately. It listens on a network port for incoming job requests and executes them.

When setting up to run a remote external job, you specify a remote host and port as the `destination` attribute of the job. In addition, you must specify a credential for a remote external job.

See Also:

- "Creating Remote External Jobs" on page 27-6
- "Enabling and Disabling Remote External Jobs" on page 28-13

Scheduler Support for Oracle Data Guard

Beginning with Oracle Database 11*g* Release 1, the Scheduler can run jobs based on whether a database is a primary database or a logical standby in an Oracle Data Guard environment.

For a physical standby database, any changes made to Scheduler objects or any database changes made by Scheduler jobs on the primary database are applied to the physical standby like any other database changes. For the primary database and logical standby databases, there is additional functionality that enables you to specify that a job can run only when the database is in the role of the primary database, or can run only when the database is in a logical standby role.

You do this using the `DBMS_SCHEDULER.SET_ATTRIBUTE` procedure to set the `database_role` job attribute to one of two values: `PRIMARY` or `LOGICAL STANDBY`. (To run a job in both roles, you can make a copy of the job and set `database_role` to `PRIMARY` for one job and to `LOGICAL STANDBY` for the other).

On switchover or failover, the Scheduler automatically switches to running jobs specific to the new role. DML is replicated to the job event log so that on failover, a record of what had run successfully on the primary database until it failed is available.

See Also:

- "Examples of Setting Attributes" on page 28-24 for an example of setting the `database_role` attribute
- "Example of Creating a Job In an Oracle Data Guard Environment" on page 28-29
- *Oracle Data Guard Concepts and Administration*

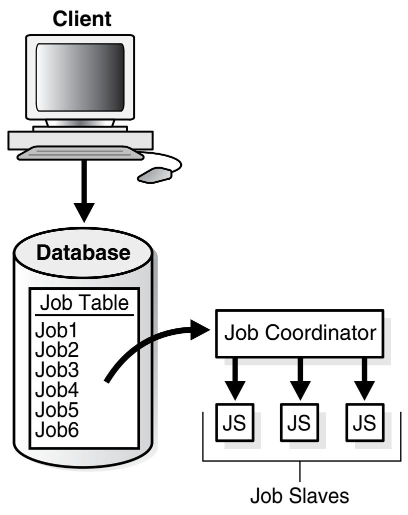
Scheduler Architecture

This section discusses the Scheduler's architecture, and describes:

- The Job Table
- The Job Coordinator
- How Jobs Execute
- Job Slaves
- Using the Scheduler in Real Application Clusters Environments

Figure 26–3 illustrates how jobs are handled by the database.

Figure 26–3 Scheduler Components



The Job Table

The job table is a container for all the jobs, with one table per database. The job table stores information for all jobs such as the owner name or the level of logging. You can find this information in the `*_SCHEDULER_JOBS` views.

Jobs are database objects, and can therefore accumulate and take up too much space. To avoid this, job objects are automatically dropped by default after completion. This behavior is controlled by the `auto_drop` job attribute.

See "Scheduler Data Dictionary Views" on page 28-31 for the available job views and administration.

The Job Coordinator

The job coordinator background process (`cjqNNN`) is automatically started and stopped on an as-needed basis. At database startup, the job coordinator is not started, but the database does monitor whether there are any jobs to be executed, or windows to be opened in the near future. If so, it starts the coordinator.

As long as there are jobs or windows running, the coordinator continues to run. After there has been a certain period of Scheduler inactivity and there are no jobs or windows scheduled in the near future, the coordinator is automatically stopped.

When the database determines whether or not to start the job coordinator, it takes the service affinity of jobs into account. For example, if there is only one job scheduled in the near future and the job class to which this job belongs has service affinity for only two out of the four RAC instances, only the job coordinators for those two instances are started. See "Service Affinity when Using the Scheduler" on page 26-16 for more information.

The job coordinator:

- Controls and spawns the job slaves
- Queries the job table
- Picks up jobs from the job table on a regular basis and places them in a memory cache. This improves performance by avoiding going to the disk
- Takes jobs from the memory cache and passes them to job slaves for execution

- Cleans up the job slave pool when slaves are no longer needed
- Goes to sleep when no jobs are scheduled
- Wakes up when a new job is about to be executed or a job was created using the `CREATE_JOB` procedure
- Upon database startup after an abnormal database shutdown, recovers any jobs that were running.

You do not need to set when the job coordinator checks the job table; the system chooses the time frame automatically. The coordinator automatically determines how many job slaves to start based on CPU load and the number of outstanding jobs. In special scenarios, you can limit the maximum number of slaves to be started by the coordinator by setting the `MAX_JOB_SLAVE_PROCESSES` parameter with the `DBMS_SCHEDULER.SET_SCHEDULER_ATTRIBUTE` procedure.

One job coordinator is used per instance. This is also the case in RAC environments.

> **See Also:** "Scheduler Data Dictionary Views" on page 28-31 for job coordinator administration and "Using the Scheduler in Real Application Clusters Environments" on page 26-16 for RAC information

How Jobs Execute

When a job is picked for processing, the job slave:

1. Gathers all the metadata needed to run the job. As an example, arguments of the program and privilege information.
2. Starts a database session as the owner of the job, starts a transaction, and then starts executing the job.
3. Once the job is complete, the slave commits and ends the transaction.
4. Closes the session.

Job Slaves

Job slaves actually execute the jobs you submit. They are awakened by the job coordinator when it is time for a job to be executed. They gather metadata to run the job from the job table.

When a job is done, the slaves:

- Reschedule the job if required
- Update the state in the job table to reflect whether the job has completed or is scheduled to run again
- Insert an entry into the job log table
- Update the run count, and if necessary, failure count and retry count
- Clean up
- Look for new work (if none, they go to sleep)

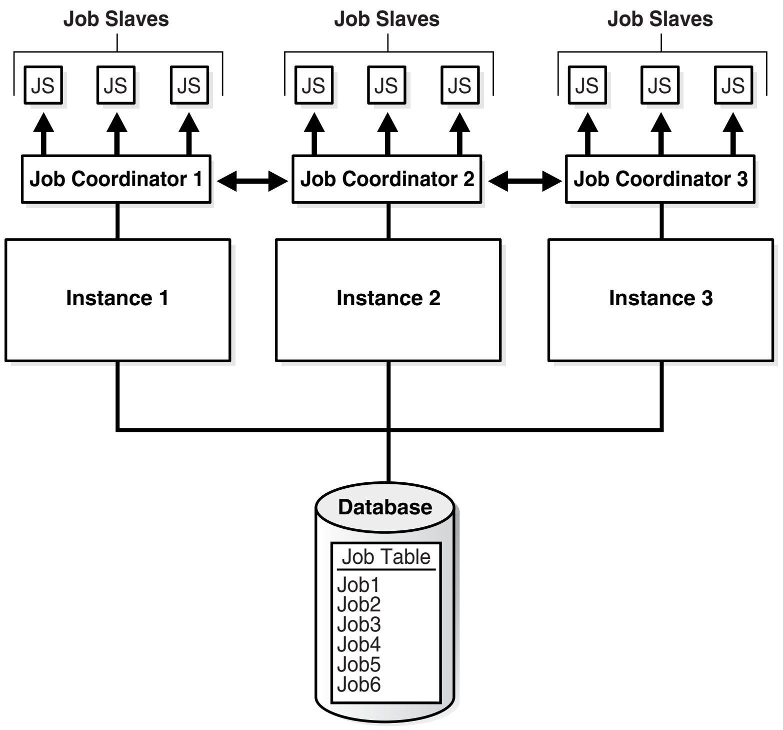
The Scheduler dynamically sizes the slave pool as required.

Using the Scheduler in Real Application Clusters Environments

In a Real Application Clusters (RAC) environment, the Scheduler uses one job table for each database and one job coordinator for each instance. The job coordinators communicate with each other to keep information current. The Scheduler attempts to balance the load of the jobs of a job class across all available instances when the job class has no service affinity, or across the instances assigned to a particular service when the job class does have service affinity.

Figure 26–4 illustrates a typical RAC architecture, with each instance's job coordinator exchanging information with the others.

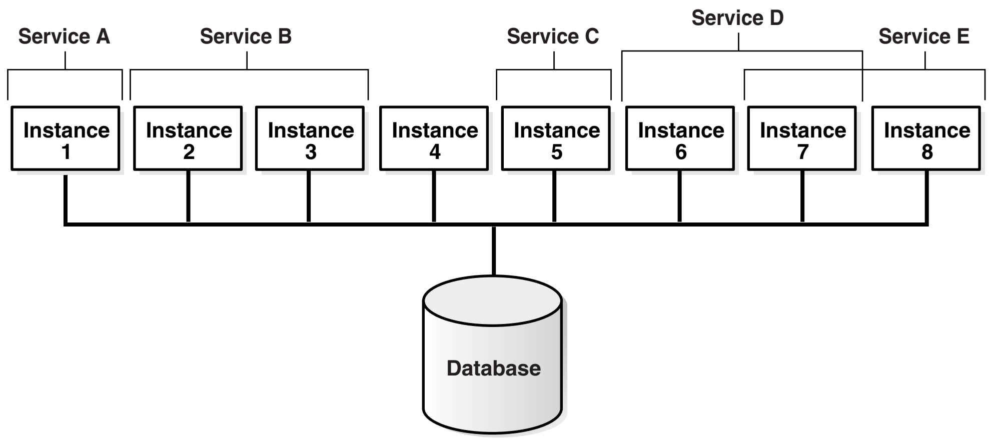
Figure 26–4 RAC Architecture and the Scheduler



Service Affinity when Using the Scheduler

The Scheduler enables you to specify the database service under which a job should be run (service affinity). This ensures better availability than instance affinity because it guarantees that other nodes can be dynamically assigned to the service if an instance goes down. Instance affinity does not have this capability, so, when an instance goes down, none of the jobs with an affinity to that instance will be able to run until the instance comes back up. Figure 26–5 illustrates a typical example of how services and instances could be used.

Figure 26–5 Service Affinity and the Scheduler



In Figure 26–5, you could change the properties of the services and the Scheduler will automatically recognize the change.

Each job class can specify a database service. If a service is not specified, the job class belongs to an internal service that is guaranteed to be mapped to every running instance.

27 Scheduling Jobs with Oracle Scheduler

Oracle Database provides database job capabilities through Oracle Scheduler (the Scheduler). This chapter explains how to use the various Scheduler components, and discusses the following topics:

Note: This chapter describes how to use the `DBMS_SCHEDULER` package to work with Scheduler components. You can accomplish the same tasks using Oracle Enterprise Manager.

Scheduler Objects and Their Naming

Each Scheduler object is a complete database schema object of the form `[schema.]name`. Scheduler objects exactly follow the naming rules for database objects and share the SQL namespace with other database objects.

When names for Scheduler objects are used in the `DBMS_SCHEDULER` package, SQL naming rules continue to be followed. By default, Scheduler object names are uppercase unless they are surrounded by double quotes. For example, when creating a job, `job_name => 'my_job'` is the same as `job_name => 'My_Job'` and `job_name => 'MY_JOB'`, but not the same as `job_name => '"my_job"'`. These naming rules are also followed in those cases where comma-delimited lists of Scheduler object names are used within the `DBMS_SCHEDULER` package.

See *Oracle Database SQL Language Reference* for details regarding naming objects.

Using Jobs

A job is the combination of a schedule and a program, along with any additional arguments required by the program. This section introduces you to basic job tasks, and discusses the following topics:

- Job Tasks and Their Procedures
- Creating Jobs
- Copying Jobs
- Altering Jobs
- Running Jobs
- Stopping Jobs
- Dropping Jobs
- Disabling Jobs
- Enabling Jobs

See Also: "Jobs" on page 26-4 for an overview of jobs.

Job Tasks and Their Procedures

Table 27–1 illustrates common job tasks and their appropriate procedures and privileges:

Table 27–1 Job Tasks and Their Procedures

Task	Procedure	Privilege Needed
Create a job	`CREATE_JOB` or `CREATE_JOBS`	`CREATE JOB` or `CREATE ANY JOB`
Alter a job	`SET_ATTRIBUTE` or `SET_JOB_ATTRIBUTES`	`ALTER` or `CREATE ANY JOB` or be the owner
Run a job	`RUN_JOB`	`ALTER` or `CREATE ANY JOB` or be the owner
Copy a job	`COPY_JOB`	`ALTER` or `CREATE ANY JOB` or be the owner
Drop a job	`DROP_JOB`	`ALTER` or `CREATE ANY JOB` or be the owner
Stop a job	`STOP_JOB`	`ALTER` or `CREATE ANY JOB` or be the owner
Disable a job	`DISABLE`	`ALTER` or `CREATE ANY JOB` or be the owner
Enable a job	`ENABLE`	`ALTER` or `CREATE ANY JOB` or be the owner

See "Scheduler Privileges" on page 28-30 for further information regarding privileges.

Creating Jobs

You create one or more jobs using the `CREATE_JOB` or `CREATE_JOBS` procedures or Enterprise Manager. The `CREATE_JOB` procedure is used to create a single job. This procedure is overloaded to enable you to create different types of jobs that are based on different objects. Multiple jobs can be created using the `CREATE_JOBS` procedure.

For each job being created, you specify a job type, an action, a schedule, and other attributes. The job type specifies whether to create a regular job or a lightweight job. If you do specify a job type, the default type is regular.

For example, the following statement creates a single job called `update_sales`, which calls a stored procedure in the OPS schema that updates a sales summary table:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB (
   job_name           =>  'update_sales',
   job_type           =>  'STORED_PROCEDURE',
   job_action         =>  'OPS.SALES_PKG.UPDATE_SALES_SUMMARY',
   start_date         =>  '28-APR-03 07.00.00 PM Australia/Sydney',
   repeat_interval    =>  'FREQ=DAILY;INTERVAL=2', /* every other day */
   end_date           =>  '20-NOV-04 07.00.00 PM Australia/Sydney',
   job_class          =>  'batch_update_jobs',
   comments           =>  'My new job');
END;
/
```

You can create a job in another schema by specifying `schema.job_name`. The creator of a job is, therefore, not necessarily the job owner. The job owner is the user in whose schema the job is created, while the job creator is the user who is creating the job. Jobs are executed with the privileges of the schema in which the job is created. The NLS environment of the job when it runs is that which was present at the time the job was created.

After a job is created, it can be queried using the `*_SCHEDULER_JOBS` views. Jobs are created disabled by default and need to be enabled to run.

Jobs are set to be automatically dropped by default after they complete. Setting the `auto_drop` attribute to `FALSE` causes the job to persist. Note that repeating jobs are not auto-dropped unless the job end date passes, the maximum number of runs (`max_runs`) is reached, or the maximum number of failures is reached (`max_failures`).

Setting Job Attributes

You can set job attributes when creating the job, or you can set them after the job is created by using the `SET_ATTRIBUTE` or `SET_JOB_ATTRIBUTES` procedures or Enterprise Manager. (Some job attributes can be set only after the job is created.)

When you set the `COMMIT_SEMANTICS` parameter of a job to TRANSACTIONAL or ABSORB_ERRORS, you can perform multiple operations within the scope of a single transaction.

See *Oracle Database PL/SQL Packages and Types Reference* for information about the `SET_ATTRIBUTE` and `SET_JOB_ATTRIBUTES` procedures and about the various job attributes.

Setting Job Arguments

After creating a job, you may need to set job arguments if:

- The inline job action is a stored procedure or other executable that requires arguments
- The job references a named program object and you want to override one or more default program arguments
- The job references a named program object and one or more of the program arguments were not assigned a default value

To set job arguments, use the `SET_JOB_ARGUMENT_VALUE` or `SET_JOB_ANYDATA_VALUE` procedures or Enterprise Manager.

SET_JOB_ANYDATA_VALUE is used for complex data types that must be encapsulated in an ANYDATA object.

Note:

- The SET_JOB_ARGUMENT_VALUE procedure can be used to set arguments of lightweight jobs but only if the arguments are of type VARCHAR2.

An example of a job that might need arguments is one that starts a reporting program that requires a start date and end date. The following code example sets the end date job argument, which is the second argument expected by the reporting program:

```
BEGIN
DBMS_SCHEDULER.SET_JOB_ARGUMENT_VALUE (
   job_name                => 'ops_reports',
   argument_position       => 2,
   argument_value          => '12-DEC-03');
END;
/
```

If you use this procedure on an argument whose value has already been set, it will be overwritten. You can set argument values using either the argument name or the argument position. To use argument name, the job must reference a named program object, and the argument must have been assigned a name in the program object. If a program is inlined, only setting by position is supported. Arguments are not supported for jobs of type plsql_block.

To remove a value that has been set, use the RESET_JOB_ARGUMENT procedure. This procedure can be used for both regular and ANYDATA arguments.

See *Oracle Database PL/SQL Packages and Types Reference* for information about the SET_JOB_ARGUMENT_VALUE and SET_JOB_ANYDATA_VALUE procedures.

Ways of Creating Jobs

Because the CREATE_JOB procedure is overloaded, there are several different ways of using it. In addition to inlining a job during the job creation, you can also create a job that points to a named program and schedule. This is discussed in the following sections:

- Creating Jobs Using a Named Program
- Creating Jobs Using a Named Schedule
- Creating Jobs Using a Named Program and Schedule

Creating Jobs Using a Named Program You can create a job by pointing to a named program instead of inlining its action. To create a job using a named program, you specify the value for program_name in the CREATE_JOB procedure when creating the job and do not specify the values for job_type, job_action, and number_of_arguments.

To use an existing program when creating a job, the owner of the job must be the owner of the program or have EXECUTE privileges on it. An example of using the CREATE_JOB procedure with a named program is the following statement, which creates a regular job called my_new_job1:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB (
   job_name          =>  'my_new_job1',
   program_name      =>  'my_saved_program',
   repeat_interval   =>  'FREQ=DAILY;BYHOUR=12',
   comments          =>  'Daily at noon');
END;
/
```

The following statement creates a lightweight job that uses the program `MY_PROG` as a job template.

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB (
   job_name         =>  'my_lightweight_job1',
   program_name     =>  'MY_PROG',
   repeat_interval  =>  'FREQ=DAILY;BY_HOUR=9',
   end_time         =>  '30-APR-07 04.00.00 AM Australia/Sydney',
   job_style        => 'LIGHTWEIGHT',
   comments         => 'New lightweight job based on a program');
END;
/
```

Creating Jobs Using a Named Schedule You can also create a job by pointing to a named schedule instead of inlining its schedule. To create a job using a named schedule, you specify the value for `schedule_name` in the `CREATE_JOB` procedure when creating the job and do not specify the values for `start_date`, `repeat_interval`, and `end_date`.

You can use any named schedule to create a job because all schedules are created with access to `PUBLIC`. An example of using the `CREATE_JOB` procedure with a named schedule is the following statement, which creates a regular job called `my_new_job2`:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB (
   job_name                =>  'my_new_job2',
   job_type                =>  'PLSQL_BLOCK',
   job_action              =>  'BEGIN SALES_PKG.UPDATE_SALES_SUMMARY; END;',
   schedule_name           =>  'my_saved_schedule');
END;
/
```

Creating Jobs Using a Named Program and Schedule A job can also be created by pointing to both a named program and schedule. An example of using the `CREATE_JOB` procedure with a named program and schedule is the following statement, which creates a regular job called `my_new_job3` based on the existing program `my_saved_program1` and the existing schedule `my_saved_schedule1`:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB (
   job_name            =>  'my_new_job3',
   program_name        =>  'my_saved_program1',
   schedule_name       =>  'my_saved_schedule1');
END;
/
```

The following statement creates a lightweight job that is based on the existing program `MY_PROG` and the existing schedule `MY_SCHED`.

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB (
   job_name            =>  'my_lightweight_job2',
   program_name        =>  'my_prog',
   schedule_name       =>  'my_sched',
   job_style           =>  'LIGHTWEIGHT');
```

```
END;
/
```

Creating Remote External Jobs

The `CREATE JOB` and `CREATE EXTERNAL JOB` privileges are both required for any schema that creates remote external jobs.

To create a remote external job:

1. Create the job using the `CREATE_JOB` procedure.
2. Create a credential using the `CREATE_CREDENTIAL` procedure of the `DBMS_SCHEDULER` package.

   The following example creates a credential named `NICKID`, which consists of the username `NICK` and the password `firesign`:

   ```
   SQL> EXEC DBMS_SCHEDULER.CREATE_CREDENTIAL('NICKID', 'NICK', 'firesign');
   ```

3. Set the `credential_name` attribute of the job using the `SET_ATTRIBUTE` procedure.

   The job owner must have `EXECUTE` privileges on the credential or be the owner of the credential.
4. Set the `destination` attribute of the job using the `SET_ATTRIBUTE` procedure.

   The attribute must be of the form *host*:*port*, where *host* is the host name or IP address of the remote host, and *port* is the port on which the Scheduler agent on that host listens. To determine this port number, view the file `schagent.conf`, which is located in the Scheduler agent home directory on the remote host.
5. Enable the job using the `ENABLE_JOB` procedure.

Example 1

The following example creates a remote external job named `CLEANLOGS` that uses a credential named `LOGOWNER`. The destination host and port number are `app455` and `12345`.

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB(
   job_name             => 'CLEANLOGS',
   job_type             => 'EXECUTABLE',
   job_action           => '/home/logowner/cleanlogs',
   repeat_interval      => 'FREQ=DAILY; BYHOUR=23',
   enabled              => FALSE);
DBMS_SCHEDULER.SET_ATTRIBUTE('CLEANLOGS', 'credential_name', 'LOGOWNER');
DBMS_SCHEDULER.SET_ATTRIBUTE('CLEANLOGS', 'destination', 'app455:12345');
DBMS_SCHEDULER.ENABLE('CLEANLOGS');
END;
/
```

Example 2

The following example creates the same remote external job for multiple remote hosts. The PL/SQL code includes a loop that iterates over the host names. `remote_cred` is the name of a credential that is valid on all hosts. The list of destinations is a list of host names and Scheduler agent ports. The executable being run on all hosts is the application `/u01/app/ext_backup`.

```
declare
job_prefix varchar2(30) := 'remote_';
```

```
job_name varchar2(30);
destinations dbms_utility.lname_array;
begin

   destinations(1) := 'host1:1234';
   destinations(2) := 'host2:1234';
   destinations(3) := 'host3:1234';
   destinations(4) := 'host4:1234';

  for i in 1..destinations.LAST loop
    job_name := dbms_scheduler.generate_job_name(job_prefix);
    dbms_scheduler.create_job(job_name,
    job_type=>'executable',
    job_action=>'/u01/app/ext_backup',
    number_of_arguments=>0,
    enabled=>false);

    dbms_scheduler.set_attribute(job_name,'destination',destinations(i));
    dbms_scheduler.set_attribute(job_name,'credential_name','remote_cred');
    dbms_scheduler.enable(job_name);
  end loop;
end;
/
```

Example 3

The example illustrates how a remote external job can submit SQL statements to a remote Oracle database. The job action runs a shell script that uses SQL*Plus to submit the statements. The script must reside on the remote host. The script, shown below, starts by setting all environment variables required to run SQL*Plus on Linux.

```
#!/bin/sh

export ORACLE_HOME=/u01/app/oracle/product/11.1.0/db_1
export ORACLE_SID=orcl
export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:$ORACLE_HOME/lib

$ORACLE_HOME/bin/sqlplus /nolog << EOF
set serveroutput on;
CONNECT scott/tiger;
select * from dual;
EXIT;
EOF
```

See Also:

- "About Remote External Jobs" on page 26-12
- "Capturing Standard Error Output for External Jobs" on page 27-9
- "Stopping External Jobs" on page 27-10

Copying Jobs

You copy a job using the COPY_JOB procedure or Enterprise Manager. This call copies all the attributes of the old job to the new job except the new job is created disabled and has another name.

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the COPY_JOB procedure.

Altering Jobs

You alter a job using the SET_ATTRIBUTE or SET_JOB_ATTRIBUTES procedures or Enterprise Manager. All jobs can be altered, and, with the exception of the job name, all job attributes can be changed. If there is a running instance of the job when the change is made, it is not affected by the call. The change is only seen in future runs of the job.

In general, you should not alter a job that was automatically created for you by the database. Jobs that were created by the database have the column SYSTEM set to TRUE in job views. The attributes of a job are available in the *_SCHEDULER_JOBS views.

It is perfectly valid for running jobs to alter their own job attributes, however, these changes will not be picked up until the next scheduled run of the job.

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the SET_ATTRIBUTE and SET_JOB_ATTRIBUTES procedures and "Configuring the Scheduler" on page 28-1.

Running Jobs

Normally, jobs are executed asynchronously. The user creates a job and the API immediately returns and indicates whether the creation was successful. To find out whether the job succeeded, the user has to query the job table or the job log. While this is the expected behavior, for special cases, the database also allows users to run jobs synchronously.

Running Jobs Asynchronously

You can schedule a job to run asynchronously based on the schedule defined when the job is created. In this case, the job is submitted to the job coordinator and is picked up by the job slaves for execution.

Running Jobs Synchronously

After a job has been created, you can run the job synchronously using the RUN_JOB procedure with the use_current_session argument set to TRUE. In this case, the job will run within the user session that invoked the RUN_JOB call instead of being picked up by the coordinator and being executed by a job slave.

You can use the RUN_JOB procedure to test a job or to run it outside of its specified schedule. Running a job with RUN_JOB with the use_current_session argument set to TRUE does not change the count for failure_count and run_count for the job. The job run will, however, be reflected in the job log. Runtime errors generated by the job are passed back to the invoker of RUN_JOB.

When using RUN_JOB to run a job that points to a chain, use_current_session must be set to FALSE.

Job Run Environment

Jobs are run with the privileges that are granted to the job owner directly or indirectly through default logon roles. External OS roles are not supported. Given sufficient privileges, users can create jobs in other users' schemas. The creator and the owner of the job can, therefore, be different. For example, if user jim has the CREATE ANY JOB privilege and creates a job in the scott schema, then the job will run with the privileges of scott.

The NLS environment of the session in which the job was created is saved and is used when the job is being executed. To alter the NLS environment in which a job runs, a job must be created in a session with different NLS settings.

Capturing Standard Error Output for External Jobs

When a local external job or remote external job writes output to `stderr`, the first 200 bytes are recorded in the `ADDITIONAL_INFO` column of the `*_SCHEDULER_JOB_RUN_DETAILS` views. The information is in the following name/value pair format:

```
STANDARD_ERROR="text"
```

Note: The `ADDITIONAL_INFO` column can have multiple name/value pairs. The order is indeterminate, so you must parse the field to locate the `STANDARD_ERROR` name/value pair.

To retrieve the entire standard error text, you can use the `DBMS_SCHEDULER.GET_FILE` procedure. See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about this procedure.

Stopping Jobs

You stop one or more running jobs using the `STOP_JOB` procedure or Enterprise Manager. `STOP_JOB` accepts a comma-delimited list of jobs and job classes. If a job class is supplied, all running jobs in the job class are stopped. For example, the following statement stops job `job1` and all jobs in the job class `dw_jobs`.

```
BEGIN
DBMS_SCHEDULER.STOP_JOB('job1, sys.dw_jobs');
END;
/
```

All instances of the designated jobs are stopped. After stopping a job, the state of a one-time job is set to `STOPPED`, and the state of a repeating job is set to `SCHEDULED` (because the next run of the job is scheduled). In addition, an entry is made in the job log with `OPERATION` set to '`STOPPED`', and `ADDITIONAL_INFO` set to '`REASON="Stop job called by user: *username*"`'.

By default, the Scheduler tries to gracefully stop a job using an interrupt mechanism. This method gives control back to the slave process, which can collect statistics of the job run. If the `force` option is set to `TRUE`, the job is abruptly terminated and certain runtime statistics might not be available for the job run.

If `commit_semantics` is set to `STOP_ON_FIRST_ERROR`, then the call returns on the first error and the previous stop operations that were successful are committed to disk. If `commit_semantics` is set to `ABSORB_ERRORS`, then the call tries to absorb any errors and attempts to stop the rest of the jobs and commits all the stop operations that were successful. By default, `commit_semantics` is set to `STOP_ON_FIRST_ERROR`.

Stopping a job that is running a chain automatically stops all running steps (by calling `STOP_JOB` with the `force` option set to `TRUE` on each step).

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `STOP_JOB` procedure.

Caution: When a job is stopped, only the current transaction is rolled back. This can cause data inconsistency.

Stopping External Jobs

The Scheduler offers implementors of external jobs a mechanism to gracefully clean up after their external jobs when `STOP_JOB` is called with `force` set to `FALSE`. On Unix, this is done by sending a `SIGTERM` signal to the process launched by the Scheduler agent. The implementor of the external job is expected to trap the `SIGTERM` in an interrupt handler, clean up whatever work the job has done, and exit. On Windows, `STOP_JOB` with `force` set to `FALSE` is supported only on Windows XP, Windows 2003, and later operating systems. On those platforms, the process launched by the Scheduler agent is a console process. To stop it, the Scheduler sends a `CTRL-BREAK` to the process. The `CTRL_BREAK` can be handled by registering a handler with the `SetConsoleCtrlHandler()` routine.

Dropping Jobs

You drop one or more jobs using the `DROP_JOB` procedure or Enterprise Manager. `DROP_JOB` accepts a comma-delimited list of jobs and job classes. If a job class is supplied, all jobs in the job class are dropped, although the job class itself is not dropped.

For example, the following statement drops jobs `job1` and `job3`, and all jobs in job classes `jobclass1` and `jobclass2`:

```
BEGIN
DBMS_SCHEDULER.DROP_JOB ('job1, job3, sys.jobclass1, sys.jobclass2');
END;
/
```

Dropping a job results in the job being removed from the job table, its metadata being removed, and it no longer being visible in the `*_SCHEDULER_JOBS` views. Therefore, no more runs of the job will be executed.

If an instance of the job is running at the time of the `DROP_JOB` call, the call results in an error. You can still drop the job by setting the `force` option in the call to `TRUE`. Setting the `force` option to `TRUE` first attempts to stop the running job instance by using an interrupt mechanism (by calling `STOP_JOB` with the `force` option set to `FALSE`), and then drops the job.

Alternatively, you can call `STOP_JOB` to first stop the job and then call `DROP_JOB` to drop it. If you have the `MANAGE SCHEDULER` privilege, you can call `STOP_JOB` with `force`, if the regular `STOP_JOB` call failed to stop the job, and then call `DROP_JOB`.

By default, `force` is set to `FALSE`.

If `commit_semantics` is set to `STOP_ON_FIRST_ERROR`, then the call returns on the first error and the previous drop operations that were successful are committed to disk. If `commit_semantics` is set to `TRANSACTIONAL` and `force` is set to `FALSE`, then the call returns on the first error and the previous drop operations before the error are rolled back. If `commit_semantics` is set to `ABSORB_ERRORS`, then the call tries to absorb any errors and attempts to drop the rest of the jobs and commits all the drops that were successful. By default, `commit_semantics` is set to `STOP_ON_FIRST_ERROR`.

The `DROP_JOB_CLASS` procedure should be used to drop a job class. See "Dropping Job Classes" on page 27-22 for information about how to drop job classes.

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `DROP_JOB` procedure.

Disabling Jobs

You disable one or more jobs using the `DISABLE` procedure or Enterprise Manager. A job can also become disabled for other reasons. For example, a job will be disabled when the job class it belongs to is dropped. A job is also disabled if either the program or the schedule that it points to is dropped. Note that if the program or schedule that the job points to is disabled, the job will not be disabled and will therefore result in an error when the Scheduler tries to run the job.

Disabling a job means that, although the metadata of the job is there, it should not run and the job coordinator will not pick up these jobs for processing. When a job is disabled, its `state` in the job table is changed to `disabled`.

When a job is disabled with the `force` option set to `FALSE` and the job is currently running, an error is returned. When `force` is set to `TRUE`, the job is disabled, but the currently running instance is allowed to finish.

If `commit_semantics` is set to `STOP_ON_FIRST_ERROR`, then the call returns on the first error and the previous disable operations that were successful are committed to disk. If `commit_semantics` is set to `TRANSACTIONAL` and `force` is set to `FALSE`, then the call returns on the first error and the previous disable operations before the error are rolled back. If `commit_semantics` is set to `ABSORB_ERRORS`, then the call tries to absorb any errors and attempts to disable the rest of the jobs and commits all the disable operations that were successful. By default, `commit_semantics` is set to `STOP_ON_FIRST_ERROR`.

You can also disable several jobs in one call by providing a comma-delimited list of job names or job class names to the `DISABLE` procedure call. For example, the following statement combines jobs with job classes:

```
BEGIN
DBMS_SCHEDULER.DISABLE('job1, job2, job3, sys.jobclass1, sys.jobclass2');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `DISABLE` procedure.

Enabling Jobs

You enable one or more jobs by using the `ENABLE` procedure or Enterprise Manager. The effect of using this procedure is that the job will now be picked up by the job coordinator for processing. Jobs are created disabled by default, so you need to enable them before they can run. When a job is enabled, a validity check is performed. If the check fails, the job is not enabled.

If `commit_semantics` is set to `STOP_ON_FIRST_ERROR`, then the call returns on the first error and the previous enable operations that were successful are committed to disk. If `commit_semantics` is set to `TRANSACTIONAL`, then the call returns on the first error and the previous enable operations before the error are rolled back. If `commit_semantics` is set to `ABSORB_ERRORS`, then the call tries to absorb any errors and attempts to enable the rest of the jobs and commits all the enable operations that were successful. By default, `commit_semantics` is set to `STOP_ON_FIRST_ERROR`.

You can enable several jobs in one call by providing a comma-delimited list of job names or job class names to the ENABLE procedure call. For example, the following statement combines jobs with job classes:

```
BEGIN
DBMS_SCHEDULER.ENABLE ('job1, job2, job3,
   sys.jobclass1, sys.jobclass2, sys.jobclass3');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the ENABLE procedure.

Using Programs

A program is a collection of metadata about a particular task. This section introduces you to basic program tasks, and discusses the following topics:

- Program Tasks and Their Procedures
- Creating Programs
- Altering Programs
- Dropping Programs
- Disabling Programs
- Enabling Programs

See Also: "Programs" on page 26-3 for an overview of programs.

Program Tasks and Their Procedures

Table 27–2 illustrates common program tasks and their appropriate procedures and privileges:

Table 27–2 Program Tasks and Their Procedures

Task	Procedure	Privilege Needed
Create a program	CREATE_PROGRAM	CREATE JOB or CREATE ANY JOB
Alter a program	SET_ATTRIBUTE	ALTER or CREATE ANY JOB or be the owner
Drop a program	DROP_PROGRAM	ALTER or CREATE ANY JOB or be the owner
Disable a program	DISABLE	ALTER or CREATE ANY JOB or be the owner
Enable a program	ENABLE	ALTER or CREATE ANY JOB or be the owner

See "Scheduler Privileges" on page 28-30 for further information regarding privileges.

Creating Programs

You create programs by using the CREATE_PROGRAM procedure or Enterprise Manager. By default, programs are created in the schema of the creator. To create a program in another user's schema, you need to qualify the program name with the schema name. For other users to use your programs, they must have EXECUTE privileges on the program, therefore, once a program has been created, you have to grant the EXECUTE privilege on it. An example of creating a program is the following, which creates a program called my_program1:

```
BEGIN
DBMS_SCHEDULER.CREATE_PROGRAM (
   program_name           => 'my_program1',
   program_action         => '/usr/local/bin/date',
   program_type           => 'EXECUTABLE',
   comments               => 'My comments here');
END;
/
```

Defining Program Arguments

After creating a program, you can define a name or default value for each program argument. If no default value is defined for a program argument, the job that references the program must supply an argument value. (The job can also override a default value.) All argument values must be defined before the job can be enabled.

To set program argument values, use the `DEFINE_PROGRAM_ARGUMENT` or `DEFINE_ANYDATA_ARGUMENT` procedures. `DEFINE_ANYDATA_ARGUMENT` is used for complex types that must be encapsulated in an `ANYDATA` object. An example of a program that might need arguments is one that starts a reporting program that requires a start date and end date. The following code example sets the end date argument, which is the second argument expected by the reporting program. The example also assigns a name to the argument so that you can refer to the argument by name (instead of position) from other package procedures, including `SET_JOB_ANYDATA_VALUE` and `SET_JOB_ARGUMENT_VALUE`.

```
BEGIN
DBMS_SCHEDULER.DEFINE_PROGRAM_ARGUMENT (
   program_name            => 'operations_reporting',
   argument_position       => 2,
   argument_name           => 'end_date',
   argument_type           => 'VARCHAR2',
   default_value           => '12-DEC-03');
END;
/
```

You can drop a program argument either by name or by position, as in the following:

```
BEGIN
DBMS_SCHEDULER.DROP_PROGRAM_ARGUMENT (
   program_name            => 'operations_reporting',
   argument_position       => 2);

DBMS_SCHEDULER.DROP_PROGRAM_ARGUMENT (
   program_name            => 'operations_reporting',
   argument_name           => 'end_date');
END;
/
```

In some special cases, program logic is dependent on the Scheduler environment. The Scheduler has some predefined metadata arguments that can be passed as an argument to the program for this purpose. For example, for some jobs whose schedule is a window name, it is useful to know how much longer the window will be open when the job is started. This is possible by defining the window end time as a metadata argument to the program.

If a program needs access to specific job metadata, you can define a special metadata argument using the `DEFINE_METADATA_ARGUMENT` procedure, so values will be filled in by the Scheduler when the program is executed.

See Also: *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `DEFINE_PROGRAM_ARGUMENT`, `DEFINE_ANYDATA_ARGUMENT`, and `DEFINE_METADATA_ARGUMENT` procedures

Altering Programs

You can use Enterprise Manager or the `DBMS_SCHEDULER.SET_ATTRIBUTE` and `DBMS_SCHEDULER.SET_ATTRIBUTE_NULL` package procedures to alter programs. See *Oracle Database PL/SQL Packages and Types Reference* for more information on the `DBMS_SCHEDULER` package procedures.

The following are instructions for altering a program with Enterprise Manager:

1. Access the Database Home page.
2. At the top of the page, click **Server** to display the Server page.
3. In the Oracle Scheduler section, click **Programs**

   The Scheduler Programs page appears. It displays existing programs.
4. Select a program, and then click **Edit**.

   The Edit Program page appears.
5. Next to the Enabled heading, select **Yes** or **No**.
6. In the Description field, change any comments.
7. From the Type drop-down list, select one of the following:

   - **`PLSQL_BLOCK`**

     A Source field appears. Enter or alter the PL/SQL code in this field.
   - **`STORED_PROCEDURE`**

     A Procedure Name field appears. If the field contains a stored procedure name, click **View Procedure** to view or edit the stored procedure. If the field is blank, or if you want to change stored procedures, click **Select Procedure**. A Select Procedure page then appears. Select a stored procedure and then click **Select** to return to the Edit Program page. (Click **Help** at the top of the page for help with using the Select Procedure page.)

     With a procedure name selected, a list of arguments appears under the Arguments heading on the Edit Program page. Optionally enter default values for one or more arguments.
   - **`EXECUTABLE`**

     An Executable Name field appears. Enter the full path of the executable. Under the Arguments heading, edit or delete arguments, or click **Add Another Row** to add an argument.
8. Click **Apply** to save your changes.

If any currently running jobs use the program that you altered, they continue to run with the program as defined before the alter operation.

Dropping Programs

You drop one or more programs using the `DROP_PROGRAM` procedure or Enterprise Manager.

Running jobs that point to the program are not affected by the `DROP_PROGRAM` call, and are allowed to continue. Any arguments that pertain to the program are also dropped when the program is dropped. You can drop several programs in one call by providing a comma-delimited list of program names. For example, the following statement drops three programs:

```
BEGIN
DBMS_SCHEDULER.DROP_PROGRAM('program1, program2, program3');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `DROP_PROGRAM` procedure.

Disabling Programs

You disable one or more programs using the `DISABLE` procedure or Enterprise Manager. When a program is disabled, the status is changed to `disabled`. A disabled program implies that, although the metadata is still there, jobs that point to this program cannot run.

Running jobs that point to the program are not affected by the `DISABLE` call, and are allowed to continue. Any argument that pertains to the program will not be affected when the program is disabled.

A program can also become disabled for other reasons. For example, if a program argument is dropped or `number_of_arguments` is changed so that all arguments are no longer defined.

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `DISABLE` procedure.

Enabling Programs

You enable one or more programs using the `ENABLE` procedure or Enterprise Manager. When a program is enabled, the enabled flag is set to `TRUE`. Programs are created disabled by default, therefore, you have to enable them before you can enable jobs that point to them. Before programs are enabled, validity checks are performed to ensure that the action is valid and that all arguments are defined.

You can enable several programs in one call by providing a comma-delimited list of program names to the `ENABLE` procedure call. For example, the following statement enables three programs:

```
BEGIN
DBMS_SCHEDULER.ENABLE('program1, program2, program3');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `ENABLE` procedure.

Using Schedules

A schedule defines when a job should be run or when a window should open. Schedules can be shared among users by creating and saving them as objects in the database.

This section introduces you to basic schedule tasks, and discusses the following topics:

- Schedule Tasks and Their Procedures
- Creating Schedules
- Altering Schedules
- Dropping Schedules
- Setting the Repeat Interval

See Also: "Schedules" on page 26-4 for an overview of schedules.

Schedule Tasks and Their Procedures

Table 27–3 illustrates common schedule tasks and the procedures you use to handle them.

Table 27–3 Schedule Tasks and Their Procedures

Task	Procedure	Privilege Needed
Create a schedule	CREATE_SCHEDULE	CREATE JOB or CREATE ANY JOB
Alter a schedule	SET_ATTRIBUTE	ALTER or CREATE ANY JOB or be the owner
Drop a schedule	DROP_SCHEDULE	ALTER or CREATE ANY JOB or be the owner

See "Scheduler Privileges" on page 28-30 for further information regarding privileges.

Creating Schedules

You create schedules by using the CREATE_SCHEDULE procedure or Enterprise Manager. Schedules are created in the schema of the user creating the schedule, and are enabled when first created. You can create a schedule in another user's schema. Once a schedule has been created, it can be used by other users. The schedule is created with access to PUBLIC. Therefore, there is no need to explicitly grant access to the schedule. An example of creating a schedule is the following statement:

```
BEGIN
DBMS_SCHEDULER.CREATE_SCHEDULE (
  schedule_name     => 'my_stats_schedule',
  start_date        => SYSTIMESTAMP,
  end_date          => SYSTIMESTAMP + INTERVAL '30' day,
  repeat_interval   => 'FREQ=HOURLY; INTERVAL=4',
  comments          => 'Every 4 hours');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the CREATE_SCHEDULE procedure.

Altering Schedules

You alter a schedule by using the SET_ATTRIBUTE procedure or Enterprise Manager. Altering a schedule changes the definition of the schedule. With the exception of schedule name, all attributes can be changed. The attributes of a schedule are available in the *_SCHEDULER_SCHEDULES views.

If a schedule is altered, the change will not affect running jobs and open windows that use this schedule. The change will only be in effect the next time the jobs runs or the window opens.

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the SET_ATTRIBUTE procedure.

Dropping Schedules

You drop a schedule using the DROP_SCHEDULE procedure or Enterprise Manager. This procedure call will delete the schedule object from the database.

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the DROP_SCHEDULE procedure.

Setting the Repeat Interval

You control when and how often a job repeats by setting the repeat_interval attribute of the job itself or of the named schedule that the job references. You can set repeat_interval with DBMS_SCHEDULER package procedures or with Enterprise Manager.

The result of evaluating the repeat_interval is a set of timestamps. The Scheduler runs the job at each timestamp. Note that the start date from the job or schedule also helps determine the resulting set of timestamps. (See *Oracle Database PL/SQL Packages and Types Reference* for more information about repeat_interval evaluation.) If no value for repeat_interval is specified, the job runs only once at the specified start date.

Immediately after a job is started, the repeat_interval is evaluated to determine the next scheduled execution time of the job. It is possible that the next scheduled execution time arrives while the job is still running. A new instance of the job, however, will not be started until the current one completes.

There are two ways to specify the repeat interval:

- Using the Scheduler Calendaring Syntax
- Using a PL/SQL Expression

Using the Scheduler Calendaring Syntax

The primary method of setting how often a job will repeat is by setting the repeat_interval attribute with a Scheduler calendaring expression. See *Oracle Database PL/SQL Packages and Types Reference* for a detailed description of the calendaring syntax for repeat_interval as well as the CREATE_SCHEDULE procedure.

Examples of Calendaring Expressions

The following examples illustrate simple repeat intervals. For simplicity, it is assumed that there is no contribution to the evaluation results by the start date.

Run every Friday. (All three examples are equivalent.)

```
FREQ=DAILY; BYDAY=FRI;
FREQ=WEEKLY; BYDAY=FRI;
FREQ=YEARLY; BYDAY=FRI;
```

Run every other Friday.

```
FREQ=WEEKLY; INTERVAL=2; BYDAY=FRI;
```

Run on the last day of every month.

```
FREQ=MONTHLY; BYMONTHDAY=-1;
```

Run on the next to last day of every month.

```
FREQ=MONTHLY; BYMONTHDAY=-2;
```

Run on March 10th. (Both examples are equivalent)

```
FREQ=YEARLY; BYMONTH=MAR; BYMONTHDAY=10;
FREQ=YEARLY; BYDATE=0310;
```

Run every 10 days.

```
FREQ=DAILY; INTERVAL=10;
```

Run daily at 4, 5, and 6PM.

```
FREQ=DAILY; BYHOUR=16,17,18;
```

Run on the 15th day of every other month.

```
FREQ=MONTHLY; INTERVAL=2; BYMONTHDAY=15;
```

Run on the 29th day of every month.

```
FREQ=MONTHLY; BYMONTHDAY=29;
```

Run on the second Wednesday of each month.

```
FREQ=MONTHLY; BYDAY=2WED;
```

Run on the last Friday of the year.

```
FREQ=YEARLY; BYDAY=-1FRI;
```

Run every 50 hours.

```
FREQ=HOURLY; INTERVAL=50;
```

Run on the last day of every other month.

```
FREQ=MONTHLY; INTERVAL=2; BYMONTHDAY=-1;
```

Run hourly for the first three days of every month.

```
FREQ=HOURLY; BYMONTHDAY=1,2,3;
```

Here are some more complex repeat intervals:

Run on the last workday of every month (assuming that workdays are Monday through Friday).

```
FREQ=MONTHLY; BYDAY=MON,TUE,WED,THU,FRI; BYSETPOS=-1
```

Run on the last workday of every month, excluding company holidays. (This example references an existing named schedule called `Company_Holidays`.)

```
FREQ=MONTHLY; BYDAY=MON,TUE,WED,THU,FRI; EXCLUDE=Company_Holidays; BYSETPOS=-1
```

Run at noon every Friday and on company holidays.

```
FREQ=YEARLY;BYDAY=FRI;BYHOUR=12;INCLUDE=Company_Holidays
```

Run on these three holidays: July 4th, Memorial Day, and Labor Day. (This example references three existing named schedules—`JUL4`, `MEM`, and `LAB`—where each defines a single date corresponding to a holiday.)

```
JUL4,MEM,LAB
```

Examples of Calendaring Expression Evaluation

A repeat interval of "`FREQ=MINUTELY;INTERVAL=2;BYHOUR=17; BYMINUTE=2,4,5,50,51,7;`" with a start date of 28-FEB-2004 23:00:00 will generate the following schedule:

```
SUN 29-FEB-2004 17:02:00
SUN 29-FEB-2004 17:04:00
SUN 29-FEB-2004 17:50:00
MON 01-MAR-2004 17:02:00
MON 01-MAR-2004 17:04:00
MON 01-MAR-2004 17:50:00
...
```

A repeat interval of "`FREQ=MONTHLY;BYMONTHDAY=15,-1`" with a start date of 29-DEC-2003 9:00:00 will generate the following schedule:

```
WED 31-DEC-2003 09:00:00
THU 15-JAN-2004 09:00:00
SAT 31-JAN-2004 09:00:00
SUN 15-FEB-2004 09:00:00
SUN 29-FEB-2004 09:00:00
MON 15-MAR-2004 09:00:00
WED 31-MAR-2004 09:00:00
...
```

A repeat interval of "`FREQ=MONTHLY;`" with a start date of 29-DEC-2003 9:00:00 will generate the following schedule. (Note that because there is no `BYMONTHDAY` clause, the day of month is retrieved from the start date.)

```
MON 29-DEC-2003 09:00:00
THU 29-JAN-2004 09:00:00
SUN 29-FEB-2004 09:00:00
MON 29-MAR-2004 09:00:00
...
```

Example of Using a Calendaring Expression

As an example of using the calendaring syntax, consider the following statement:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB (
   job_name             => 'scott.my_job1',
   start_date           => '15-JUL-04 01.00.00 AM Europe/Warsaw',
   repeat_interval      => 'FREQ=MINUTELY; INTERVAL=30;',
   end_date             => '15-SEP-04 01.00.00 AM Europe/Warsaw',
   comments             => 'My comments here');
END;
/
```

This creates `my_job1` in `scott`. It will run for the first time on July 15th and then run until September 15. The job is run every 30 minutes.

Using a PL/SQL Expression

When you need more complicated capabilities than the calendaring syntax provides, you can use PL/SQL expressions. You cannot, however, use PL/SQL expressions for windows or in named schedules. The PL/SQL expression must evaluate to a date or a timestamp. Other than this restriction, there are no limitations, so with sufficient programming, you can create every possible repeat interval. As an example, consider the following statement:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB (
   job_name             => 'scott.my_job2',
   start_date           => '15-JUL-04 01.00.00 AM Europe/Warsaw',
   repeat_interval      => 'SYSTIMESTAMP + INTERVAL '30' MINUTE',
   end_date             => '15-SEP-04 01.00.00 AM Europe/Warsaw',
   comments             => 'My comments here');
END;
/
```

This creates `my_job1` in `scott`. It will run for the first time on July 15th and then every 30 minutes until September 15. The job is run every 30 minutes because `repeat_interval` is set to `SYSTIMESTAMP + INTERVAL '30' MINUTE`, which returns a date 30 minutes into the future.

Differences Between PL/SQL Expression and Calendaring Syntax Behavior

The following are important differences in behavior between a calendaring expression and PL/SQL repeat interval:

- Start date

  Using the calendaring syntax, the start date is a reference date only. This means that the schedule is valid as of this date. It does not mean that the job will start on the start date.

  Using a PL/SQL expression, the start date represents the actual time that the job will start executing for the first time.

- Next run time

  Using the calendaring syntax, the next time the job will run is fixed.

  Using the PL/SQL expression, the next time the job will run depends on the actual start time of the current run of the job. As an example of the difference, if a job started at 2:00 PM and its schedule was to repeat every 2 hours, then, if the repeat interval was specified with the calendaring syntax, it would repeat at 4, 6 and so on. If PL/SQL was used and the job started at 2:10, then the job would repeat at 4:10, and if the next job actually started at 4:11, then the subsequent run would be at 6:11.

To illustrate these two points, consider a situation where you have a start date of 15-July-2003 1:45:00 and you want it to repeat every two hours. A calendar expression of "`FREQ=HOURLY; INTERVAL=2; BYMINUTE=0;`" will generate the following schedule:

```
TUE 15-JUL-2003  03:00:00
TUE 15-JUL-2003  05:00:00
TUE 15-JUL-2003  07:00:00
TUE 15-JUL-2003  09:00:00
TUE 15-JUL-2003  11:00:00
...
```

Note that the calendar expression repeats every two hours on the hour.

A PL/SQL expression of "`SYSTIMESTAMP + interval '2' hour`", however, might have a run time of the following:

```
TUE 15-JUL-2003  01:45:00
TUE 15-JUL-2003  03:45:05
TUE 15-JUL-2003  05:45:09
TUE 15-JUL-2003  07:45:14
TUE 15-JUL-2003  09:45:20
...
```

Repeat Intervals and Daylight Savings

For repeating jobs, the next time a job is scheduled to run is stored in a timestamp with time zone column. When using the calendaring syntax, the time zone is retrieved from `start_date`. For more information on what happens when `start_date` is not specified, see *Oracle Database PL/SQL Packages and Types Reference*.

In the case of repeat intervals that are based on PL/SQL expressions, the time zone is part of the timestamp that is returned by the PL/SQL expression. In both cases, it is important to use region names. For example, `"Europe/Istanbul"`, instead of absolute time zone offsets such as `"+2:00"`. Only when a time zone is specified as a region name will the Scheduler follow daylight savings adjustments that apply to that region.

Using Job Classes

Jobs classes provide a way to group jobs for resource allocation and prioritization, and a way to easily assign a set of attribute values to member jobs.

There is a default job class that is created with the database. If you create a job without specifying a job class, the job will be assigned to this default job class (`DEFAULT_JOB_CLASS`). The default job class has the `EXECUTE` privilege granted to `PUBLIC` so any database user who has the privilege to create a job can create a job in the default job class.

This section introduces you to basic job class tasks, and discusses the following topics:

- Job Class Tasks and Their Procedures
- Creating Job Classes
- Altering Job Classes
- Dropping Job Classes

See Also: "Job Classes" on page 26-8 for an overview of job classes.

Job Class Tasks and Their Procedures

Table 27–4 illustrates common job class tasks and their appropriate procedures and privileges:

Table 27–4 Job Class Tasks and Their Procedures

Task	Procedure	Privilege Needed
Create a job class	`CREATE_JOB_CLASS`	`MANAGE SCHEDULER`
Alter a job class	`SET_ATTRIBUTE`	`MANAGE SCHEDULER`
Drop a job class	`DROP_JOB_CLASS`	`MANAGE SCHEDULER`

See "Scheduler Privileges" on page 28-30 for further information regarding privileges.

Creating Job Classes

You create a job class using the `CREATE_JOB_CLASS` procedure or Enterprise Manager. For example, the following statement creates a job class for all finance jobs:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB_CLASS (
   job_class_name             =>  'finance_jobs',
   resource_consumer_group    =>  'finance_group');
END;
/
```

To query job classes, use the `*_SCHEDULER_JOB_CLASSES` views.

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `SET_ATTRIBUTE` procedure and "Configuring the Scheduler" on page 28-1 for examples of creating job classes.

Altering Job Classes

You alter a job class by using the `SET_ATTRIBUTE` procedure or Enterprise Manager. Other than the job class name, all the attributes of a job class can be altered. The attributes of a job class are available in the `*_SCHEDULER_JOB_CLASSES` views.

When a job class is altered, running jobs that belong to the class are not affected. The change only takes effect for jobs that have not started running yet.

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `SET_ATTRIBUTE` procedure and "Configuring the Scheduler" on page 28-1.

Dropping Job Classes

You drop one or more job classes using the `DROP_JOB_CLASS` procedure or Enterprise Manager. Dropping a job class means that all the metadata about the job class is removed from the database.

You can drop several job classes in one call by providing a comma-delimited list of job class names to the `DROP_JOB_CLASS` procedure call. For example, the following statement drops three job classes:

```
BEGIN
DBMS_SCHEDULER.DROP_JOB_CLASS('jobclass1, jobclass2, jobclass3');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `DROP_JOB_CLASS` procedure.

Using Windows

Windows provide a way to automatically activate different resource plans at different times. Running jobs can then see a change in the resources that are allocated to them when there is a change in resource plan.

The key attributes of a window are its:

- Schedule

  This controls when the window is in effect.

- Duration

This controls how long the window is open.

- Resource plan

  This names the resource plan that activates when the window opens.

Only one window can be in effect at any given time. Windows belong to the SYS schema.

All window activity is logged in the *_SCHEDULER_WINDOW_LOG views, otherwise known as the **window logs**. See "Window Logs" on page 28-10 for examples of window logging.

This section introduces you to basic window tasks, and discusses the following topics:

- Window Tasks and Their Procedures
- Creating Windows
- Dropping Windows
- Opening Windows
- Closing Windows
- Dropping Windows
- Disabling Windows
- Enabling Windows
- Overlapping Windows

See Also: "Windows" on page 26-9 for an overview of windows.

Window Tasks and Their Procedures

Table 27–5 illustrates common window tasks and the procedures you use to handle them.

Table 27–5 Window Tasks and Their Procedures

Task	Procedure	Privilege Needed
Create a window	CREATE_WINDOW	MANAGE SCHEDULER
Open a window	OPEN_WINDOW	MANAGE SCHEDULER
Close a window	CLOSE_WINDOW	MANAGE SCHEDULER
Alter a window	SET_ATTRIBUTE	MANAGE SCHEDULER
Drop a window	DROP_WINDOW	MANAGE SCHEDULER
Disable a window	DISABLE	MANAGE SCHEDULER
Enable a window	ENABLE	MANAGE SCHEDULER

See "Scheduler Privileges" on page 28-30 for further information regarding privileges.

Creating Windows

You can use Enterprise Manager or the DBMS_SCHEDULER.CREATE_WINDOW package procedure to create windows. There is one difference between these methods, other than the fact that one uses PL/SQL, and the other a graphical user interface. When using the package procedure, you can leave the resource_plan parameter NULL. In this case, when the window opens, the current plan remains in effect. See *Oracle*

Database PL/SQL Packages and Types Reference and "Configuring the Scheduler" on page 28-1 for more information.

The following are instructions for creating a window with Enterprise Manager:

1. Access the Database Home page.
2. At the top of the page, click **Server** to display the Server page.
3. In the Oracle Scheduler section, click **Windows**.

   The Scheduler Windows page appears. It displays existing windows.
4. Click **Create**.

   The Create Window page appears.
5. Enter a name for the window.
6. Choose a resource plan from the Resource Plan drop-down list, or create a resource plan.

   You can use the default, `INTERNAL_PLAN`. To view the contents of an existing resource plan, click **View Resource Plan**. If you choose to create a new resource plan, click **Create Resource Plan** and follow those steps.
7. Select a priority, **Low** or **High**.
8. Enter optional comments in the **Description** field.
9. Under the Schedule heading, do one of the following:
   - To create a schedule, select **Use a calendar**.
   - To use an existing schedule, select **Use an existing schedule**. A schedule with its information is displayed. If you want a different schedule, click **Select Schedule**, in which case the Select Schedule page is displayed. Select one of the schedules listed under the Results heading, or enter the schema and a text string for the schedule name, and then click **Go**. The schedule with the search string in its name is returned. Select the desired schedule and click **Select**.

     Note: The Scheduler does not check if there is already a window defined for that schedule. Therefore, this may result in windows that overlap. Also, using a named schedule that has a PL/SQL expression as its repeat interval is not supported for windows.

     Click **OK**, and skip the remaining steps in this procedure.
10. If you want to change the time zone, click the flashlight icon next to the Time Zone field and follow the steps.
11. Under the Repeating drop-down list, choose how often you want the window to repeat. If you choose a value other than **Do Not Repeat**, the page changes so that you can enter the interval and enter a starting time.
12. Under the **Start** heading, select whether you want the schedule to start **Immediately** or **Later**. If you choose **Later**, enter a date.
13. Under the **Duration** heading, enter how long the window is to remain open.
14. Click **OK** to save the window.

Altering Windows

You alter a window using the SET_ATTRIBUTE procedure or Enterprise Manager. With the exception of WINDOW_NAME, all the attributes of a window can be changed when it is altered. The attributes of a window are available in the *_SCHEDULER_WINDOWS views.

When a window is altered, it does not affect an active window. The changes only take effect the next time the window opens.

All windows can be altered. If you alter a window that is disabled, it will remain disabled after it is altered. An enabled window will be automatically disabled, altered, and then reenabled, if the validity checks performed during the enable process are successful.

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the SET_ATTRIBUTE procedure and "Configuring the Scheduler" on page 28-1.

Opening Windows

When a window opens, the Scheduler switches to the resource plan that has been associated with it during its creation. If there are jobs running when the window opens, the resources allocated to them might change due to the switch in resource plan.

There are two ways a window can open:

- According to the window's schedule
- Manually, using the OPEN_WINDOW procedure

  This procedure opens the window independent of its schedule. This window will open and the resource plan associated with it will take effect immediately. Only an enabled window can be manually opened.

  In the OPEN_WINDOW procedure, you can specify the time interval that the window should be open for, using the duration attribute. The duration is of type interval day to second. If the duration is not specified, then the window will be opened for the regular duration as stored with the window.

  Opening a window manually has no impact on regular scheduled runs of the window.

  When a window that was manually opened closes, the rules about overlapping windows are applied to determine which other window should be opened at that time if any at all.

  You can force a window to open even if there is one already open by setting the force option to TRUE in the OPEN_WINDOW call or Enterprise Manager.

  When the force option is set to TRUE, the Scheduler automatically closes any window that is open at that time, even if it has a higher priority. For the duration of this manually opened window, the Scheduler does not open any other scheduled windows even if they have a higher priority. You can open a window that is already open. In this case, the window stays open for the duration specified in the call, from the time the OPEN_WINDOW command was issued.

  Consider an example to illustrate this. window1 was created with a duration of four hours. It has how been open for two hours. If at this point you reopen window1 using the OPEN_WINDOW call and do not specify a duration, then window1 will be open for another four hours because it was created with that duration. If you specified a duration of 30 minutes, the window will close in 30 minutes.

When a window opens, an entry is made in the window log.

A window can fail to switch resource plans if the current resource plan has been manually switched using the ALTER SYSTEM statement with the FORCE option, or using the DBMS_RESOURCE_MANAGER.SWITCH_PLAN package procedure with the allow_scheduler_plan_switches argument set to FALSE. In this case, the failure to switch resource plans is written to the window log.

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the OPEN_WINDOW procedure and the DBMS_RESOURCE_MANAGER.SWITCH_PLAN procedure.

Closing Windows

There are two ways a window can close:

- Based on a schedule

  A window will close based on the schedule defined at creation time.

- Manually, using the CLOSE_WINDOW procedure

  The CLOSE_WINDOW procedure will close an open window prematurely.

A closed window means that it is no longer in effect. When a window is closed, the Scheduler will switch the resource plan to the one that was in effect outside the window or in the case of overlapping windows to another window. If you try to close a window that does not exist or is not open, an error is generated.

A job that is running will not close when the window it is running in closes unless the attribute stop_on_window_close was set to TRUE when the job was created. However, the resources allocated to the job may change because the resource plan may change.

When a running job has a window group as its schedule, the job will not be stopped when its window is closed if another window that is also a member of the same window group then becomes active. This is the case even if the job was created with the attribute stop_on_window_close set to TRUE.

When a window is closed, an entry will be added to the window log DBA_SCHEDULER_WINDOW_LOG.

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the CLOSE_WINDOW procedure.

Dropping Windows

You drop one or more windows using the DROP_WINDOW procedure or Enterprise Manager. When a window is dropped, all metadata about the window is removed from the *_SCHEDULER_WINDOWS views. All references to the window are removed from window groups.

You can drop several windows in one call by providing a comma-delimited list of window names or window group names to the DROP_WINDOW procedure. For example, the following statement drops both windows and window groups:

```
BEGIN
DBMS_SCHEDULER.DROP_WINDOW ('window1, window2,
  window3, windowgroup1, windowgroup2');
END;
```

```
/
```

Note that if a window group name is provided, then the windows in the window group are dropped, but the window group is not dropped. To drop the window group, you must use the `DROP_WINDOW_GROUP` procedure.

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `DROP_WINDOW` procedure.

Disabling Windows

You disable one or more windows using the `DISABLE` procedure or with Enterprise Manager. This means that the window will not open, however, the metadata of the window is still there, so it can be reenabled. Because the `DISABLE` procedure is used for several Scheduler objects, when disabling windows, they must be preceded by `SYS`.

A window can also become disabled for other reasons. For example, a window will become disabled when it is at the end of its schedule. Also, if a window points to a schedule that no longer exists, it becomes disabled.

If there are jobs that have the window as their schedule, you will not be able to disable the window unless you set `force` to `TRUE` in the procedure call. By default, `force` is set to `FALSE`. When the window is disabled, those jobs that have the window as their schedule will not be disabled.

You can disable several windows in one call by providing a comma-delimited list of window names or window group names to the `DISABLE` procedure call. For example, the following statement disables both windows and window groups:

```
BEGIN
DBMS_SCHEDULER.DISABLE ('sys.window1, sys.window2,
   sys.window3, sys.windowgroup1, sys.windowgroup2');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `DISABLE` procedure and Admin for a list of why windows may be disabled.

Enabling Windows

You enable one or more windows using the `ENABLE` procedure or Enterprise Manager. An enabled window is one that can be opened. Windows are, by default, created `enabled`. When a window is enabled using the `ENABLE` procedure, a validity check is performed and only if this is successful will the window be enabled. When a window is enabled, it is logged in the window log table. Because the `ENABLE` procedure is used for several Scheduler objects, when enabling windows, they must be preceded by `SYS`.

You can enable several windows in one call by providing a comma-delimited list of window names. For example, the following statement enables three windows:

```
BEGIN
DBMS_SCHEDULER.ENABLE ('sys.window1, sys.window2, sys.window3');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `ENABLE` procedure.

Overlapping Windows

Although Oracle does not recommend it, windows can overlap. Because only one window can be active at one time, the following rules are used to determine which window will be active when windows overlap:

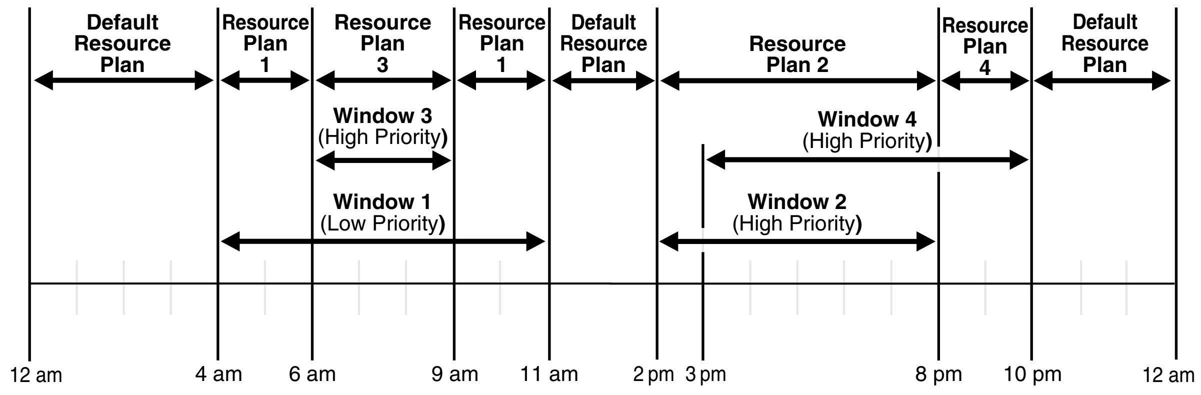
- If windows of the same priority overlap, the window that is active will stay open. However, if the overlap is with a window of higher priority, the lower priority window will close and the window with the higher priority will open. Jobs currently running that had a schedule naming the low priority window may be stopped depending on the behavior you assigned when you created the job.
- If at the end of a window there are multiple windows defined, the window with the highest priority will open. If all windows have the same priority, the window that has the highest percentage of time remaining will open.
- An open window that is dropped will be automatically closed. At that point, the previous rule applies.

Whenever two windows overlap, an entry is written in the Scheduler log.

Examples of Overlapping Windows

Figure 27–1 illustrates a typical example of how windows, resource plans, and priorities might be determined for a 24 hour schedule. In the following two examples, assume that Window1 has been associated with Resource Plan1, Window2 with Resource Plan2, and so on.

Figure 27–1 Windows and Resource Plans (Example 1)



In Figure 27–1, the following occurs:

- From 12AM to 4AM

  No windows are open, so a default resource plan is in effect.
- From 4AM to 6AM

  Window1 has been assigned a low priority, but it opens because there are no high priority windows. Therefore, Resource Plan 1 is in effect.
- From 6AM to 9AM

  Window3 will open because it has a higher priority than Window1, so Resource Plan 3 is in effect.
- From 9AM to 11AM

Even though Window1 was closed at 6AM because of a higher priority window opening, at 9AM, this higher priority window is closed and Window1 still has two hours remaining on its original schedule. It will be reopened for these remaining two hours and resource plan will be in effect.

- From 11AM to 2PM

  A default resource plan is in effect because no windows are open.

- From 2PM to 3PM

  Window2 will open so Resource Plan 2 is in effect.

- From 3PM to 8PM

  Window4 is of the same priority as Window2, so it will not interrupt Window2. Therefore, Resource Plan 2 is in effect.

- From 8PM to 10PM

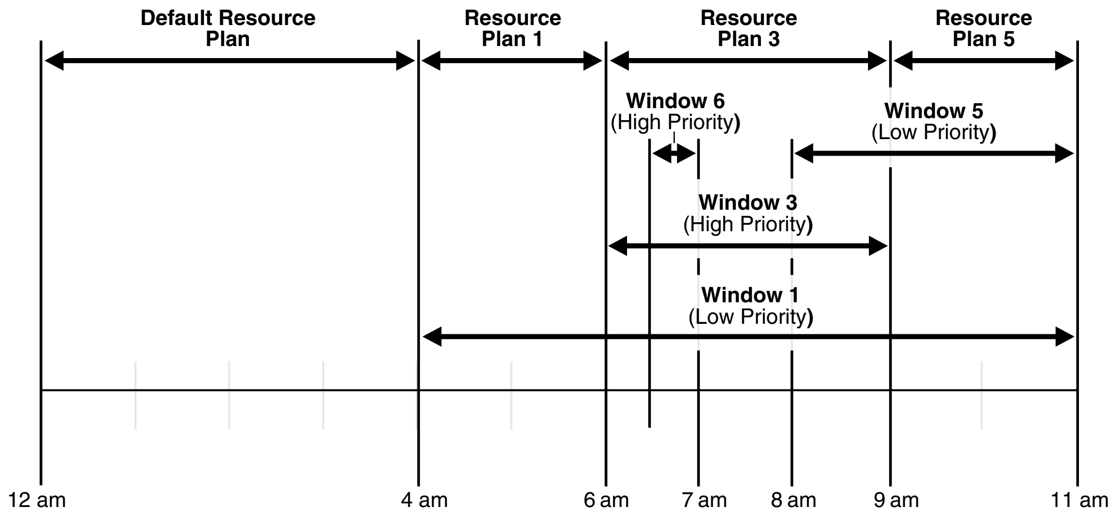
  Window4 will open so Resource Plan 4 is in effect.

- From 10PM to 12AM

  A default resource plan is in effect because no windows are open.

Figure 27–2 illustrates another example of how windows, resource plans, and priorities might be determined for a 24 hour schedule.

Figure 27–2 Windows and Resource Plans (Example 2)



In Figure 27–2, the following occurs:

- From 12AM to 4AM

  A default resource plan is in effect.

- From 4AM to 6AM

  Window1 has been assigned a low priority, but it opens because there are no high priority windows, so Resource Plan 1 is in effect.

- From 6AM to 9AM

  Window3 will open because it has a higher priority than Window1. Note that Window6 does not open because another high priority window is already in effect.

- From 9AM to 11AM

  At 9AM, Window5 or Window1 are the two possibilities. They both have low priorities, so the choice is made based on which has a greater percentage of its duration remaining. Window5 has a larger percentage of time remaining compared to the total duration than Window1. Even if Window1 were to extend to, say, 11:30AM, Window5 would have 2/3 * 100% of its duration remaining, while Window1 would have only 2.5/7 * 100%, which is smaller. Thus, Resource Plan 5 will be in effect.

Using Window Groups

Window groups provide an easy way to schedule jobs that must run during multiple time periods throughout the day, week, and so on. If you create a window group, add windows to it, and then name this window group in a job's `schedule_name` attribute, the job runs during all the windows in the window group.

Window groups reside in the `SYS` schema. This section introduces you to basic window group tasks, and discusses the following topics:

- Window Group Tasks and Their Procedures
- Creating Window Groups
- Dropping Window Groups
- Adding a Member to a Window Group
- Dropping a Member from a Window Group
- Enabling a Window Group
- Disabling a Window Group

See Also: "Window Groups" on page 26-10 for an overview of window groups.

Window Group Tasks and Their Procedures

Table 27–6 illustrates common window group tasks and the procedures you use to handle them.

Table 27–6 Window Group Tasks and Their Procedures

Task	Procedure	Privilege Needed
Create a window group	`CREATE_WINDOW_GROUP`	`MANAGE SCHEDULER`
Drop a window group	`DROP_WINDOW_GROUP`	`MANAGE SCHEDULER`
Add a member to a window group	`ADD_WINDOW_GROUP_MEMBER`	`MANAGE SCHEDULER`
Drop a member to a window group	`REMOVE_WINDOW_GROUP_MEMBER`	`MANAGE SCHEDULER`
Enable a window group	`ENABLE`	`MANAGE SCHEDULER`
Disable a window group	`DISABLE`	`MANAGE SCHEDULER`

See "Scheduler Privileges" on page 28-30 for further information regarding privileges.

Creating Window Groups

You create a window group by using the `CREATE_WINDOW_GROUP` procedure or Enterprise Manager. You can specify the member windows of the group when you create the group, or you can add them later using the `ADD_WINDOW_GROUP_MEMBER` procedure. A window group cannot be a member of another window group. You can, however, create a window group that has no members.

If you create a window group and you specify a member window that does not exist, an error is generated and the window group is not created. If a window is already a member of a window group, it is not added again.

Window groups are created in the `SYS` schema. Window groups, like windows, are created with access to `PUBLIC`, therefore, no privileges are required to access window groups.

The following statement creates a window group called `downtime` and adds two windows (`weeknights` and `weekends`) to it:

```
BEGIN
DBMS_SCHEDULER.CREATE_WINDOW_GROUP (
   group_name   =>  'downtime',
   window_list  =>  'weeknights, weekends');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `CREATE_WINDOW_GROUP` procedure.

Dropping Window Groups

You drop one or more window groups by using the `DROP_WINDOW_GROUP` procedure or Enterprise Manager. This call will drop the window group but not the windows that are members of this window group. If you want to drop all the windows that are members of this group but not the window group itself, you can use the `DROP_WINDOW` procedure and provide the name of the window group to the call.

You can drop several window groups in one call by providing a comma-delimited list of window group names to the `DROP_WINDOW_GROUP` procedure call. For example, the following statement drops three window groups:

```
BEGIN
DBMS_SCHEDULER.DROP_WINDOW_GROUP('windowgroup1, windowgroup2, windowgroup3');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about adding and dropping window groups.

Adding a Member to a Window Group

You add windows to a window group by using the `ADD_WINDOW_GROUP_MEMBER` procedure.

You can add several members to a window group in one call, by specifying a comma-delimited list of windows. For example, the following statement adds three windows to the window group `window_group1`:

```
BEGIN
DBMS_SCHEDULER.ADD_WINDOW_GROUP_MEMBER ('window_group1',
   'window1, window2, window3');
END;
/
```

If an already open window is added to a window group, the Scheduler will not start jobs that point to this window group until the next window in the window group opens.

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `ADD_WINDOW_GROUP_MEMBER` procedure.

Dropping a Member from a Window Group

You can drop one or more windows from a window group by using the `REMOVE_WINDOW_GROUP_MEMBER` procedure or Enterprise Manager. Jobs with the `stop_on_window_close` flag set will only be stopped when a window closes. Dropping an open window from a window group has no impact on this.

You can remove several members from a window group in one call by specifying a comma-delimited list of windows. For example, the following statement drops three windows:

```
BEGIN
DBMS_SCHEDULER.REMOVE_WINDOW_GROUP_MEMBER('window_group1', 'window1, window2,
   window3');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `REMOVE_WINDOW_GROUP_MEMBER` procedure.

Enabling a Window Group

You enable one or more window groups using the `ENABLE` procedure or Enterprise Manager. By default, window groups are created `ENABLED`. For example:

```
BEGIN
DBMS_SCHEDULER.ENABLE('sys.windowgroup1', 'sys.windowgroup2, sys.windowgroup3');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `ENABLE` procedure.

Disabling a Window Group

You disable a window group using the `DISABLE` procedure or Enterprise Manager. This means that jobs with the window group as a schedule will not run even if the member windows open, however, the metadata of the window group is still there, so it can be reenabled. Note that the members of the window group will still open.

You can also disable several window groups in one call by providing a comma-delimited list of window group names to the `DISABLE` procedure call. For example, the following statement disables three window groups:

```
BEGIN
DBMS_SCHEDULER.DISABLE('sys.windowgroup1, sys.windowgroup2, sys.windowgroup3');
END;
/
```

Note that, in this example, the window group will be disabled, but the windows that are members of the window group will not be disabled.

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `DISABLE` procedure.

Using Events

The Scheduler works with two kinds of events:

- Events that the Scheduler raises to notify applications of a change in job state (for example, job complete)
- Events that applications raise to notify the Scheduler to start a job

This section provides details on how to work with both kinds of events, and includes the following topics:

- Using Events Raised by the Scheduler
- Using Events Raised by an Application

See Also:

- "Events" on page 26-6 for an overview of Scheduler events
- "Examples of Creating Jobs and Schedules Based on Events" on page 28-28
- "Using Chains" on page 27-40 for information on how to use events with chains to achieve precise control over process flow

Using Events Raised by the Scheduler

You can set up a job so that the Scheduler raises an event when the job changes state. You do so by setting the `raise_events` job attribute. Because you cannot set this attribute with the `CREATE_JOB` procedure, you must first create the job and then alter the job with the `SET_ATTRIBUTE` procedure.

By default, until you alter a job with `SET_ATTRIBUTE`, a job does not raise any state change events.

Table 27–7 summarizes the one administration task involving events raised by the Scheduler.

Table 27–7 Event Tasks and Their Procedures for Events Raised by the Scheduler

Task	Procedure	Privilege Needed
Altering a Job to Raise Events	`SET_ATTRIBUTE`	`CREATE ANY JOB` or ownership of job being altered or `ALTER` privileges on the job

After you enable job state change events for a job, the Scheduler raises these events by enqueuing messages onto the Scheduler event queue `SYS.SCHEDULER$_EVENT_QUEUE`. This queue is a secure queue, so depending on your application, you may have to configure the queue to enable certain users to perform operations on it. See *Oracle Streams Concepts and Administration* for information on secure queues.

To prevent unlimited growth of the Scheduler event queue, events raised by the Scheduler expire in 24 hours by default. (Expired events are deleted from the queue.) You can change this expiry time by setting the `event_expiry_time` Scheduler attribute with the `SET_SCHEDULER_ATTRIBUTE` procedure. See *Oracle Database PL/SQL Packages and Types Reference* for more information.

Altering a Job to Raise Events

To enable job state change events for a job, you use the SET_ATTRIBUTE procedure to turn on bit flags in the raise_events job attribute. Each bit flag represents a different job state to raise an event for. For example, turning on the least significant bit enables "job started" events to be raised. To enable multiple state change event types in one call, you add the desired bit flag values together and supply the result as an argument to SET_ATTRIBUTE. For a list of bit flags, see the discussion of DBMS_SCHEDULER.SET_ATTRIBUTE in *Oracle Database PL/SQL Packages and Types Reference*.

The following example enables multiple state change events for job dw_reports. It enables the following event types, both of which indicate some kind of error. (Event types are defined as constants in the package.)

- job_failed (bit flag value = 4)
- job_sch_lim_reached (bit flag value = 64)

```
BEGIN
DBMS_SCHEDULER.SET_ATTRIBUTE('dw_reports', 'raise_events',
   DBMS_SCHEDULER.JOB_FAILED + DBMS_SCHEDULER.JOB_SCH_LIM_REACHED);
END;
/
```

Consuming Scheduler-Raised Events with your Application

To consume Scheduler events, your application must subscribe to the Scheduler event queue SYS.SCHEDULER$_EVENT_QUEUE. This queue is a secure queue and is owned by SYS. To create a subscription to this queue for a user, do the following:

1. Log in to the database as the SYS user or as a user with the MANAGE ANY QUEUE privilege.
2. Subscribe to the queue using a new or existing agent.
3. Run the package procedure DBMS_AQADM.ENABLE_DB_ACCESS as follows:

   ```
   DBMS_AQADM.ENABLE_DB_ACCESS(agent_name, db_username);
   ```

   where *agent_name* references the agent that you used to subscribe to the events queue, and *db_username* is the user for whom you want to create a subscription.

There is no need to grant dequeue privileges to the user. The dequeue privilege is granted on the Scheduler event queue to PUBLIC.

As an alternative, the user can subscribe to the Scheduler event queue using the ADD_EVENT_QUEUE_SUBSCRIBER procedure, as shown in the following example:

```
DBMS_SCHEDULER.ADD_EVENT_QUEUE_SUBSCRIBER(subscriber_name);
```

where *subscriber_name* is the name of the Oracle Streams Advanced Queuing (AQ) agent to be used to subscribe to the Scheduler event queue. (If it is NULL, an agent is created whose name is the user name of the calling user.) This call both creates a subscription to the Scheduler event queue and grants the user permission to dequeue using the designated agent. The subscription is rule-based. The rule permits the user to see only events raised by jobs that the user owns, and filters out all other messages. After the subscription is in place, the user can either poll for messages at regular intervals or register with AQ for notification.

See *Oracle Streams Advanced Queuing User's Guide* for more information.

Scheduler Event Queue

The Scheduler event queue `SYS.SCHEDULER$_EVENT_QUEUE` is of type `scheduler$_event_info`. The following are details on this type.

```
create or replace type sys.scheduler$_event_info as object
(
  event_type         VARCHAR2(4000),
  object_owner       VARCHAR2(4000),
  object_name        VARCHAR2(4000),
  event_timestamp    TIMESTAMP WITH TIME ZONE,
  error_code         NUMBER,
  error_msg          VARCHAR2(4000),
  event_status       NUMBER,
  log_id             NUMBER,
  run_count          NUMBER,
  failure_count      NUMBER,
  retry_count        NUMBER,
  spare1             NUMBER,
  spare2             NUMBER,
  spare3             VARCHAR2(4000),
  spare4             VARCHAR2(4000),
  spare5             TIMESTAMP WITH TIME ZONE,
  spare6             TIMESTAMP WITH TIME ZONE,
  spare7             RAW(2000),
  spare8             RAW(2000),
);
```

Attribute	Description
`event_type`	One of "`JOB_STARTED`", "`JOB_SUCCEEDED`", "`JOB_FAILED`", "`JOB_BROKEN`", "`JOB_COMPLETED`", "`JOB_STOPPED`", "`JOB_SCH_LIM_REACHED`", "`JOB_DISABLED`", "`JOB_CHAIN_STALLED`", "`JOB_OVER_MAX_DUR`". For descriptions of these event types, see the `SET_ATTRIBUTE` procedure in *Oracle Database PL/SQL Packages and Types Reference*.
`object_owner`	Owner of the job that raised the event.
`object_name`	Name of the job that raised the event.
`event_timestamp`	Time at which the event occurred.
`error_code`	Applicable only when an error is thrown during job execution. Contains the top-level error code.
`error_msg`	Applicable only when an error is thrown during job execution. Contains the entire error stack.
`event_status`	Adds further qualification to the event type. If `event_type` is "`JOB_STARTED`," a status of 1 indicates that it is a normal start, and a status of 2 indicates that it is a retry. If `event_type` is "`JOB_FAILED`," a status of 4 indicates that it was a failure due to an error that was thrown during job execution, and a status of 8 indicates that it was an abnormal termination of some kind. If `event_type` is "`JOB_STOPPED`," a status of 16 indicates that it was a normal stop, and a status of 32 indicates that it was a stop with the `FORCE` option set to `TRUE`.
`log_id`	Points to the ID in the scheduler job log from which additional information can be obtained. Note that there need not always be a log entry corresponding to an event. In such cases, `log_id` is `NULL`.
`run_count`	Run count for the job when the event was raised.

Attribute	Description
failure_count	Failure count for the job when the event was raised.
retry_count	Retry count for the job when the event was raised.
spare1 – spare8	Currently not implemented

Using Events Raised by an Application

Your application can raise an event to notify the Scheduler to start a job. A job started in this way is referred to as an event-based job. The job can optionally retrieve the message content of the event.

To create an event-based job, you must set these two additional attributes:

- `queue_spec`

  A queue specification that includes the name of the queue where your application enqueues messages to raise job start events, or in the case of a secure queue, the queue name followed by a comma and the agent name.

- `event_condition`

  A conditional expression based on message properties that must evaluate to TRUE for the message to start the job. The expression must have the syntax of an Oracle Streams Advanced Queuing rule. Accordingly, you can include user data properties in the expression, provided that the message payload is an object type, and that you prefix object attributes in the expression with `tab.user_data`.

  For more information on rules, see the `DBMS_AQADM.ADD_SUBSCRIBER` procedure in *Oracle Database PL/SQL Packages and Types Reference*.

  The following example sets `event_condition` to select only card-swipe events that occur after midnight and before 9:00 a.m. Assume that the message payload is an object with two attributes called `event_type` and `event_timestamp`.

  ```
  event_condition = 'tab.user_data.event_type = ''CARD_SWIPE'' and
  extract hour from tab.user_data.event_timestamp < 9'
  ```

You can specify `queue_spec` and `event_condition` as inline job attributes, or you can create an **event schedule** with these attributes and point to this schedule from the job.

Note: The Scheduler runs the event-based job for each occurrence of an event that matches `event_condition`. However, events that occur while the job is already running are ignored; the event gets consumed, but does not trigger another run of the job.

Table 27–8 describes common administration tasks involving events raised by an application (and consumed by the Scheduler) and the procedures associated with them.

Table 27–8 Event Tasks and Their Procedures for Events Raised by an Application

Task	Procedure	Privilege Needed
Creating an Event-Based Job	CREATE_JOB	CREATE JOB or CREATE ANY JOB
Altering an Event-Based Job	SET_ATTRIBUTE	CREATE ANY JOB or ownership of the job being altered or ALTER privileges on the job
Creating an Event Schedule	CREATE_EVENT_SCHEDULE	CREATE JOB or CREATE ANY JOB
Altering an Event Schedule	SET_ATTRIBUTE	CREATE ANY JOB or ownership of the schedule being altered or ALTER privileges on the schedule

See Also: *Oracle Streams Advanced Queuing User's Guide* for information on how to create queues and enqueue messages.

Creating an Event-Based Job

You use the CREATE_JOB procedure or Enterprise Manager to create an event-based job. The job can include event information inline as job attributes or can specify event information by pointing to an event schedule.

Like jobs based on time schedules, event-based jobs are not auto-dropped unless the job end date passes, max_runs is reached, or the maximum number of failures (max_failures) is reached.

Specifying Event Information as Job Attributes To specify event information as job attributes, you use an alternate syntax of CREATE_JOB that includes the queue_spec and event_condition attributes.

The following example creates a job that starts whenever someone swipes a badge to enter a data center:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB (
   job_name            =>  'my_job',
   program_name        =>  'my_program',
   event_condition     =>  'tab.user_data.event_type = ''CARD_SWIPE''',
   queue_spec          =>  'entry_events_q, entry_agent1',
   enabled             =>  TRUE,
   comments            =>  'Start job when someone swipes a badge');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for more information regarding the CREATE_JOB procedure.

Specifying Event Information in an Event Schedule To specify event information with an event schedule, you set the job's schedule_name attribute to the name of an event schedule, as shown in the following example:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB (
   job_name            =>  'my_job',
   program_name        =>  'my_program',
   schedule_name       =>  'entry_events_schedule',
   enabled             =>  TRUE,
   comments            =>  'Start job when someone swipes a badge');
END;
```

```
/
```

See "Creating an Event Schedule" on page 27-38 for more information.

Altering an Event-Based Job

You alter an event-based job by using the `SET_ATTRIBUTE` procedure. For jobs that specify the event inline, you cannot set the `queue_spec` and `event_condition` attributes individually with `SET_ATTRIBUTE`. Instead, you must set an attribute called `event_spec`, and pass an event condition and queue specification as the third and fourth arguments, respectively, to `SET_ATTRIBUTE`.

The following is an example of using the `event_spec` attribute:

```
BEGIN
DBMS_SCHEDULER.SET_ATTRIBUTE ('my_job', 'event_spec',
   'tab.user_data.event_type = ''BAD_BADGE''', 'entry_events_q, entry_agent1');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for more information regarding the `SET_ATTRIBUTE` procedure.

Creating an Event Schedule

You can create a schedule that is based on an event. You can then reuse the schedule for multiple jobs. To do so, use the `CREATE_EVENT_SCHEDULE` procedure, or use Enterprise Manager. The following is an example of creating an event schedule:

```
BEGIN
DBMS_SCHEDULER.CREATE_EVENT_SCHEDULE (
   schedule_name     =>  'entry_events_schedule',
   start_date        =>  SYSTIMESTAMP,
   event_condition   =>  'tab.user_data.event_type = ''CARD_SWIPE''',
   queue_spec        =>  'entry_events_q, entry_agent1');
END;
/
```

You can drop an event schedule using the `DROP_SCHEDULE` procedure. See *Oracle Database PL/SQL Packages and Types Reference* for more information on `CREATE_EVENT_SCHEDULE`.

Altering an Event Schedule

You alter the event information in an event schedule in the same way that you alter event information in a job. For more information, see "Altering an Event-Based Job" on page 27-38.

The following example demonstrates how to use the `SET_ATTRIBUTE` procedure and the `event_spec` attribute to alter event information in an event schedule.

```
BEGIN
DBMS_SCHEDULER.SET_ATTRIBUTE ('entry_events_schedule', 'event_spec',
   'tab.user_data.event_type = ''BAD_BADGE''', 'entry_events_q, entry_agent1');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for more information regarding the `SET_ATTRIBUTE` procedure.

Passing Event Messages into an Event-Based Job

Through a metadata argument, the Scheduler can pass to an event-based job the message content of the event that started the job. The following rules apply:

- The job must use a named program of type `STORED_PROCEDURE`.
- One of the named program's arguments must be a metadata argument with `metadata_attribute` set to `EVENT_MESSAGE`.
- The stored procedure that implements the program must have an argument at the position corresponding to the named program's metadata argument. The argument type must be the data type of the queue where your application queues the job-start event.

If you use the `RUN_JOB` procedure to manually run a job that has an `EVENT_MESSAGE` metadata argument, the value passed to that argument is `NULL`.

The following example shows how to construct an event-based job that can receive the event message content:

```
create or replace procedure my_stored_proc (event_msg IN event_queue_type)
as
begin
  -- retrieve and process message body
  -- do other work
end;
/

begin
  dbms_scheduler.create_program (
      program_name => 'my_prog',
      program_action=> 'my_stored_proc',
      program_type => 'STORED_PROCEDURE',
      number_of_arguments => 1,
      enabled => FALSE) ;

  dbms_scheduler.define_metadata_argument (
      program_name => 'my_prog',
      argument_position => 1 ,
      metadata_attribute => 'EVENT_MESSAGE') ;

  dbms_scheduler.enable ('my_prog');
exception
  when others then raise ;
end ;
/

begin
  dbms_scheduler.create_job (
     job_name => 'my_evt_job' ,
     program_name => 'my_prog',
     schedule_name => 'my_evt_sch',
     enabled => true,
     auto_Drop => false) ;
exception
  when others then raise ;
end ;
/
```

Using Chains

A chain is a named series of programs that are linked together for a combined objective. To create and use a chain, you complete these steps in order:

Step	See...
1. Create a chain object	Creating Chains
2. Define the steps in the chain	Defining Chain Steps
3. Add rules	Adding Rules to a Chain
4. Enable the chain	Enabling Chains
5. Create a job that points to the chain	Creating Jobs for Chains

Other topics discussed in this section include:

- Chain Tasks and Their Procedures
- Dropping Chains
- Running Chains
- Dropping Rules from a Chain
- Disabling Chains
- Dropping Chain Steps
- Altering Chain Steps
- Handling Stalled Chains

See Also:

- "Chains" on page 26-7 for an overview of chains
- "Examples of Creating Chains" on page 28-27

Chain Tasks and Their Procedures

Table 27–9 illustrates common tasks involving chains and the procedures associated with them.

Table 27–9 Chain Tasks and Their Procedures

Task	Procedure	Privilege Needed
Create a chain	`CREATE_CHAIN`	`CREATE JOB`, `CREATE EVALUATION CONTEXT` and `CREATE RULE SET` if the owner. `CREATE ANY JOB`, `CREATE ANY RULE SET` and `CREATE ANY EVALUATION CONTEXT` otherwise
Drop a chain	`DROP_CHAIN`	Ownership of the chain or `ALTER` privileges on the chain or `CREATE ANY JOB` privileges. If not owner, also requires `DROP ANY EVALUATION CONTEXT` and `DROP ANY RULE SET`
Alter a chain	`ALTER_CHAIN`	Ownership of the chain, or `ALTER` privileges on the chain or `CREATE ANY JOB`
Alter a chain	`SET_ATTRIBUTE`	Ownership of the chain, or `ALTER` privileges on the chain or `CREATE ANY JOB`
Alter a running chain	`ALTER_RUNNING_CHAIN`	Ownership of the job, or `ALTER` privileges on the job or `CREATE ANY JOB`
Run a chain	`RUN_CHAIN`	`CREATE JOB` or `CREATE ANY JOB`. In addition, the owner of the new job must have `EXECUTE` privileges on the chain or `EXECUTE ANY PROGRAM`

Table 27–9 (Cont.) Chain Tasks and Their Procedures

Task	**Procedure**	**Privilege Needed**
Add rules to a chain	`DEFINE_CHAIN_RULE`	Ownership of the chain, or `ALTER` privileges on the chain or `CREATE ANY JOB` privileges. `CREATE RULE` if the owner of the chain, `CREATE ANY RULE` otherwise
Alter rules in a chain	`DEFINE_CHAIN_RULE`	Ownership of the chain, or `ALTER` privileges on the chain or `CREATE ANY JOB` privileges. If not owner of the chain, requires `ALTER` privileges on the rule or `ALTER ANY RULE`
Drop rules from a chain	`DROP_CHAIN_RULE`	Ownership of the chain, or `ALTER` privileges on the chain or `CREATE ANY JOB` privileges. `DROP ANY RULE` if not the owner of the chain
Enable a chain	`ENABLE`	Ownership of the chain, or `ALTER` privileges on the chain or `CREATE ANY JOB`
Disable a chain	`DISABLE`	Ownership of the chain, or `ALTER` privileges on the chain or `CREATE ANY JOB`
Create steps	`DEFINE_CHAIN_STEP`	Ownership of the chain, or `ALTER` privileges on the chain or `CREATE ANY JOB`
Drop steps	`DROP_CHAIN_STEP`	Ownership of the chain, or `ALTER` privileges on the chain or `CREATE ANY JOB`
Alter steps	`DEFINE_CHAIN_STEP`	Ownership of the chain, or `ALTER` privileges on the chain or `CREATE ANY JOB`

Creating Chains

You create a chain by using the `CREATE_CHAIN` procedure. After creating the chain object with `CREATE_CHAIN`, you define chain steps and chain rules separately.

The `rule_set_name` and `evaluation_interval` arguments are normally left `NULL`. `evaluation_interval` can define the times that chain rules get evaluated, other than when the job starts or a step completes. `rule_set_name` is for advanced users only.

See *Oracle Database PL/SQL Packages and Types Reference* for more information on `CREATE_CHAIN`.

The following is an example of creating a chain:

```
BEGIN
DBMS_SCHEDULER.CREATE_CHAIN (
   chain_name          => 'my_chain1',
   rule_set_name       => NULL,
   evaluation_interval => NULL,
   comments            => 'My first chain');
END;
/
```

Defining Chain Steps

After creating a chain object, you define one or more chain steps. Each step can point to one of the following:

- A program
- Another chain (a nested chain)
- An event

You define a step that points to a program or nested chain by using the `DEFINE_CHAIN_STEP` procedure. An example is the following, which adds two steps to `my_chain1`:

```
BEGIN
DBMS_SCHEDULER.DEFINE_CHAIN_STEP (
   chain_name      =>  'my_chain1',
   step_name       =>  'my_step1',
   program_name    =>  'my_program1');
DBMS_SCHEDULER.DEFINE_CHAIN_STEP (
   chain_name      =>  'my_chain1',
   step_name       =>  'my_step2',
   program_name    =>  'my_chain2');
END;
/
```

To define a step that waits for an event to occur, you use the `DEFINE_CHAIN_EVENT_STEP` procedure. Procedure arguments can point to an event schedule or can include an inline queue specification and event condition. This example creates a third chain step that waits for the event specified in the named event schedule:

```
BEGIN
DBMS_SCHEDULER.DEFINE_CHAIN_EVENT_STEP (
   chain_name           =>  'my_chain1',
   step_name            =>  'my_step3',
   event_schedule_name  =>  'my_event_schedule');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for more information regarding the `DEFINE_CHAIN_STEP` and `DEFINE_CHAIN_EVENT_STEP` procedures.

Adding Rules to a Chain

Chain rules define when steps run, and define dependencies between steps. Each rule has a condition and an action. If the condition evaluates to TRUE, the action is performed. The condition can contain Scheduler chain condition syntax or any syntax that is valid in a SQL `WHERE` clause. The syntax can include references to attributes of any chain step, including step completion status. A typical action is to run a specified step.

Conditions are usually based on the outcome of one or more previous steps. For example, you might want one step to run if the two previous steps succeeded, and another to run if either of the two previous steps failed.

All rules added to a chain work together to define the overall behavior of the chain. When the job starts and at the end of each step, all rules are evaluated to see what action or actions occur next. (You can cause rules to be evaluated at regular intervals also. See "Creating Chains" on page 27-41 for details.)

You add a rule to a chain with the `DEFINE_CHAIN_RULE` procedure. You call this procedure once for each rule that you want to add to the chain.

Starting the Chain

At least one rule must have a condition that always evaluates to `TRUE` so that the chain can start when the job starts. The easiest way to accomplish this is to just set the condition to '`TRUE`' if you are using Schedule chain condition syntax, or '`1=1`' if you are using SQL syntax.

Ending the Chain

At least one chain rule must contain an `action` of 'END'. A chain job does not complete until one of the rules containing the END action evaluates to TRUE. Several different rules with different END actions are common, some with error codes, and some without.

If a chain has no more running steps or it is not waiting for an event to occur, and no rules containing the END action evaluate to TRUE (or there are no rules with the END action), the job enters the CHAIN_STALLED state. See "Handling Stalled Chains" on page 27-47 for more information.

Example

The following example defines a rule that starts the chain at step 1 and a rule that starts step 2 when step 1 completes. `rule_name` and `comments` are optional and default to NULL.

```
BEGIN
DBMS_SCHEDULER.DEFINE_CHAIN_RULE (
   chain_name   =>   'my_chain1',
   condition    =>   'TRUE',
   action       =>   'START step1',
   rule_name    =>   'my_rule1',
   comments     =>   'start the chain');
DBMS_SCHEDULER.DEFINE_CHAIN_RULE (
   chain_name   =>   'my_chain1',
   condition    =>   'step1 completed',
   action       =>   'START step2',
   rule_name    =>   'my_rule2');
END;
/
```

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for information on the DEFINE_CHAIN_RULE procedure and on Scheduler chain condition syntax.
- "Examples of Creating Chains" on page 28-27

Enabling Chains

You enable a chain with the ENABLE procedure. A chain must be enabled before it can be run by a job. Enabling an already enabled chain does not return an error.

The following example enables chain `my_chain1`:

```
BEGIN
DBMS_SCHEDULER.ENABLE ('my_chain1');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for more information regarding the ENABLE procedure.

Note: Chains are automatically disabled by the Scheduler when:

- The program that one of the chain steps points to is dropped
- The nested chain that one of the chain steps points to is dropped
- The event schedule that one of the chain event steps points to is dropped

Creating Jobs for Chains

To run a chain, you must either use the `RUN_CHAIN` procedure or create a job of type '`CHAIN`'. The job action must refer to the chain name, as shown in the following example:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB (
   job_name        => 'chain_job_1',
   job_type        => 'CHAIN',
   job_action      => 'my_chain1',
   repeat_interval => 'freq=daily;byhour=13;byminute=0;bysecond=0',
   enabled         => TRUE);
END;
/
```

For every step of a chain job that is running, the Scheduler creates a **step job** with the same job name and owner as the chain job. Each step job additionally has a job subname to uniquely identify it. The job subname is included as a column in the views `*_SCHEDULER_RUNNING_JOBS`, `*_SCHEDULER_JOB_LOG`, and `*_SCHEDULER_JOB_RUN_DETAILS`. The job subname is normally the same as the step name except in the following cases:

- For nested chains, the current step name may have already been used as a job subname. In this case, the Scheduler appends '_*N*' to the step name, where *N* is an integer that results in a unique job subname.
- If there is a failure when creating a step job, the Scheduler logs a `FAILED` entry in the job log views (`*_SCHEDULER_JOB_LOG` and `*_SCHEDULER_JOB_RUN_DETAILS`) with the job subname set to '*step_name*_0'.

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for more information on the CREATE_JOB procedure.
- "Running Chains" on page 27-45 for another way to run a chain without creating a job ahead of time.

Dropping Chains

You drop a chain, including its steps and rules, by using the `DROP_CHAIN` procedure. An example of dropping a chain is the following, which drops `my_chain1`:

```
BEGIN
DBMS_SCHEDULER.DROP_CHAIN (
   chain_name   => 'my_chain1',
   force        => TRUE);
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for more information regarding the DROP_CHAIN procedure.

Running Chains

You can use the RUN_CHAIN procedure to run a chain immediately, without having to create a job ahead of time for the chain. You can also use RUN_CHAIN to run only part of a chain.

RUN_CHAIN creates a temporary job to run the specified chain. If you supply a job name, the job is created with that name, otherwise a default job name is assigned.

If you supply a list of **start steps**, only those steps are started when the chain begins running. (Steps that would normally have started do not run if they are not in the list.) If no list of start steps is given, the chain starts normally—that is, an initial evaluation is done to see which steps to start running. An example is the following, which immediately runs the chain my_chain1:

```
BEGIN
DBMS_SCHEDULER.RUN_CHAIN (
   chain_name    =>  'my_chain1',
   job_name      =>  'quick_chain_job',
   start_steps   =>  'my_step1, my_step2');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for more information regarding the RUN_CHAIN procedure.

Dropping Rules from a Chain

You drop a rule from a chain by using the DROP_CHAIN_RULE procedure. An example is the following, which drops my_rule1:

```
BEGIN
DBMS_SCHEDULER.DROP_CHAIN_RULE (
   chain_name   =>   'my_chain1',
   rule_name    =>   'my_rule1',
   force        =>   TRUE);
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for more information regarding the DROP_CHAIN_RULE procedure.

Disabling Chains

You disable a chain by using the DISABLE procedure. An example is the following, which disables my_chain1:

```
BEGIN
DBMS_SCHEDULER.DISABLE ('my_chain1');
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for more information regarding the DISABLE procedure.

Note: Chains are automatically disabled by the Scheduler when:

- The program that one of the chain steps points to is dropped
- The nested chain that one of the chain steps points to is dropped
- The event schedule that one of the chain event steps points to is dropped

Dropping Chain Steps

You drop a step from a chain by using the DROP_CHAIN_STEP procedure. An example is the following, which drops my_step2 from my_chain2:

```
BEGIN
DBMS_SCHEDULER.DROP_CHAIN_STEP (
   chain_name   =>   'my_chain2',
   step_name    =>   'my_step2',
   force        =>    TRUE);
END;
/
```

See *Oracle Database PL/SQL Packages and Types Reference* for more information regarding the DROP_CHAIN_STEP procedure.

Altering Chain Steps

You alter the SKIP, PAUSE, or RESTART_ON_RECOVERY attributes of a chain step by using the ALTER_CHAIN procedure. An example is the following, which causes my_step3 to be skipped:

```
BEGIN
DBMS_SCHEDULE.ALTER_CHAIN (
   chain_name  =>  'my_chain1',
   step_name   =>  'my_step3',
   attribute   =>  'SKIP',
   value       =>  TRUE);
END;
/
```

The ALTER_CHAIN procedure affects only future runs of the specified steps.

You alter the steps in a running chain by using the ALTER_RUNNING_CHAIN procedure. An example is the following, which causes step my_step1 to pause after it has completed—that is, its state is changed to PAUSED and its completed attribute remains FALSE:

```
BEGIN
DBMS_SCHEDULER.ALTER_RUNNING_CHAIN (
   job_name     =>   'my_job1',
   step_name    =>   'my_step1',
   attribute    =>   'PAUSE',
   value        =>    TRUE);
END;
/
```

The ALTER_RUNNING_CHAIN procedure affects only the running instance of the chain.

See *Oracle Database PL/SQL Packages and Types Reference* for more information regarding the ALTER_CHAIN procedure.

Handling Stalled Chains

A chain can become **stalled** when no steps are running, no steps are scheduled to run, no event steps are waiting for an event, and the evaluation_interval for the chain is NULL. The chain can make no further progress unless you manually intervene. In this case, the state of the job that is running the chain is set to CHAIN_STALLED. (However, the job is still listed in the *_SCHEDULER_RUNNING_JOBS views.)

You can troubleshoot a stalled chain with the views ALL_SCHEDULER_RUNNING_CHAINS, which shows the state of all steps in the chain (including any nested chains), and ALL_SCHEDULER_CHAIN_RULES, which contains all the chain rules.

You can enable the chain to continue by altering the state of one of its steps with the ALTER_RUNNING_CHAIN procedure. For example, if step 11 is waiting for step 9 to succeed before it can start, and if it makes sense to do so, you can set the state of step 9 to 'SUCCEEDED'.

Alternatively, if one or more rules are incorrect, you can use the DEFINE_CHAIN_RULE procedure to replace them (using the same rule names), or to create new rules. The new and updated rules apply to the running chain and all future chain runs. After adding or updating rules, you must run EVALUATE_RUNNING_CHAIN on the stalled chain job to trigger any required actions.

Allocating Resources Among Jobs

It is not practical to manage resource allocation at an individual job level, therefore, the Scheduler uses the concept of job classes to manage resource allocation among jobs. In addition to job classes, the Scheduler uses the Resource Manager to manage resource allocation among jobs.

Allocating Resources Among Jobs Using Resource Manager

The Database Resource Manager controls how resources are allocated among database sessions. It not only controls asynchronous sessions like jobs but also synchronous sessions like user sessions. It groups all "units of work" in the database into resource consumer groups and uses a resource plan to specify how the resources are allocated among the various groups. See Chapter 25, "Managing Resource Allocation with Oracle Database Resource Manager" for more information about what resources are controlled by the Resource Manager.

For jobs, resource allocation is specified by associating a job class with a consumer group, or by associating a job class with a database service name and mapping that database service to a consumer group. The consumer group that a job class maps to can be specified when creating a job class. If no resource consumer group or database service name is specified when a job class is created, the job class maps to the default consumer group. If both the resource_consumer_group and service attributes of a job class are set, and the designated service maps to a resource consumer group, the resource consumer group named in the resource_consumer_group attribute takes precedence.

The Scheduler tries to limit the number of jobs that are running simultaneously so that at least some jobs can complete, rather than running a lot of jobs concurrently but without enough resources for any of them to complete.

The Scheduler and the Resource Manager are tightly integrated. The job coordinator obtains database resource availability from the Resource Manager. Based on that information, the coordinator determines how many jobs to start. It will only start jobs from those job classes that will have enough resources to run. The coordinator will keep starting jobs in a particular job class that maps to a consumer group until the Resource Manager determines that the maximum resource allocated for that consumer group has been reached. This means that it is possible that there will be jobs in the job table that are ready to run but will not be picked up by the job coordinator because there are no resources to run them. Therefore, there is no guarantee that a job will run at the exact time that it was scheduled. The coordinator picks up jobs from the job table on the basis of which consumer groups still have resources available.

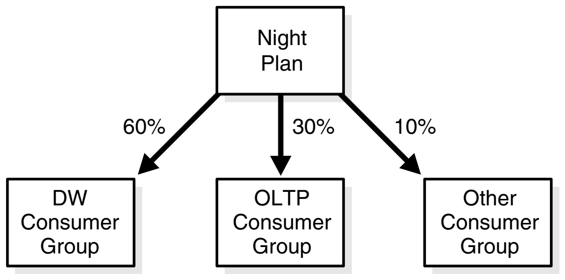
Even when jobs are running, the Resource Manager will continue to manage the resources that are assigned to each running job based on the specified resource plan. Keep in mind that the Resource Manager can only manage database processes. The active management of resources does not apply to external jobs.

In a database, only one resource plan can be in effect at one time. It is possible to manually switch the resource plan that is active on a system using the `DBMS_RESOURCE_MANAGER.SWITCH_PLAN` procedure. In special scenarios, you might want to run a specific resource plan and disable resource plan switches caused by windows opening. To do this, you can use the `DBMS_RESOURCE_MANAGER.SWITCH_PLAN` procedure with `allow_scheduler_plan_switches` set to `FALSE`. Also remember that a Scheduler window can have a resource plan attribute. The designated resource plan remains active while the window is open.

Example of Resource Allocation for Jobs

The following example can help to understand how resources are allocated for jobs. Assume that the active resource plan is called "Night Plan" and that there are three job classes: `JC1`, which maps to consumer group `DW`; `JC2`, which maps to consumer group `OLTP`; and `JC3`, which maps to the default consumer group. Figure 27–3 offers a simple graphical illustration of this scenario.

Figure 27–3 Sample Resource Plan



This resource plan clearly gives priority to jobs that are part of job class `JC1`. Consumer group `DW` gets 60% of the resources, thus jobs that belong to job class `JC1` will get 60% of the resources. Consumer group `OLTP` has 30% of the resources, which implies that jobs in job class `JC2` will get 30% of the resources. The consumer group `Other` specifies that all other consumer groups will be getting 10% of the resources. This means that all jobs that belong in job class `JC3` will share 10% of the resources and can get a maximum of 10% of the resources.

Note that resources that remain unused by one consumer group are available from use by the other consumer groups. So if the jobs in job class JC1 do not fully use the allocated 60%, the unused portion is available for use by jobs in classes JC2 and JC3. Note also that the Resource Manager does not begin to restrict resource usage at all until CPU usage reaches 100%. See Chapter 25, "Managing Resource Allocation with Oracle Database Resource Manager" for more information.

28 Administering Oracle Scheduler

This chapter provides step-by-step instructions for configuring, administering, and monitoring Oracle Scheduler (the Scheduler). It contains the following sections:

- Configuring the Scheduler
- Monitoring and Managing the Scheduler
- Enabling and Disabling Remote External Jobs
- Import/Export and the Scheduler
- Troubleshooting the Scheduler
- Examples of Using the Scheduler
- Scheduler Reference

Note: This chapter discusses the use of the Oracle-supplied `DBMS_SCHEDULER` package to administer scheduling capabilities. See the *Oracle Database PL/SQL Packages and Types Reference* for `DBMS_SCHEDULER` syntax. An easier way to administer the Scheduler is with the graphical interface of Oracle Enterprise Manager.

To administer the Scheduler with Enterprise Manager:

1. Access the Database Home page.

   See *Oracle Database 2 Day DBA* for instructions.
2. At the top of the page, click to display the **Server** property page.
3. Locate the Oracle Scheduler section on the page, and then click the desired link.

Configuring the Scheduler

The following tasks are necessary when configuring the Scheduler:

- Task 1: Setting Scheduler Privileges
- Task 2: Configuring the Scheduler Environment

Task 1: Setting Scheduler Privileges

You should have the `SCHEDULER_ADMIN` role to administer the Scheduler. Typically, database administrators will already have this role with the `ADMIN` option as part of the `DBA` (or equivalent) role. You can grant this role to another administrator by issuing the following statement:

```
GRANT SCHEDULER_ADMIN TO username;
```

Because the `SCHEDULER_ADMIN` role is a powerful role allowing a grantee to execute code as any user, you should consider granting individual Scheduler system privileges instead. Object and system privileges are granted using regular SQL grant syntax. An example is if the database administrator issues the following statement:

```
GRANT CREATE JOB TO scott;
```

After this statement is executed, `scott` can create jobs, schedules, or programs in his schema. Another example is if the database administrator issues the following statement:

```
GRANT MANAGE SCHEDULER TO adam;
```

After this statement is executed, `adam` can create, alter, or drop windows, job classes, or window groups. He will also be able to set and retrieve Scheduler attributes and purge Scheduler logs.

Setting Chain Privileges

Scheduler chains use underlying Oracle Streams Rules Engine objects along with their associated privileges. To create a chain in his own schema, a user must have the `CREATE JOB` privilege in addition to the Rules Engine privileges required to create rules, rule sets, and evaluation contexts in his own schema. These can be granted by issuing the following statement:

```
BEGIN
DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(DBMS_RULE_ADM.CREATE_RULE_OBJ, 'username'),
DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE (
   DBMS_RULE_ADM.CREATE_RULE_SET_OBJ, 'username'),
DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE (
   DBMS_RULE_ADM.CREATE_EVALUATION_CONTEXT_OBJ, 'username')
END;
/
```

To create a chain in a different schema, a user must have the `CREATE ANY JOB` privilege in addition to the privileges required to create rules, rule sets, and evaluation contexts in schemas other than his own. These can be granted by issuing the following statement:

```
BEGIN
DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE(DBMS_RULE_ADM.CREATE_ANY_RULE, 'username'),
DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE (
   DBMS_RULE_ADM.CREATE_ANY_RULE_SET, 'username'),
DBMS_RULE_ADM.GRANT_SYSTEM_PRIVILEGE (
   DBMS_RULE_ADM.CREATE_ANY_EVALUATION_CONTEXT, 'username')
END;
/
```

Altering or dropping chains in schemas other than the user's schema will require corresponding system Rules Engine privileges for rules, rule sets, and evaluation contexts. See the usage notes for `DBMS_RULE_ADM.GRANT_OBJECT_PRIVILEGE` for more information on Streams Rules Engine privileges.

See Also:

- "Scheduler Privileges" on page 28-30
- "Chain Tasks and Their Procedures" on page 27-40 for more information regarding chain privileges.

Task 2: Configuring the Scheduler Environment

This section discusses the following tasks:

- Task 2A: Creating Job Classes
- Task 2B: Creating Windows
- Task 2C: Creating Resource Plans
- Task 2D: Creating Window Groups
- Task 2E: Setting Scheduler Attributes

Task 2A: Creating Job Classes

To create job classes, use the `CREATE_JOB_CLASS` procedure. The following statement illustrates an example of creating a job class:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB_CLASS (
   job_class_name             => 'my_jobclass1',
   resource_consumer_group    => 'my_res_group1',
   comments                   => 'This is my first job class.');
END;
/
```

This statement creates a job class called `my_jobclass1` with attributes such as a resource consumer group of `my_res_group1`. To verify the job class contents, issue the following statement:

```
SELECT * FROM DBA_SCHEDULER_JOB_CLASSES;

JOB_CLASS_NAME        RESOURCE_CONSU   SERVICE   LOGGING_LEV  LOG_HISTORY    COMMENTS
-----------------     --------------   -------   -----------  -----------    --------
DEFAULT_JOB_CLASS                                       RUNS                 The default
AUTO_TASKS_JOB_CLASS  AUTO_TASK_CON                     RUNS                 System maintenance
FINANCE_JOBS          FINANCE_GROUP                     RUNS
MY_JOBCLASS1          MY_RES_GROUP1                     RUNS                 My first job class
MY_CLASS1                              my_service1      RUNS                 My second job class

5 rows selected.
```

Note that job classes are created in the `SYS` schema.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for `CREATE_JOB_CLASS` syntax, "Creating Job Classes" on page 27-22 for further information on job classes, and "Examples of Creating Job Classes" on page 28-20 for more examples of creating job classes

Task 2B: Creating Windows

To create windows, use the `CREATE_WINDOW` procedure. The following statement illustrates an example of creating a window:

```
BEGIN
DBMS_SCHEDULER.CREATE_WINDOW (
   window_name     =>  'my_window1',
   resource_plan   =>  'my_resourceplan1',
   start_date      =>  '15-APR-03 01.00.00 AM Europe/Lisbon',
   repeat_interval =>  'FREQ=DAILY',
   end_date        =>  '15-SEP-04 01.00.00 AM Europe/Lisbon',
   duration        =>  interval '50' minute,
   window_priority =>  'HIGH',
   comments        =>  'This is my first window.');
END;
/
```

To verify that the window was created properly, query the view DBA_SCHEDULER_WINDOWS. As an example, issue the following statement:

```
SELECT WINDOW_NAME, RESOURCE_PLAN, DURATION, REPEAT_INTERVAL
FROM DBA_SCHEDULER_WINDOWS;

WINDOW_NAME    RESOURCE_PLAN     DURATION         REPEAT_INTERVAL
-----------    -------------     -------------    ---------------
MY_WINDOW1     MY_RESOURCEPLAN1  +000 00:50:00    FREQ=DAILY
```

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for CREATE_WINDOW syntax, "Creating Windows" on page 27-23 for further information on windows, and "Examples of Creating Windows" on page 28-22 for more examples of creating job classes

Task 2C: Creating Resource Plans

To create resource plans, use the CREATE_SIMPLE_PLAN procedure. This procedure enables you to create consumer groups and allocate resources to them by executing a single statement.

The following statement illustrates an example of using this procedure to create a resource plan called my_simple_plan1:

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_SIMPLE_PLAN (
   simple_plan       => 'my_simple_plan1',
   consumer_group1   => 'my_group1',
   group1_cpu        => 80,
   consumer_group2   => 'my_group2',
   group2_cpu        => 20);
END;
/
```

This statement creates a resource plan called my_simple_plan1. To verify the resource plan contents, query the view DBA_RSRC_PLANS. An example is the following statement:

```
SELECT PLAN, STATUS FROM DBA_RSRC_PLANS;

PLAN                           STATUS
------------------------------ --------------------------
SYSTEM_PLAN                    ACTIVE
INTERNAL_QUIESCE               ACTIVE
INTERNAL_PLAN                  ACTIVE
MY_SIMPLE_PLAN1                ACTIVE
```

> **See Also:** "Allocating Resources Among Jobs" on page 27-47 for further information on resource plans

Task 2D: Creating Window Groups

To create window groups, use the `CREATE_WINDOW_GROUP` and `ADD_WINDOW_GROUP_MEMBER` procedures. The following statements illustrate an example of using these procedures:

```
BEGIN
DBMS_SCHEDULER.CREATE_WINDOW_GROUP (
   group_name        =>  'my_window_group1',
   comments          =>  'This is my first window group.');

DBMS_SCHEDULER.ADD_WINDOW_GROUP_MEMBER (
   group_name        =>  'my_window_group1',
   window_list       =>  'my_window1, my_window2');

DBMS_SCHEDULER.ADD_WINDOW_GROUP_MEMBER (
   group_name        =>  'my_window_group1',
   window_list       =>  'my_window3');
END;
/
```

These statements assume that you have already created `my_window2` and `my_window3`. You can do this with the `CREATE_WINDOW` procedure.

These statements create a window group called `my_window_group1` and then add `my_window1`, `my_window2`, and `my_window3` to it. To verify the window group contents, issue the following statements:

```
SELECT * FROM DBA_SCHEDULER_WINDOW_GROUPS;

WINDOW_GROUP_NAME   ENABLED  NUMBER_OF_WINDOWS   COMMENTS
-----------------   -------  -----------------   --------------------
MY_WINDOW_GROUP1    TRUE                     3   This is my first window group.

SELECT * FROM DBA_SCHEDULER_WINGROUP_MEMBERS;

WINDOW_GROUP_NAME              WINDOW_NAME
------------------------------ ---------------
MY_WINDOW_GROUP1               MY_WINDOW1
MY_WINDOW_GROUP1               MY_WINDOW2
MY_WINDOW_GROUP1               MY_WINDOW3
```

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for `CREATE_WINDOW_GROUP` syntax, "Using Window Groups" on page 27-30 for further information on window groups, and "Example of Creating Window Groups" on page 28-23 for more detailed examples of creating window groups

Task 2E: Setting Scheduler Attributes

There are several Scheduler attributes that control the behavior of the Scheduler. They are `default_timezone`, `log_history`, `max_job_slave_processes`, and `event_expiry_time`. The values of these attributes can be set by using the `SET_SCHEDULER_ATTRIBUTE` procedure. Setting these attributes requires the `MANAGE SCHEDULER` privilege. Attributes that can be set are:

- `default_timezone`

  Repeating jobs and windows that use the calendaring syntax need to know which time zone to use for their repeat intervals. They normally retrieve the time zone from `start_date`, but if no `start_date` is provided (which is not uncommon), they retrieve the time zone from the `default_timezone` Scheduler attribute.

Scheduler derives the value of `default_timezone` from the operating system environment. If Scheduler can find no compatible value from the operating system, it sets `default_timezone` to `NULL`.

It is crucial that you verify that `default_timezone` is set properly, and if not, that you set it. To verify it, run this query:

```
SQL> select dbms_scheduler.stime from dual;

STIME
---------------------------------------------------------------------------
14-OCT-04 02.56.03.206273000 PM US/PACIFIC
```

To ensure that daylight savings adjustments are followed, it is strongly recommended that you set `default_timezone` to a region name instead of an absolute time zone offset. For example, if your database resides in Miami, Florida, USA, issue the following statement:

```
DBMS_SCHEDULER.SET_SCHEDULER_ATTRIBUTE('default_timezone','US/Eastern');
```

To see a list of valid region names, run this query:

```
SELECT DISTINCT TZNAME FROM V$TIMEZONE_NAMES;
```

If you do not properly set `default_timezone`, the default time zone for repeating jobs and windows will be the absolute offset retrieved from `SYSTIMESTAMP` (the time zone of the operating system environment of the database), which means that repeating jobs and windows that do not have their `start_date` set will not follow daylight savings adjustments.

- `log_history`

  This enables you to control the amount of logging the Scheduler performs. To prevent the job log and the window log from growing indiscriminately, the Scheduler has an attribute that specifies how much history (in days) to keep. Once a day, the Scheduler automatically purges all log entries from both the job log as well as the window log that are older than the specified history. The default is 30 days.

  You can change the default by using the `SET_SCHEDULER_ATTRIBUTE` procedure. For example, to change it to 90 days, issue the following statement:

  ```
  DBMS_SCHEDULER.SET_SCHEDULER_ATTRIBUTE('log_history','90');
  ```

  The range of valid values is 1 through 999.

- `max_job_slave_processes`

  This enables you to set a maximum number of slave processes for a particular system configuration and load. Even though the Scheduler automatically determines what the optimum number of slave processes is for a given system configuration and load, you still might want to set a fixed limit on the Scheduler. If this is the case, you can set this attribute. The default value is `NULL`, and the valid range is 1-999.

  Although the number set by `max_job_slave_processes` is a real maximum, it does not mean the Scheduler will start the specified number of slaves. For example, even though this attribute is set to 10, the Scheduler might still determine that is should not start more than 3 slave processes. However, if it wants to start 15, but it is set to 10, it will not start more than 10.

- `event_expiry_time`

  This enables you to set the time in seconds before an event generated by the Scheduler expires (in other words, is automatically purged from the queue).

See *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `SET_SCHEDULER_ATTRIBUTE` procedure.

Monitoring and Managing the Scheduler

The following sections discuss how to monitor and manage the Scheduler:

- Viewing the Currently Active Window and Resource Plan
- Finding Information About Currently Running Jobs
- Monitoring and Managing Window and Job Logs
- Changing Job Priorities
- Monitoring Running Chains
- Managing Scheduler Security

Viewing the Currently Active Window and Resource Plan

You can view the currently active window and the plan associated with it by issuing the following statement:

```
SELECT WINDOW_NAME, RESOURCE_PLAN FROM DBA_SCHEDULER_WINDOWS
WHERE ACTIVE='TRUE';

WINDOW_NAME                    RESOURCE_PLAN
------------------------------ --------------------------
MY_WINDOW10                    MY_RESOURCEPLAN1
```

If there is no window active, you can view the active resource plan by issuing the following statement:

```
SELECT * FROM V$RSRC_PLAN;
```

Finding Information About Currently Running Jobs

You can check a job's state by issuing the following statement:

```
SELECT JOB_NAME, STATE FROM DBA_SCHEDULER_JOBS
WHERE JOB_NAME = 'MY_EMP_JOB1';

JOB_NAME                       STATE
------------------------------ ---------
MY_EMP_JOB1                    DISABLED
```

In this case, you could enable the job using the `ENABLE` procedure. Table 28–1 shows the valid values for job state.

Table 28–1 Job States

Job State	Description
`disabled`	The job is disabled.

Table 28–1 (Cont.) Job States

Job State	Description
`scheduled`	The job is scheduled to be executed.
`running`	The job is currently running.
`completed`	The job has completed, and is not scheduled to run again.
`stopped`	The job was scheduled to run once and was stopped while it was running.
`broken`	The job is broken.
`failed`	The job was scheduled to run once and failed.
`retry scheduled`	The job has failed at least once and a retry has been scheduled to be executed.
`succeeded`	The job was scheduled to run once and completed successfully.
`chain_stalled`	The job is of type chain and has no steps running, no steps scheduled to run, and no event steps waiting on an event, and the chain `evaluation_interval` is set to `NULL`. No progress will be made in the chain unless there is manual intervention.

You can check the progress of currently running jobs by issuing the following statement:

```
SELECT * FROM ALL_SCHEDULER_RUNNING_JOBS;
```

Note that, for the column `CPU_USED` to show valid data, the initialization parameter `RESOURCE_LIMIT` must be set to `true`.

You can find out information about a job that is part of a running chain by issuing the following statement:

```
SELECT * FROM ALL_SCHEDULER_RUNNING_CHAINS WHERE JOB_NAME='MY_JOB1';
```

You can check whether the job coordinator is running by searching for a process of the form `cjqNNN`.

> **See Also:** *Oracle Database Reference* for details regarding the `*_SCHEDULER_RUNNING_JOBS` and `DBA_SCHEDULER_JOBS` views

Monitoring and Managing Window and Job Logs

Logs have a new entry for each event that occurs so that you can track historical information. This is different from a queue, where you only want to track the latest status for an item. There are logs for jobs, job runs, and windows.

Job activity is logged in the `*_SCHEDULER_JOB_LOG` views. Altering a job is logged with an operation of `UPDATE`. Dropping a job is logged in these views with an operation of `DROP`.

> **See Also:** *Oracle Database Reference* for details on the `*_SCHEDULER_JOB_LOG` views and other Scheduler log views.

Job Logs

To see the contents of the job log, query the `DBA_SCHEDULER_JOB_LOG` view. An example is the following statement, which shows what happened for past job runs:

```
SELECT JOB_NAME, OPERATION, OWNER FROM DBA_SCHEDULER_JOB_LOG;

JOB_NAME        OPERATION     OWNER
--------        ---------     -----
MY_JOB13        CREATE        SYS
MY_JOB14        CREATE        OE
MY_NEW_JOB3     ENABLE        SYS
MY_EMP_JOB1     UPDATE        SYS
MY_JOB1         CREATE        SCOTT
MY_EMP_JOB1     UPDATE        SYS
MY_EMP_JOB      CREATE        SYS
MY_JOB14        RUN           OE
MY_JOB14        RETRY_RUN     OE
MY_JOB14        RETRY_RUN     OE
MY_JOB14        RETRY_RUN     OE
MY_JOB14        RETRY_RUN     OE
MY_JOB14        BROKEN        OE
MY_JOB14        DROP          OE
```

When `logging_level` for a job is set to `LOGGING_FULL`, the `additional_info` column of the job log contains the before and after values of the modified attribute on update operations, and contains the values of all attributes on drop operations. This enables you to trace backwards from the current job state to the state of the job on previous job runs.

Job Run Details

To further analyze each job run—why it failed, what the actual start time was, how long the job ran, and so on—query the `DBA_SCHEDULER_JOB_RUN_DETAILS` view. As an example, the following statement illustrates the status for `my_job14`:

```
select log_id, job_name, status,
to_char(log_date, 'DD-MON-YYYY HH24:MI') log_date
from dba_scheduler_job_run_details
where job_name = 'MY_JOB14';

    LOG_ID JOB_NAME              STATUS       LOG_DATE
---------- --------------------- ------------ -----------------
        69 MY_JOB14              SUCCEEDED    02-JUN-2005 03:14
       124 MY_JOB14              SUCCEEDED    03-JUN-2005 03:15
       133 MY_JOB14              FAILURE      04-JUN-2005 03:00
       146 MY_JOB14              FAILURE      05-JUN-2005 03:01
```

For every row in `SCHEDULER_JOB_LOG` that is of operation `RUN`, `RETRY_RUN`, or `RECOVERY_RUN`, there will be a corresponding row in the `*_JOB_RUN_DETAILS` view with the same `LOG_ID`. `LOG_DATE` contains the timestamp of the entry, so sorting by `LOG_DATE` should give you a chronological picture of the life of a job.

Controlling Job Logging

You can control the amount of logging that the Scheduler performs on jobs at either a class or job level. Normally, you will want to control jobs at a class level as this offers a full audit trail. To do this, use the `logging_level` attribute in the `CREATE_JOB_CLASS` procedure.

For each new class, the creator of the class must specify what the logging level is for all jobs in that class. The three possible options are:

- `DBMS_SCHEDULER.LOGGING_OFF`

  No logging will be performed for any jobs in this class.

- `DBMS_SCHEDULER.LOGGING_RUNS`

  The Scheduler will write detailed information to the job log for all runs of each job in this class.

- `DBMS_SCHEDULER.LOGGING_FULL`

  In addition to recording every run of a job, the Scheduler will record all operations performed on all jobs in this class. In other words, every time a job is created, enabled, disabled, altered, and so on will be recorded in the log.

By default, only job runs are recorded. For job classes that have very short and highly frequent jobs, the overhead of recording every single run might be too much and you might choose to turn the logging off. You might, however, prefer to have a complete audit trail of everything that happened to the jobs in a specific class, in which case you need to turn on full logging for that class.

The second way of controlling the logging level is on an individual job basis. You should keep in mind, however, that the log in many cases is used as an audit trail, thus if you want a certain level of logging, the individual job creator must not be able to turn logging off. The class-specific level is, therefore, the minimum level at which job information will be logged. A job creator can only turn on more logging for an individual job, not less.

This functionality is provided for debugging purposes. For example, if the class-specific level is set to record job runs and the job-specific logging is turned off, the Scheduler will still log the runs. If, on the other hand, the job creator turns on full logging and the class-specific level is set to record runs only, all operations on this individual job will be logged. This way, an end user can test his job by turning on full logging.

To set the logging level of an individual job, you must use the `SET_ATTRIBUTE` procedure on that job. For example, to turn on full logging for a job called `mytestjob`, issue the following statement:

```
DBMS_SCHEDULER.SET_ATTRIBUTE (
   'mytestjob', 'logging_level', DBMS_SCHEDULER.LOGGING_FULL);
```

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `CREATE_JOB_CLASS` and `SET_ATTRIBUTE` procedures and "Task 2E: Setting Scheduler Attributes" on page 28-5

Window Logs

A window log has an entry for each time you do the following:

- Create a window
- Drop a window
- Open a window
- Close a window
- Overlap windows
- Disable a window
- Enable a window

There are no logging levels for window logging, but every window operation will automatically be logged by the Scheduler.

To see the contents of the window log, query the DBA_SCHEDULER_WINDOW_LOG view. The following statement shows sample output from this view:

```
SELECT LOG_ID, TO_CHAR(LOG_DATE, 'MM/DD/YYYY'), WINDOW_NAME, OPERATION
  FROM DBA_SCHEDULER_WINDOW_LOG;

    LOG_ID TO_CHAR(LO WINDOW_NAME       OPERATION
---------- ---------- ----------------- ------------------------------
         1 10/01/2004 WEEKNIGHT_WINDOW  CREATE
         2 10/01/2004 WEEKNIGHT_WINDOW  UPDATE
         3 10/01/2004 WEEKNIGHT_WINDOW  UPDATE
         4 10/01/2004 WEEKEND_WINDOW    CREATE
         5 10/01/2004 WEEKEND_WINDOW    UPDATE
         6 10/01/2004 WEEKEND_WINDOW    UPDATE
        22 10/06/2004 WEEKNIGHT_WINDOW  OPEN
        25 10/06/2004 WEEKNIGHT_WINDOW  CLOSE
        26 10/06/2004 WEEKNIGHT_WINDOW  OPEN
        29 10/06/2004 WEEKNIGHT_WINDOW  CLOSE
```

The DBA_SCHEDULER_WINDOWS_DETAILS view provides information about every window that was active and is now closed (completed). The following statement shows sample output from that view:

```
SELECT LOG_ID, WINDOW_NAME, ACTUAL_START_DATE, ACTUAL_DURATION
  FROM DBA_SCHEDULER_WINDOW_DETAILS;

    LOG_ID WINDOW_NAME      ACTUAL_START_DATE                    ACTUAL_DURATI
---------- ---------------- ------------------------------------ -------------
        25 WEEKNIGHT_WINDOW 06-OCT-04 03.12.48.832438 PM PST8PDT +000 01:02:32
        29 WEEKNIGHT_WINDOW 06-OCT-04 06.19.37.025704 PM PST8PDT +000 03:02:00
```

Notice that log IDs correspond in both of these views, and that in this case the rows in the DBA_SCHEDULER_WINDOWS_DETAILS view correspond to the CLOSE operations in the DBA_SCHEDULER_WINDOW_LOG view.

Purging Logs

To prevent job and window logs from growing indiscriminately, use the SET_SCHEDULER_ATTRIBUTE procedure to specify how much history (in days) to keep. Once per day, the Scheduler automatically purges all log entries that are older than the specified history period from both the job log and the window log. The default history period is 30 days. For example, to change the history period to 90 days, issue the following statement:

```
DBMS_SCHEDULER.SET_SCHEDULER_ATTRIBUTE('log_history','90');
```

Some job classes are more important than others. Because of this, you can override this global history setting by using a class-specific setting. For example, suppose that there are three job classes (class1, class2, and class3), and that you want to keep 10 days of history for the window log, class1, and class3, but 30 days for class2. To achieve this, issue the following statements:

```
DBMS_SCHEDULER.SET_SCHEDULER_ATTRIBUTE('log_history','10');
DBMS_SCHEDULER.SET_ATTRIBUTE('class2','log_history','30');
```

You can also set the class-specific history when creating the job class.

Note that log entries pertaining to steps of a chain run are not purged until the entries for the main chain job are purged.

Purging Logs Manually

The PURGE_LOG procedure enables you to manually purge logs. As an example, the following statement purges all entries from both the job and window logs:

```
DBMS_SCHEDULER.PURGE_LOG();
```

Another example is the following, which purges all entries from the jog log that are older than three days. The window log is not affected by this statement.

```
DBMS_SCHEDULER.PURGE_LOG(log_history => 3, which_log => 'JOB_LOG');
```

The following statement purges all window log entries older than 10 days and all job log entries older than 10 days that relate to job1 and to the jobs in class2:

```
DBMS_SCHEDULER.PURGE_LOG(log_history => 10, job_name => 'job1, sys.class2');
```

Changing Job Priorities

You can change job priorities by using the SET_ATTRIBUTE procedure. Job priorities must be in the range 1-5 with 1 being the highest priority. For example, the following statement changes the job priority for my_job1 to a setting of 1:

```
BEGIN
DBMS_SCHEDULER.SET_ATTRIBUTE (
   name           =>   'my_emp_job1',
   attribute      =>   'job_priority',
   value          =>   1);
END;
/
```

You can verify that the attribute was changed by issuing the following statement:

```
SELECT JOB_NAME, JOB_PRIORITY FROM DBA_SCHEDULER_JOBS;

JOB_NAME                       JOB_PRIORITY
------------------------------ ------------
MY_EMP_JOB                                3
MY_EMP_JOB1                               1
MY_NEW_JOB1                               3
MY_NEW_JOB2                               3
MY_NEW_JOB3                               3
```

See Also: *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the SET_ATTRIBUTE procedure

Monitoring Running Chains

You can check the state of a running chain by querying the *_SCHEDULER_RUNNING_CHAINS views. The results contain a row describing the current state of every step in every running instance of a chain. For example, the following statement displays the state of all steps in the running job MY_CHAIN_JOB. It also shows the state of all steps of any nested chain jobs that are running or have completed.

```
SELECT * FROM USER_SCHEDULER_RUNNING_CHAINS WHERE JOB_NAME = 'MY_CHAIN_JOB';
```

See "Using Chains" on page 27-40 for more information regarding chains.

Managing Scheduler Security

You should grant the CREATE JOB system privilege to regular users who need to be able to use the Scheduler to schedule and run jobs. You should grant MANAGE SCHEDULER to any database administrator who needs to be able to manage system resources. Granting any other Scheduler system privilege or role should not be done without great caution. In particular, the CREATE ANY JOB system privilege and the SCHEDULER_ADMIN role, which includes it, are very powerful because they allow execution of code as any user. They should only be granted to very powerful roles or users.

A particularly important issue from a security point of view is handling external jobs. Only users that need to run jobs outside of the database should be allowed to do so. You must grant the CREATE EXTERNAL JOB system privilege to those users. See "Creating Remote External Jobs" on page 27-6 for further information. Security for the Scheduler has no other special requirements. See *Oracle Database Security Guide* for details regarding security.

> **Note:** When upgrading from Oracle Database 10g Release 1 to 10g Release 2 or later, CREATE EXTERNAL JOB is automatically granted to all users and roles that have the CREATE JOB privilege. Oracle recommends that you revoke this privilege from users that don't need it.

Enabling and Disabling Remote External Jobs

Oracle Scheduler (the Scheduler) can schedule and run external jobs on a remote host. The remote host does not need an Oracle database installed; however, a Scheduler agent must be installed on the remote host so that the scheduling database can start remote external jobs on that host and receive job output and error information. The agent must register with every database that is to be permitted to start remote external jobs on the agent's host. An initial setup is also required for each database that is to run remote external jobs. For each database, this setup enables secure communications between the database and remote Scheduler agents.

Enabling remote external jobs includes the following steps:

1. Setting Up the Database on page 28-13
2. Installing and Configuring the Scheduler Agent on page 28-14

If at any time you want to disable remote external jobs—that is, remove the capability to start remote external jobs from a particular Oracle database—you can follow the instructions in "Disabling Remote External Jobs" on page 28-16.

> **See Also:** "About Remote External Jobs" on page 26-12

Setting Up the Database

To set up the database to run remote external jobs:

1. Ensure that the XML DB option is installed on the database host.

   This option is installed by default. To establish if XML DB is installed, check the RESOURCE_VIEW view using the following command in SQL*Plus:

   ```
   SQL> DESC RESOURCE_VIEW
   ```

   If XML DB is not installed, this command returns an "object does not exist" error.

Note: If XML DB is not installed, you must install it before continuing.

---

2. Run the script `prvtrsch.plb` on the database host using the following steps:

   a. Start SQL*Plus and connect as the `SYS` user.

   b. Issue the following command:

   ```
   SQL> @ORACLE_HOME/rdbms/admin/prvtrsch.plb
   ```

   You need to run this script only once on a database host.

3. Set a registration password for the Scheduler agents using the `SET_AGENT_REGISTRATION_PASS` procedure.

   Before a database can execute jobs using a remote Scheduler agent, the agent must be registered with the database. To make the registration of remote Scheduler agents secure, an agent registration password must be set on the database. You can choose to only allow a certain number of Scheduler agents to register or to have the password expire after a specified duration.

   The following example sets the agent registration password for a database host to `mypassword`.

   ```
   SQL> EXEC DBMS_SCHEDULER.SET_AGENT_REGISTRATION_PASS('mypassword')
   ```

Note: The `MANAGE SCHEDULER` privilege is required to set an agent registration password.

Installing and Configuring the Scheduler Agent

Before you can run remote external jobs, you must install and start the Scheduler agent on the remote host. The Scheduler agent is located in the installation media for the Oracle Database Gateway, which is included in the Database CD pack. It is also available online at:

`http://www.oracle.com/technology/software`

To install and configure the Scheduler agent on a remote host:

1. Log in to the remote host.

   - For Windows, log in as an administrator.
   - For UNIX and Linux, log in as the user under which you want the Scheduler agent to run. This user requires no special privileges.

2. Run the Oracle Universal Installer from the installation media for Oracle Database Gateway.

   - For Windows, run `setup.exe`.
   - For UNIX and Linux, use the following command:

   ```
   $/directory_path/runInstaller
   ```

   where *`directory_path`* is the path to the Oracle Database Gateway installation media.

3. On the Products Selection page, select **Oracle Scheduler Agent**.
4. On the Oracle Scheduler Agent page, enter the host name of the machine on which the Scheduler agent will run.

   When this page is displayed, the installer uses a default value for the host name. You can also choose to retain the default value.
5. (UNIX only) The Oracle Universal Installer prompts you to run the script `root.sh`. Enter the following command as the `root` user.

   ```
   #/script_path/root.sh
   ```

   where *`script_path`* is the path where the script is located. The script is located in the directory that you chose for the installation.
6. On the Summary page, click **Finish** to complete the agent installation.
7. Review the agent configuration parameters by using a text editor to view the file `schagent.conf`, which is located in the Scheduler agent home directory.

   Note the port number, because you will need this information when creating remote external jobs. Change any agent configuration parameters as required.
8. Register the Scheduler agent with a database that will run remote external jobs on the agent's host. Use the following command:

   ```
   schagent -registerdatabase database_host database_xmldb_http_port
   ```

   You will be prompted to enter the agent registration password that you previously set on the database in "Setting Up the Database" on page 28-13.

   database_xmldb_http_port is the port that the database listens on for HTTP connections. You can determine this port by issuing the following command on the database:

   ```
   SQL> SELECT DBMS_XDB.GETHTTPPORT() FROM DUAL;
   ```

   Note: The `schagent` executable can be found in the `bin` subdirectory of the newly created agent directory.
9. Repeat the previous step for each database that will run remote external jobs on the agent's host.
10. Start the Scheduler agent.
    - On UNIX or Linux operating systems, use the following command:

      ```
      schagent -start
      ```
    - On Windows, a service must be installed and started to start the agent:

      ```
      schagent -installagentservice
      ```

      The name of the service is `OracleSchedulerExecutionAgent`. Before starting the service, you can use the Services item in the Windows Control Panel to set the user that the service runs as. The Services icon is found under Administrative Tools in the Control Panel.

Note: Do not confuse this service with the `OracleJobScheduler` service, which runs on a Windows computer on which an Oracle database is installed, and manages the running of local external jobs on that computer.

Stopping the Scheduler Agent

On UNIX and Linux operating systems, the agent can be stopped with the following command:

```
schagent -stop
```

On Windows, the agent can be stopped by stopping the `OracleSchedulerExecutionAgent` service.

Disabling Remote External Jobs

You can disable the capability of a database to run remote external jobs by dropping the `REMOTE_SCHEDULER_AGENT` user. Use the following command:

```
DROP USER REMOTE_SCHEDULER_AGENT CASCADE;
```

Registration of new scheduler agents and execution of remote external jobs is disabled until you run `prvtrsch.plb` again.

Import/Export and the Scheduler

You must use the Data Pump utilities (`impdp` and `expdp`) to export Scheduler objects. You cannot use the earlier import/export utilities (`IMP` and `EXP`) with the Scheduler. Also, Scheduler objects cannot be exported while the database is in read-only mode.

An export generates the DDL that was used to create the Scheduler objects. All attributes are exported. When an import is done, all the database objects are recreated in the new database. All schedules are stored with their time zones, which are maintained in the new database. For example, schedule "Monday at 1 PM PST in a database in San Francisco" would be the same if it was exported and imported to a database in Germany.

Although Scheduler credentials are exported, for security reasons, the passwords in these credentials are not exported. After you import Scheduler credentials, you must reset the passwords using the `SET_ATTRIBUTE` procedure of the `DBMS_SCHEDULER` package.

See Also: *Oracle Database Utilities* for details on Data Pump

Troubleshooting the Scheduler

This section contains the following troubleshooting topics:

- Understanding Why a Job Fails to Run
- Job Recovery After a Failure
- Understanding Why a Program Becomes Disabled
- Understanding Why a Window Fails to Take Effect

Understanding Why a Job Fails to Run

A job may fail to run for several reasons. Before troubleshooting a job that you suspect did not run, check that the job is not running by issuing the following statement:

```
SELECT JOB_NAME, STATE FROM DBA_SCHEDULER_JOBS;
```

Typical output will resemble the following:

```
JOB_NAME                       STATE
------------------------------ ---------
MY_EMP_JOB                     DISABLED
MY_EMP_JOB1                    FAILED
MY_NEW_JOB1                    DISABLED
MY_NEW_JOB2                    BROKEN
MY_NEW_JOB3                    COMPLETED
```

There are four types of jobs that are not running:

- Failed Jobs
- Broken Jobs
- Disabled Jobs
- Completed Jobs

See Also: "Job Recovery After a Failure" on page 28-18

Failed Jobs

If a job has the status of FAILED in the job table, it was scheduled to run once but the execution has failed. If the job was specified as restartable, all retries have failed.

If a job fails in the middle of execution, only the last transaction of that job is rolled back. If your job executes multiple transactions, you need to be careful about setting restartable to TRUE. You can query failed jobs by querying the *_SCHEDULER_JOB_RUN_DETAILS views.

Broken Jobs

A broken job is one that has exceeded a certain number of failures. This number is set in max_failures, and can be altered. In the case of a broken job, the entire job is broken, and it will not be run until it has been fixed. For debugging and testing, you can use the RUN_JOB procedure.

You can query broken jobs by querying the *_SCHEDULER_JOBS and *_SCHEDULER_JOB_LOG views.

Disabled Jobs

A job can become disabled for the following reasons:

- The job was manually disabled
- The job class it belongs to was dropped
- The program, chain, or schedule that it points to was dropped
- A window or window group is its schedule and the window or window group is dropped

Completed Jobs

A job will be completed if end_date or max_runs is reached. (If a job recently completed successfully but is scheduled to run again, the job state is SCHEDULED.)

Job Recovery After a Failure

The Scheduler attempts to recover jobs that are interrupted when:

- The database abnormally shuts down
- A job slave process is killed or otherwise fails
- For an external job, the external job process that starts the executable or script is killed or otherwise fails. (The external job process is extjob on Unix. On Windows, it is the external job service.)
- For an external job, the process that runs the end-user executable or script is killed or otherwise fails.

Job recovery proceeds as follows:

- The Scheduler adds an entry to the job log for the instance of the job that was running when the failure occurred. In the log entry, the OPERATION is 'RUN', the STATUS is 'STOPPED', and ADDITIONAL_INFO contains one of the following:
  - REASON="Job slave process was terminated"
  - REASON="ORA-01014: ORACLE shutdown in progress"
- If restartable is set to TRUE for the job, the job is restarted.
- If restartable is set to FALSE for the job:
  - If the job is a run-once job and auto_drop is set to TRUE, the job run is done and the job is dropped.
  - If the job is a run-once job and auto_drop is set to FALSE, the job is disabled and the job state is set to 'STOPPED'.
  - If the job is a repeating job, the Scheduler schedules the next job run and the job state is set to 'SCHEDULED'.

When a job is restarted as a result of this recovery process, the new run is entered into the job log with the operation 'RECOVERY_RUN'.

Understanding Why a Program Becomes Disabled

A program can become disabled if a program argument is dropped or number_of_arguments is changed so that all arguments are no longer defined.

See "Using Programs" on page 27-12 for more information regarding programs.

Understanding Why a Window Fails to Take Effect

A window can fail to take effect for the following reasons:

- A window becomes disabled when it is at the end of its schedule
- A window that points to a schedule that no longer exists is disabled

See "Using Windows" on page 27-22 for more information regarding windows.

Examples of Using the Scheduler

This section discusses the following topics:

- Examples of Creating Jobs
- Examples of Creating Job Classes
- Examples of Creating Programs
- Examples of Creating Windows
- Examples of Setting Attributes
- Examples of Creating Chains
- Examples of Creating Jobs and Schedules Based on Events
- Example of Creating a Job In an Oracle Data Guard Environment

Examples of Creating Jobs

This section contains several examples of creating jobs. To create a job, you use the `CREATE_JOB` or the `CREATE_JOBS` procedures.

Example 28–1 Creating a Single Regular Job

The following statement creates a single regular job called `my_job1` in the `oe` schema:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB (
   job_name             => 'oe.my_job1',
   job_type             => 'PLSQL_BLOCK',
   job_action           => 'BEGIN DBMS_STATS.GATHER_TABLE_STATS(''oe'',
                            ''sales''); END;',
   start_date           => '15-JUL-03 1.00.00AM US/Pacific',
   repeat_interval      => 'FREQ=DAILY',
   end_date             => '15-SEP-03 1.00.00AM US/Pacific',
   enabled              =>  TRUE,
   comments             => 'Gather table statistics');
END;
/
```

This job gathers table statistics on the `sales` table. It will run for the first time on July 15th and then once a day until September 15. To verify that the job was created, issue the following statement:

```
SELECT JOB_NAME FROM DBA_SCHEDULER_JOBS WHERE JOB_NAME = 'MY_JOB1';

JOB_NAME
------------------------------
MY_JOB1
```

Example 28–2 Creating a Set of Regular Jobs

The following example creates a set of regular jobs:

```
DECLARE
 newjob sys.job;
 newjobarr sys.job_array;
BEGIN
 -- Create an array of JOB object types
 newjobarr := sys.job_array();
 -- Allocate sufficient space in the array
 newjobarr.extend(5);

 -- Add definitions for 5 jobs
 FOR i IN 1..5 LOOP
   -- Create a JOB object type
   newjob := sys.job(job_name => 'TESTJOB' || to_char(i),
                     job_style => 'REGULAR',
                     job_template => 'PROG1',
                     repeat_interval => 'FREQ=MINUTELY;INTERVAL_15',
                     start_date => systimestamp + interval '600' second,
                     max_runs => 2,
                     auto_drop => FALSE,
                     enabled _> TRUE
                    );

   -- Add it to the array
   newjobarr(i) := newjob;
 END LOOP;

 -- Call CREATE_JOBS to create jobs in one transaction
 DBMS_SCHEDULER.CREATE_JOBS(newjobarr, 'TRANSACTIONAL');
END;
/
```

Example 28–3 Creating a Set of Lightweight Jobs

The following example creates a set of lightweight jobs in one transaction:

```
DECLARE
 newjob sys.job;
 newjobarr sys.job_array;
BEGIN
 newjobarr := sys.job_array();
 newjobarr.extend(5);
 FOR i IN 1..5 LOOP
   newjob := sys.job(job_name => 'lwjob_' || to_char(i),
                     job_style => 'LIGHTWEIGHT',
                     job_template => 'PROG1',
                     repeat_interval => 'FREQ=MINUTELY;INTERVAL=15',
                     start_date => systimestamp + interval '10' second,
                     enabled => TRUE
                    );
   newjobarr(i) := newjob;
 end loop;

 DBMS_SCHEDULER.CREATE_JOBS(newjobarr, 'TRANSACTIONAL');
END;
/
```

See Also: *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `CREATE_JOB` procedure and "Creating Jobs" on page 27-2 for further information

Examples of Creating Job Classes

This section contains several examples of creating job classes. To create a job class, you use the `CREATE_JOB_CLASS` procedure.

Example 28–4 Creating a Job Class

The following statement creates a job class:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB_CLASS (
   job_class_name             =>  'my_class1',
   service                    =>  'my_service1',
   comments                   =>  'This is my first job class');
END;
/
```

This creates `my_class1` in `SYS`. It uses a service called `my_service1`. To verify that the job class was created, issue the following statement:

```
SELECT JOB_CLASS_NAME FROM DBA_SCHEDULER_JOB_CLASSES
WHERE JOB_CLASS_NAME = 'MY_CLASS1';

JOB_CLASS_NAME
------------------------------
MY_CLASS1
```

Example 28–5 Creating a Job Class

The following statement creates a job class:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB_CLASS (
   job_class_name            =>  'finance_jobs',
   resource_consumer_group   =>  'finance_group',
   service                   =>  'accounting',
   comments                  =>  'All finance jobs');
END;
/
```

This creates `finance_jobs` in `SYS`. It assigns a resource consumer group called `finance_group`, and designates service affinity for the `accounting` service. Note that if the `accounting` service is mapped to a resource consumer group other than `finance_group`, jobs in this class run under the `finance_group` consumer group, because the `resource_consumer_group` attribute takes precedence.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `CREATE_JOB_CLASS` procedure and "Creating Job Classes" on page 27-22 for further information

Examples of Creating Programs

This section contains several examples of creating programs. To create a program, you use the `CREATE_PROGRAM` procedure.

Example 28–6 Creating a Program

The following statement creates a program in the `oe` schema:

```
BEGIN
DBMS_SCHEDULER.CREATE_PROGRAM (
   program_name          => 'oe.my_program1',
   program_type          => 'PLSQL_BLOCK',
   program_action        => 'BEGIN DBMS_STATS.GATHER_TABLE_STATS(''oe'',
                             ''sales''); END;',
   number_of_arguments   => 0,
   enabled               => TRUE,
   comments              => 'My comments here');
END;
/
```

This creates `my_program1`, which uses PL/SQL to gather table statistics on the `sales` table. To verify that the program was created, issue the following statement:

```
SELECT PROGRAM_NAME FROM DBA_SCHEDULER_PROGRAMS
WHERE PROGRAM_NAME = 'MY_PROGRAM1';

PROGRAM_NAME
-------------------------
MY_PROGRAM1
```

Example 28–7 Creating a Program

The following statement creates a program in the `oe` schema:

```
BEGIN
DBMS_SCHEDULER.CREATE_PROGRAM (
   program_name           => 'oe.my_saved_program1',
   program_action         => '/usr/local/bin/date',
   program_type           => 'EXECUTABLE',
   comments               => 'My comments here');
END;
/
```

This creates `my_saved_program1`, which uses an executable.

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `CREATE_PROGRAM` procedure and "Creating Programs" on page 27-12 for further information

Examples of Creating Windows

This section contains several examples of creating windows. To create a window, you use the `CREATE_WINDOW` procedure.

Example 28–8 Creating a Window

The following statement creates a window called `my_window1` in `SYS`:

```
BEGIN
DBMS_SCHEDULER.CREATE_WINDOW (
   window_name          =>  'my_window1',
   resource_plan        =>  'my_res_plan1',
   start_date           =>  '15-JUL-03 1.00.00AM US/Pacific',
   repeat_interval      =>  'FREQ=DAILY',
   end_date             =>  '15-SEP-03 1.00.00AM US/Pacific',
   duration             =>  interval '80' MINUTE,
   comments             =>  'This is my first window');
END;
/
```

This window will open once a day at 1AM for 80 minutes every day from May 15th to October 15th. To verify that the window was created, issue the following statement:

```
SELECT WINDOW_NAME FROM DBA_SCHEDULER_WINDOWS WHERE WINDOW_NAME = 'MY_WINDOW1';

WINDOW_NAME
------------------------------
```

```
MY_WINDOW1
```

Example 28–9 Creating a Window

The following statement creates a window called `my_window2` in `SYS`:

```
BEGIN
DBMS_SCHEDULER.CREATE_WINDOW (
   window_name       => 'my_window2',
   schedule_name     => 'my_stats_schedule',
   resource_plan     => 'my_resourceplan1',
   duration          => interval '60' minute,
   comments          => 'My window');
END;
/
```

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `CREATE_WINDOW` procedure and "Creating Windows" on page 27-23 for further information

Example of Creating Window Groups

This section contains an example of creating a window group. To create a window group, you use the `CREATE_WINDOW_GROUP` procedure.

Example 28–10 Creating a Window Group

The following statement creates a window group called `my_window_group1`:

```
BEGIN
DBMS_SCHEDULER.CREATE_WINDOW_GROUP ('my_windowgroup1');
END;
/
```

Then, you could add three windows (`my_window1`, `my_window2`, and `my_window3`) to `my_window_group1` by issuing the following statements:

```
BEGIN
DBMS_SCHEDULER.ADD_WINDOW_GROUP_MEMBER (
   group_name   =>  'my_window_group1',
   window_list  =>  'my_window1, my_window2');

DBMS_SCHEDULER.ADD_WINDOW_GROUP_MEMBER (
   group_name   =>  'my_window_group1',
   window_list  =>  'my_window3');
END;
/
```

To verify that the window group was created and the windows added to it, issue the following statement:

```
SELECT * FROM DBA_SCHEDULER_WINDOW_GROUPS;

WINDOW_GROUP_NAME    ENABLED   NUMBER_OF_WINDOWS   COMMENTS
-----------------    -------   -----------------   ---------------
MY_WINDOW_GROUP1     TRUE                      3   This is my first window group
```

> **See Also:** *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `CREATE_WINDOW_GROUP` and `ADD_WINDOW_GROUP_MEMBER` procedures and "Creating Window Groups" on page 27-30 for further information

Examples of Setting Attributes

This section contains several examples of setting attributes. To set attributes, you use `SET_ATTRIBUTE` and `SET_SCHEDULER_ATTRIBUTE` procedures.

Example 28–11 Setting the Repeat Interval Attribute

The following example resets the frequency `my_emp_job1` will run to daily:

```
BEGIN
DBMS_SCHEDULER.SET_ATTRIBUTE (
   name           =>   'my_emp_job1',
   attribute      =>   'repeat_interval',
   value          =>   'FREQ=DAILY');
END;
/
```

To verify the change, issue the following statement:

```
SELECT JOB_NAME, REPEAT_INTERVAL FROM DBA_SCHEDULER_JOBS
WHERE JOB_NAME =  'MY_EMP_JOB1';

JOB_NAME             REPEAT_INTERVAL
----------------     ---------------
MY_EMP_JOB1          FREQ=DAILY
```

Example 28–12 Setting the Comments Attribute

The following example resets the comments for `my_saved_program1`:

```
BEGIN
DBMS_SCHEDULER.SET_ATTRIBUTE (
   name           =>   'my_saved_program1',
   attribute      =>   'comments',
   value          =>   'For nightly table stats');
END;
/
```

To verify the change, issue the following statement:

```
SELECT PROGRAM_NAME, COMMENTS FROM DBA_SCHEDULER_PROGRAMS;

PROGRAM_NAME        COMMENTS
------------        -----------------------
MY_PROGRAM1         My comments here
MY_SAVED_PROGRAM1   For nightly table stats
```

Example 28–13 Setting the Duration Attribute

The following example resets the duration of `my_window3` to 90 minutes:

```
BEGIN
DBMS_SCHEDULER.SET_ATTRIBUTE (
   name           =>   'my_window3',
   attribute      =>   'duration',
   value          =>   interval '90' minute);
END;
/
```

To verify the change, issue the following statement:

```
SELECT WINDOW_NAME, DURATION FROM DBA_SCHEDULER_WINDOWS
WHERE WINDOW_NAME = 'MY_WINDOW3';
```

```
WINDOW_NAME        DURATION
-----------        ---------------
MY_WINDOW3         +000 00:90:00
```

Example 28–14   Setting the Database Role Attribute

The following example sets the database role of the job `my_job` to `LOGICAL STANDBY`.

```
BEGIN
DBMS_SCHEDULER.SET_ATTRIBUTE (
   name        => 'my_job',
   attribute   => 'database_role',
   value       =>'LOGICAL STANDBY');
END;
/
```

To verify the change in database role, issue the following command:

```
SELECT JOB_NAME, DATABASE_ROLE FROM DBA_SCHEDULER_JOB_ROLES
    WHERE JOB_NAME = 'MY_JOB';

JOB_NAME             DATABASE_ROLE
--------             -----------------
MY_JOB               LOGICAL STANDBY
```

Example 28–15   Setting the Event Expiration Attribute

The following example sets the time in seconds to 3600 when an event expires:

```
BEGIN
DBMS_SCHEDULER.SET_SCHEDULER_ATTRIBUTE (
   attribute     =>   event_expiry_time,
   value         =>   3600);
END;
/
```

Example 28–16   Setting Multiple Job Attributes for a Set of Regular Jobs

The following example sets four different attributes for each of the five regular jobs created in Example 28–2, "Creating a Set of Regular Jobs" on page 28-19:

```
DECLARE
 newattr sys.jobattr;
 newattrarr sys.jobattr_array;
 j number;
BEGIN
 -- Create new JOBATTR array
 newattrarr := sys.jobattr_array();

 -- Allocate enough space in the array
 newattrarr.extend(20);
 j := 1;
 FOR i IN 1..5 LOOP
   -- Create and initialize a JOBATTR object type
   newattr := sys.jobattr(job_name => 'TESTJOB' || to_char(i),
                          attr_name => 'MAX_FAILURES',
                          attr_value => 5);
   -- Add it to the array.
   newattrarr(j) := newattr;
   j := j + 1;
   newattr := sys.jobattr(job_name => 'TESTJOB' || to_char(i),
                          attr_name => 'COMMENTS',
                          attr_value => 'Bogus comment');
   newattrarr(j) := newattr;
   j := j + 1;
   newattr := sys.jobattr(job_name => 'TESTJOB' || to_char(i),
                          attr_name => 'END_DATE',
                          attr_value => systimestamp + interval '24' hour);
   newattrarr(j) := newattr;
   j := j + 1;
   newattr := sys.jobattr(job_name => 'TESTJOB' || to_char(i),
                          attr_name => 'SCHEDULE_LIMIT',
                          attr_value => interval '1' hour);
   newattrarr(j) := newattr;
   j := j + 1;
 END LOOP;

 -- Call SET_JOB_ATTRIBUTES to set all 20 set attributes in one transaction
 DBMS_SCHEDULER.SET_JOB_ATTRIBUTES(newattrarr, 'TRANSACTIONAL');
END;
/
```

Example 28–17 Setting Attributes for a Set of Lightweight Jobs

The following example sets multiple attributes for a set of lightweight jobs. Note that not all regular job attributes are supported for lightweight jobs:

```
DECLARE
 newattr sys.jobattr;
 newattrarr sys.jobattr_array;
 j number;
BEGIN
 -- Create new JOBATTR array
 newattrarr := sys.jobattr_array();

 -- Allocate enough space in the array
 newattrarr.extend(10);
 j := 1;
 FOR i IN 1..5 LOOP
   -- Create and initialize JOBATTR object type
   newattr := sys.jobattr(job_name => 'lwjob_' || to_char(i),
                          attr_name => 'END_DATE',
                          attr_value => systimestamp + interval '24' hour);
   -- Add it to array.
   newattrarr(j) := newattr;
   j := j + 1;

   newattr := sys.jobattr(job_name => 'lwjob_' || to_char(i),
                          attr_name => 'RESTARTABLE',
                          attr_value => TRUE);
   newattrarr(j) := newattr;
   j := j + 1;
 END LOOP;

 -- Call SET_JOB_ATTRIBUTES to set all 20 set attributes in one transaction
 DBMS_SCHEDULER.SET_JOB_ATTRIBUTES(newattrarr, 'TRANSACTIONAL');
END;
/
```

See Also: *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `SET_SCHEDULER_ATTRIBUTE` procedure and "Task 2E: Setting Scheduler Attributes" on page 28-5

Examples of Creating Chains

This section contains examples of creating chains. To create chains, you use the `CREATE_CHAIN` procedure. After creating a chain, you add steps to the chain with the `DEFINE_CHAIN_STEP` procedure and define the rules with the `DEFINE_CHAIN_RULE` procedure.

Example 28–18 Creating a Chain

The following example creates a chain where `my_program1` runs before `my_program2` and `my_program3`. `my_program2` and `my_program3` run in parallel after `my_program1` has completed.

```
BEGIN
DBMS_SCHEDULER.CREATE_CHAIN (
   chain_name            =>  'my_chain1',
   rule_set_name         =>  NULL,
   evaluation_interval   =>  NULL,
   comments              =>  NULL);
END;
/

--- define three steps for this chain.
BEGIN
DBMS_SCHEDULER.DEFINE_CHAIN_STEP('my_chain1', 'step1', 'my_program1');
DBMS_SCHEDULER.DEFINE_CHAIN_STEP('my_chain1', 'step2', 'my_program2');
DBMS_SCHEDULER.DEFINE_CHAIN_STEP('my_chain1', 'step3', 'my_program3');
END;
/

--- define corresponding rules for the chain.
BEGIN
DBMS_SCHEDULER.DEFINE_CHAIN_RULE('my_chain1', 'TRUE', 'START step1');
DBMS_SCHEDULER.DEFINE_CHAIN_RULE (
   'my_chain1', 'step1 COMPLETED', 'Start step2, step3');
DBMS_SCHEDULER.DEFINE_CHAIN_RULE (
   'my_chain1', 'step2 COMPLETED AND step3 COMPLETED', 'END');
END;
/
```

Example 28–19 Creating a Chain

The following example creates a chain where first `my_program1` runs. If it succeeds, `my_program2` runs; otherwise, `my_program3` runs.

```
BEGIN
DBMS_SCHEDULER.CREATE_CHAIN (
   chain_name            => 'my_chain2',
   rule_set_name         => NULL,
   evaluation_interval   => NULL,
   comments              => NULL);
END;
/

--- define three steps for this chain.
BEGIN
```

```
DBMS_SCHEDULER.DEFINE_CHAIN_STEP('my_chain2', 'step1', 'my_program1');
DBMS_SCHEDULER.DEFINE_CHAIN_STEP('my_chain2', 'step2', 'my_program2');
DBMS_SCHEDULER.DEFINE_CHAIN_STEP('my_chain2', 'step3', 'my_program3');
END;
/

--- define corresponding rules for the chain.
BEGIN
DBMS_SCHEDULER.DEFINE_CHAIN_RULE ('my_chain2', 'TRUE', 'START step1');
DBMS_SCHEDULER.DEFINE_CHAIN_RULE (
   'my_chain2', 'step1 SUCCEEDED', 'Start step2');
DBMS_SCHEDULER.DEFINE_CHAIN_RULE (
   'my_chain2', 'step1 COMPLETED AND step1 NOT SUCCEEDED', 'Start step3');
DBMS_SCHEDULER.DEFINE_CHAIN_RULE (
   'my_chain2', 'step2 COMPLETED OR step3 COMPLETED', 'END');
END;
/
```

See Also: *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `CREATE_CHAIN`, `DEFINE_CHAIN_STEP`, and `DEFINE_CHAIN_RULE` procedures and "Task 2E: Setting Scheduler Attributes" on page 28-5

Examples of Creating Jobs and Schedules Based on Events

This section contains examples of creating event-based jobs and event schedules. To create event-based jobs, you use the `CREATE_JOB` procedure. To create event-based schedules, you use the `CREATE_EVENT_SCHEDULE` procedure.

These examples assume the existence of an application that, when it detects the arrival of a file on a system, enqueues an event onto the queue `my_events_q`.

Example 28–20 Creating an Event-Based Schedule

The following example illustrates creating a schedule that can be used to start a job whenever the Scheduler receives an event indicating that a file arrived on the system before 9AM:

```
BEGIN
DBMS_SCHEDULER.CREATE_EVENT_SCHEDULE (
   schedule_name     =>  'scott.file_arrival',
   start_date        =>  systimestamp,
   event_condition   =>  'tab.user_data.object_owner = ''SCOTT''
      and tab.user_data.event_name = ''FILE_ARRIVAL''
      and extract hour from tab.user_data.event_timestamp < 9',
   queue_spec        =>  'my_events_q');
END;
/
```

Example 28–21 Creating an Event-Based Job

The following example creates a job that starts when the Scheduler receives an event indicating that a file arrived on the system:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB (
   job_name            =>  my_job,
   program_name        =>  my_program,
   start_date          =>  '15-JUL-04 1.00.00AM US/Pacific',
   event_condition     =>  'tab.user_data.event_name = ''FILE_ARRIVAL''',
   queue_spec          =>  'my_events_q'
   enabled             =>  TRUE,
   comments            =>  'my event-based job');
END;
/
```

See Also: *Oracle Database PL/SQL Packages and Types Reference* for detailed information about the `CREATE_JOB` and `CREATE_EVENT_SCHEDULE` procedures

Example of Creating a Job In an Oracle Data Guard Environment

In an Oracle Data Guard environment, the Scheduler includes additional support for two database roles: primary and logical standby. You can configure a job to run only when the database is in the primary role or only when the database is in the logical standby role. To do so, you set the `database_role` attribute. This example explains how to enable a job to run in both database roles. The method used is to create two copies of the job and assign a different `database_role` attribute to each.

By default, a job runs when the database is in the role that it was in when the job was created. You can run the same job in both roles using the following steps:

1. Copy the job
2. Enable the new job
3. Change the `database_role` attribute of the new job to the required role

The example starts by creating a job called `primary_job` on the primary database. It then makes a copy of this job and sets its `database_role` attribute to '`LOGICAL STANDBY`'. If the primary database then becomes a logical standby, the job continues to run according to its schedule.

When you copy a job, the new job is disabled, so you must enable the new job.

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB (
     job_name       => 'primary_job',
     program_name   => 'my_prog',
     schedule_name  => 'my_sched');

DBMS_SCHEDULER.COPY_JOB('primary_job','standby_job');
DBMS_SCHEDULER.ENABLE(name=>'standby_job', commit_semantics=>'ABSORB_ERRORS');
DBMS_SCHEDULER.SET_ATTRIBUTE('standby_job','database_role','LOGICAL STANDBY');
END;
/
```

After you execute this example, the data in the `DBA_SCHEDULER_JOB_ROLES` view is as follows:

```
SELECT JOB_NAME, DATABASE_ROLE FROM DBA_SCHEDULER_JOB_ROLES
   WHERE JOB_NAME IN ('PRIMARY_JOB','STANDBY_JOB');

JOB_NAME                DATABASE_ROLE
--------                ----------------
PRIMARY_JOB             PRIMARY
STABDBY_JOB             LOGICAL STANDBY
```

Note: For a physical standby database, any changes made to Scheduler objects or any database changes made by Scheduler jobs on the primary database are applied to the physical standby like any other database changes.

Scheduler Reference

This section contains reference information for Oracle Scheduler. It contains the following topics:

- Scheduler Privileges
- Scheduler Data Dictionary Views

Scheduler Privileges

Table 28–2 lists the various Scheduler privileges.

Table 28–2 Scheduler Privileges

Privilege Name	Operations Authorized
System Privileges:	
`CREATE JOB`	This privilege enables you to create jobs, chains, schedules, programs, and credentials in your own schema. You will always be able to alter and drop jobs, schedules and programs in your own schema, even if you do not have the `CREATE JOB` privilege. In this case, the job must have been created in your schema by another user with the `CREATE ANY JOB` privilege.
`CREATE ANY JOB`	This privilege enables you to create, alter, and drop jobs, chains, schedules, programs, and regular credentials in any schema except `SYS`. This privilege is very powerful and should be used with care because it allows the grantee to execute code as any other user.
`CREATE EXTERNAL JOB`	This privilege is required to create jobs that run outside of the database. Owners of jobs of type '`EXECUTABLE`' or jobs that point to programs of type '`EXECUTABLE`' require this privilege. To run a job of type '`EXECUTABLE`', you must have this privilege and the `CREATE JOB` privilege. This privilege is also required to retrieve files from a remote host and to save files to one or more remote hosts.
`EXECUTE ANY PROGRAM`	This privilege enables your jobs to use programs or chains from any schema.
`EXECUTE ANY CLASS`	This privilege enables your jobs to run under any job class.
`MANAGE SCHEDULER`	This is the most important privilege for administering the Scheduler. It enables you to create, alter, and drop job classes, windows, and window groups. It also enables you to set and retrieve Scheduler attributes, purge Scheduler logs, drop public credentials, set the agent password for a database.
Object Privileges:	

Table 28–2 (Cont.) Scheduler Privileges

Privilege Name	Operations Authorized
EXECUTE	This privilege can only be granted for programs, chains, and job classes. It enables you to create a job that runs with the program, chain, or job class. It also enables you to view object attributes.
ALTER	This privilege enables you to alter or drop the object it is granted on. Altering includes such operations as enabling, disabling, defining or dropping program arguments, setting or resetting job argument values and running a job. For programs, jobs, and chains, this privilege enables you to view object attributes. This privilege can only be granted on jobs, chains, programs and schedules. For other types of Scheduler objects, you can grant the MANAGE SCHEDULER system privilege. This privilege can be granted for:
	jobs (DROP_JOB, RUN_JOB, ALTER_RUNNING_CHAIN, SET_JOB_ARGUMENT_VALUE, RESET_JOB_ARGUMENT_VALUE, SET_JOB_ANYDATA_VALUE) and (STOP_JOB without the force option)
	chains (DROP_CHAIN, ALTER_CHAIN, DEFINE_CHAIN_RULE, DEFINE_CHAIN_STEP, DEFINE_CHAIN_EVENT_STEP, DROP_CHAIN_RULE, and DROP_CHAIN_STEP)
	programs (DROP_PROGRAM, DEFINE_PROGRAM_ARGUMENT, DEFINE_ANYDATA_ARGUMENT, DEFINE_METADATA_ARGUMENT, DROP_PROGRAM_ARGUMENT, SET_ATTRIBUTE_NULL)
	schedules (DROP_SCHEDULE)
ALL	This privilege authorizes operations allowed by all other object privileges possible for a given object. It can be granted on jobs, programs, chains, schedules and job classes.

The SCHEDULER_ADMIN role is created with all of the system privileges shown in Table 28–2 (with the ADMIN option). The SCHEDULER_ADMIN role is granted to DBA (with the ADMIN option).

The following object privileges are granted to PUBLIC: SELECT ALL_SCHEDULER_* views, SELECT USER_SCHEDULER_* views, SELECT SYS.SCHEDULER$_JOBSUFFIX_S (for generating a job name), and EXECUTE SYS.DEFAULT_JOB_CLASS.

Scheduler Data Dictionary Views

You can check Scheduler information by using many views. An example is the following, which shows information for completed instances of my_job1:

```
SELECT JOB_NAME, STATUS, ERROR#
FROM DBA_SCHEDULER_JOB_RUN_DETAILS WHERE JOB_NAME = 'MY_JOB1';

JOB_NAME     STATUS           ERROR#
--------     --------------   ------
MY_JOB1      FAILURE           20000
```

Table 28–3 contains views associated with the Scheduler. The *_SCHEDULER_JOBS, *_SCHEDULER_SCHEDULES, *_SCHEDULER_PROGRAMS, *_SCHEDULER_RUNNING_JOBS, *_SCHEDULER_JOB_LOG, *_SCHEDULER_JOB_RUN_DETAILS views are particularly useful for managing jobs. See *Oracle Database Reference* for details regarding Scheduler views.

Note: In the following table, the asterisk at the beginning of a view name can be replaced with DBA, ALL, or USER.

Table 28–3 Scheduler Views

View	Description
`*_SCHEDULER_SCHEDULES`	These views show all schedules.
`*_SCHEDULER_PROGRAMS`	These views show all programs.
`*_SCHEDULER_PROGRAM_ARGS`	These views show all arguments defined for all programs as well as the default values if they exist.
`*_SCHEDULER_JOBS`	These views show all jobs, enabled as well as disabled.
`*_SCHEDULER_RUNNING_CHAINS`	These views show all chains that are running.
`*_SCHEDULER_CHAIN_STEPS`	These views show all steps for all chains.
`*_SCHEDULER_CHAINS`	These views show all chains.
`*_SCHEDULER_CHAIN_RULES`	These views show all rules for all chains.
`*_SCHEDULER_GLOBAL_ATTRIBUTE`	These views show the current values of Scheduler attributes.
`*_SCHEDULER_JOB_ARGS`	These views show all set argument values for all jobs.
`*_SCHEDULER_JOB_CLASSES`	These views show all job classes.
`*_SCHEDULER_WINDOWS`	These views show all windows.
`*_SCHEDULER_JOB_RUN_DETAILS`	These views show all completed (failed or successful) job runs.
`*_SCHEDULER_WINDOW_GROUPS`	These views show all window groups.
`*_SCHEDULER_WINGROUP_MEMBERS`	These views show the members of all window groups, one row for each group member.
`*_SCHEDULER_RUNNING_JOBS`	These views show state information on all jobs that are currently being run.
`*_SCHEDULER_JOB_LOG`	These views show all state changes made to jobs.
`*_SCHEDULER_WINDOW_LOG`	These views show all state changes made to windows.
`*_SCHEDULER_WINDOW_DETAILS`	These views show all completed window runs.
`*_SCHEDULER_CREDENTIALS`	These views show all credentials.
`*_SCHEDULER_JOB_ROLES`	These views show all jobs by Oracle Data Guard database role .

Part V

Distributed Database Management

Part VII discusses the management of a distributed database environment. It contains the following sections:

29 Distributed Database Concepts

This chapter describes the basic concepts and terminology of Oracle Database distributed database architecture. It contains the following topics:

Distributed Database Architecture

A **distributed database system** allows applications to access data from local and remote databases. In a **homogenous distributed database system**, each database is an Oracle Database. In a **heterogeneous distributed database system**, at least one of the databases is not an Oracle Database. Distributed databases use a **client/server** architecture to process information requests.

This section contains the following topics:

Homogenous Distributed Database Systems

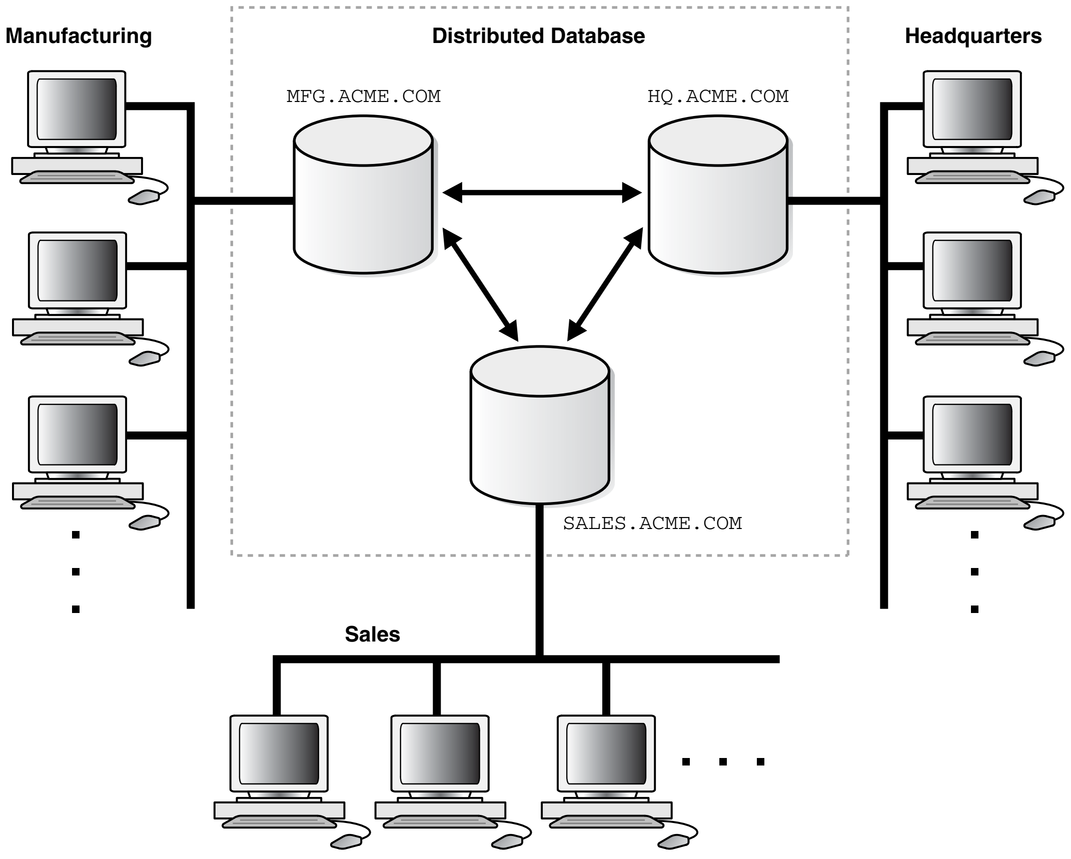
A homogenous distributed database system is a network of two or more Oracle Databases that reside on one or more machines. Figure 29–1 illustrates a distributed system that connects three databases: `hq`, `mfg`, and `sales`. An application can simultaneously access or modify the data in several databases in a single distributed environment. For example, a single query from a Manufacturing client on local database `mfg` can retrieve joined data from the `products` table on the local database and the `dept` table on the remote `hq` database.

For a client application, the location and platform of the databases are transparent. You can also create **synonyms** for remote objects in the distributed system so that users can access them with the same syntax as local objects. For example, if you are connected to database `mfg` but want to access data on database `hq`, creating a synonym on `mfg` for the remote `dept` table enables you to issue this query:

```
SELECT * FROM dept;
```

In this way, a distributed system gives the appearance of native data access. Users on `mfg` do not have to know that the data they access resides on remote databases.

Figure 29–1 Homogeneous Distributed Database



An Oracle Database distributed database system can incorporate Oracle Databases of different versions. All supported releases of Oracle Database can participate in a distributed database system. Nevertheless, the applications that work with the distributed database must understand the functionality that is available at each node in the system. A distributed database application cannot expect an Oracle7 database to understand the SQL extensions that are only available with Oracle Database.

Distributed Databases Versus Distributed Processing

The terms **distributed database** and **distributed processing** are closely related, yet have distinct meanings. There definitions are as follows:

- Distributed database

  A set of databases in a distributed system that can appear to applications as a single data source.

- Distributed processing

  The operations that occurs when an application distributes its tasks among different computers in a network. For example, a database application typically distributes front-end presentation tasks to client computers and allows a back-end database server to manage shared access to a database. Consequently, a distributed database application processing system is more commonly referred to as a client/server database application system.

Distributed database systems employ a distributed processing architecture. For example, an Oracle Database server acts as a client when it requests data that another Oracle Database server manages.

Distributed Databases Versus Replicated Databases

The terms distributed database system and **database replication** are related, yet distinct. In a **pure** (that is, not replicated) distributed database, the system manages a single copy of all data and supporting database objects. Typically, distributed database applications use distributed transactions to access both local and remote data and modify the global database in real-time.

Note: This book discusses only pure distributed databases.

The term **replication** refers to the operation of copying and maintaining database objects in multiple databases belonging to a distributed system. While replication relies on distributed database technology, database replication offers applications benefits that are not possible within a pure distributed database environment.

Most commonly, replication is used to improve local database performance and protect the availability of applications because alternate data access options exist. For example, an application may normally access a local database rather than a remote server to minimize network traffic and achieve maximum performance. Furthermore, the application can continue to function if the local server experiences a failure, but other servers with replicated data remain accessible.

See Also:

- *Oracle Database Advanced Replication* for more information about Oracle Database replication features
- *Oracle Streams Concepts and Administration* for information about Oracle Streams, another method of sharing information between databases

Heterogeneous Distributed Database Systems

In a heterogeneous distributed database system, at least one of the databases is a non-Oracle Database system. To the application, the heterogeneous distributed database system appears as a single, local, Oracle Database. The local Oracle Database server hides the distribution and heterogeneity of the data.

The Oracle Database server accesses the non-Oracle Database system using Oracle Heterogeneous Services in conjunction with an **agent**. If you access the non-Oracle Database data store using an Oracle Transparent Gateway, then the agent is a system-specific application. For example, if you include a Sybase database in an Oracle Database distributed system, then you need to obtain a Sybase-specific transparent gateway so that the Oracle Database in the system can communicate with it.

Alternatively, you can use **generic connectivity** to access non-Oracle Database data stores so long as the non-Oracle Database system supports the ODBC or OLE DB protocols.

Note: Other than the introductory material presented in this chapter, this book does not discuss Oracle Heterogeneous Services. See *Oracle Database Heterogeneous Connectivity Administrator's Guide* for more detailed information about Heterogeneous Services.

Heterogeneous Services

Heterogeneous Services (HS) is an integrated component within the Oracle Database server and the enabling technology for the current suite of Oracle Transparent Gateway products. HS provides the common architecture and administration mechanisms for Oracle Database gateway products and other heterogeneous access facilities. Also, it provides upwardly compatible functionality for users of most of the earlier Oracle Transparent Gateway releases.

Transparent Gateway Agents

For each non-Oracle Database system that you access, Heterogeneous Services can use a transparent gateway agent to interface with the specified non-Oracle Database system. The agent is specific to the non-Oracle Database system, so each type of system requires a different agent.

The transparent gateway agent facilitates communication between Oracle Database and non-Oracle Database systems and uses the Heterogeneous Services component in the Oracle Database server. The agent executes SQL and transactional requests at the non-Oracle Database system on behalf of the Oracle Database server.

See Also: Your Oracle-supplied gateway-specific documentation for information about transparent gateways

Generic Connectivity

Generic connectivity enables you to connect to non-Oracle Database data stores by using either a Heterogeneous Services ODBC agent or a Heterogeneous Services OLE DB agent. Both are included with your Oracle product as a standard feature. Any data source compatible with the ODBC or OLE DB standards can be accessed using a generic connectivity agent.

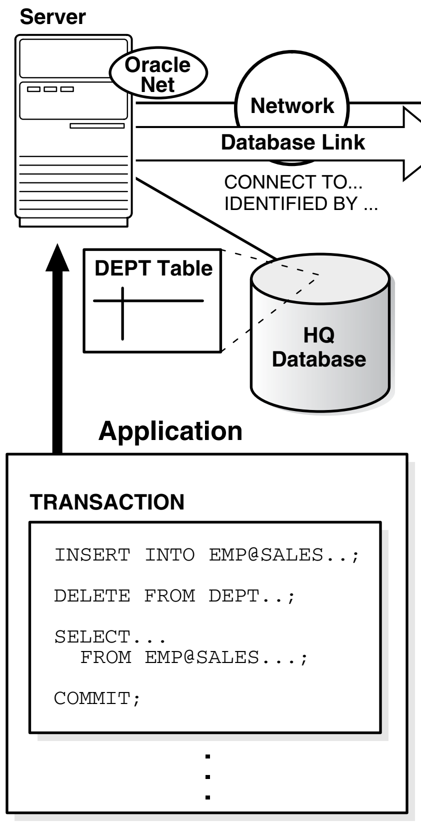
The advantage to generic connectivity is that it may not be required for you to purchase and configure a separate system-specific agent. You use an ODBC or OLE DB driver that can interface with the agent. However, some data access features are only available with transparent gateway agents.

Client/Server Database Architecture

A database server is the Oracle software managing a database, and a client is an application that requests information from a server. Each computer in a network is a node that can host one or more databases. Each node in a distributed database system can act as a client, a server, or both, depending on the situation.

In Figure 29–2, the host for the `hq` database is acting as a database server when a statement is issued against its local data (for example, the second statement in each transaction issues a statement against the local `dept` table), but is acting as a client when it issues a statement against remote data (for example, the first statement in each transaction is issued against the remote table `emp` in the `sales` database).

Figure 29–2 An Oracle Database Distributed Database System



```
INSERT INTO EMP@SALES..;

DELETE FROM DEPT..;

SELECT...
  FROM EMP@SALES...;

COMMIT;
```

A client can connect **directly** or **indirectly** to a database server. A direct connection occurs when a client connects to a server and accesses information from a database contained on that server. For example, if you connect to the `hq` database and access the `dept` table on this database as in Figure 29–2, you can issue the following:

```
SELECT * FROM dept;
```

This query is direct because you are not accessing an object on a remote database.

In contrast, an indirect connection occurs when a client connects to a server and then accesses information contained in a database on a different server. For example, if you connect to the `hq` database but access the `emp` table on the remote `sales` database as in Figure 29–2, you can issue the following:

```
SELECT * FROM emp@sales;
```

This query is indirect because the object you are accessing is not on the database to which you are directly connected.

Database Links

The central concept in distributed database systems is a **database link**. A database link is a connection between two physical database servers that allows a client to access them as one logical database.

This section contains the following topics:

- What Are Database Links?
- Why Use Database Links?

- Global Database Names in Database Links
- Names for Database Links
- Types of Database Links
- Users of Database Links
- Creation of Database Links: Examples
- Schema Objects and Database Links
- Database Link Restrictions

What Are Database Links?

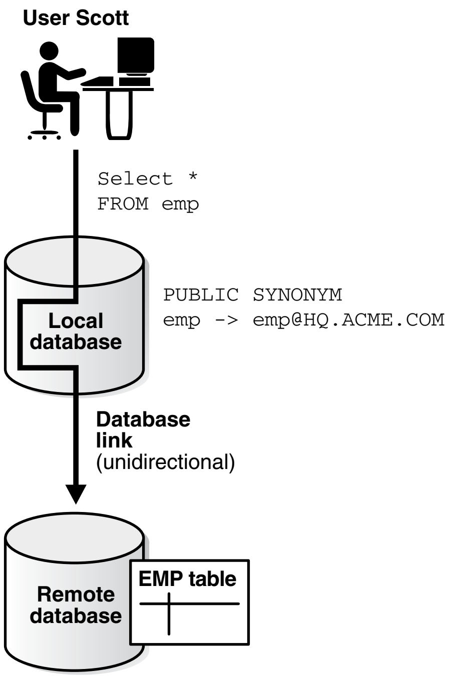
A database link is a pointer that defines a one-way communication path from an Oracle Database server to another database server. The link pointer is actually defined as an entry in a data dictionary table. To access the link, you must be connected to the local database that contains the data dictionary entry.

A database link connection is one-way in the sense that a client connected to local database A can use a link stored in database A to access information in remote database B, but users connected to database B cannot use the same link to access data in database A. If local users on database B want to access data on database A, then they must define a link that is stored in the data dictionary of database B.

A database link connection allows local users to access data on a remote database. For this connection to occur, each database in the distributed system must have a unique **global database name** in the network domain. The global database name uniquely identifies a database server in a distributed system.

Figure 29–3 shows an example of user `scott` accessing the `emp` table on the remote database with the global name `hq.acme.com`:

Figure 29–3 Database Link



Database links are either private or public. If they are private, then only the user who created the link has access; if they are public, then all database users have access.

One principal difference among database links is the way that connections to a remote database occur. Users access a remote database through the following types of links:

Type of Link	Description
Connected user link	Users connect as themselves, which means that they must have an account on the remote database with the same username as their account on the local database.
Fixed user link	Users connect using the username and password referenced in the link. For example, if Jane uses a fixed user link that connects to the `hq` database with the username and password `scott/tiger`, then she connects as `scott`, Jane has all the privileges in `hq` granted to `scott` directly, and all the default roles that `scott` has been granted in the `hq` database.
Current user link	A user connects as a global user. A local user can connect as a global user in the context of a stored procedure, without storing the global user's password in a link definition. For example, Jane can access a procedure that Scott wrote, accessing Scott's account and Scott's schema on the `hq` database. Current user links are an aspect of Oracle Advanced Security.

Create database links using the `CREATE DATABASE LINK` statement. After a link is created, you can use it to specify schema objects in SQL statements.

See Also:

- *Oracle Database SQL Language Reference* for syntax of the `CREATE DATABASE` statement
- *Oracle Database Advanced Security Administrator's Guide* for information about Oracle Advanced Security

What Are Shared Database Links?

A shared database link is a link between a local server process and the remote database. The link is shared because multiple client processes can use the same link simultaneously.

When a local database is connected to a remote database through a database link, either database can run in dedicated or shared server mode. The following table illustrates the possibilities:

Local Database Mode	Remote Database Mode
Dedicated	Dedicated
Dedicated	Shared server
Shared server	Dedicated
Shared server	Shared server

A shared database link can exist in any of these four configurations. Shared links differ from standard database links in the following ways:

- Different users accessing the same schema object through a database link can share a network connection.

- When a user needs to establish a connection to a remote server from a particular server process, the process can reuse connections already established to the remote server. The reuse of the connection can occur if the connection was established on the same server process with the same database link, possibly in a different session. In a non-shared database link, a connection is not shared across multiple sessions.
- When you use a shared database link in a shared server configuration, a network connection is established directly out of the shared server process in the local server. For a non-shared database link on a local shared server, this connection would have been established through the local dispatcher, requiring context switches for the local dispatcher, and requiring data to go through the dispatcher.

See Also: *Oracle Database Net Services Administrator's Guide* for information about shared server

Why Use Database Links?

The great advantage of database links is that they allow users to access another user's objects in a remote database so that they are bounded by the privilege set of the object owner. In other words, a local user can access a link to a remote database without having to be a user on the remote database.

For example, assume that employees submit expense reports to Accounts Payable (A/P), and further suppose that a user using an A/P application needs to retrieve information about employees from the `hq` database. The A/P users should be able to connect to the `hq` database and execute a stored procedure in the remote `hq` database that retrieves the desired information. The A/P users should not need to be `hq` database users to do their jobs; they should only be able to access `hq` information in a controlled way as limited by the procedure.

See Also:

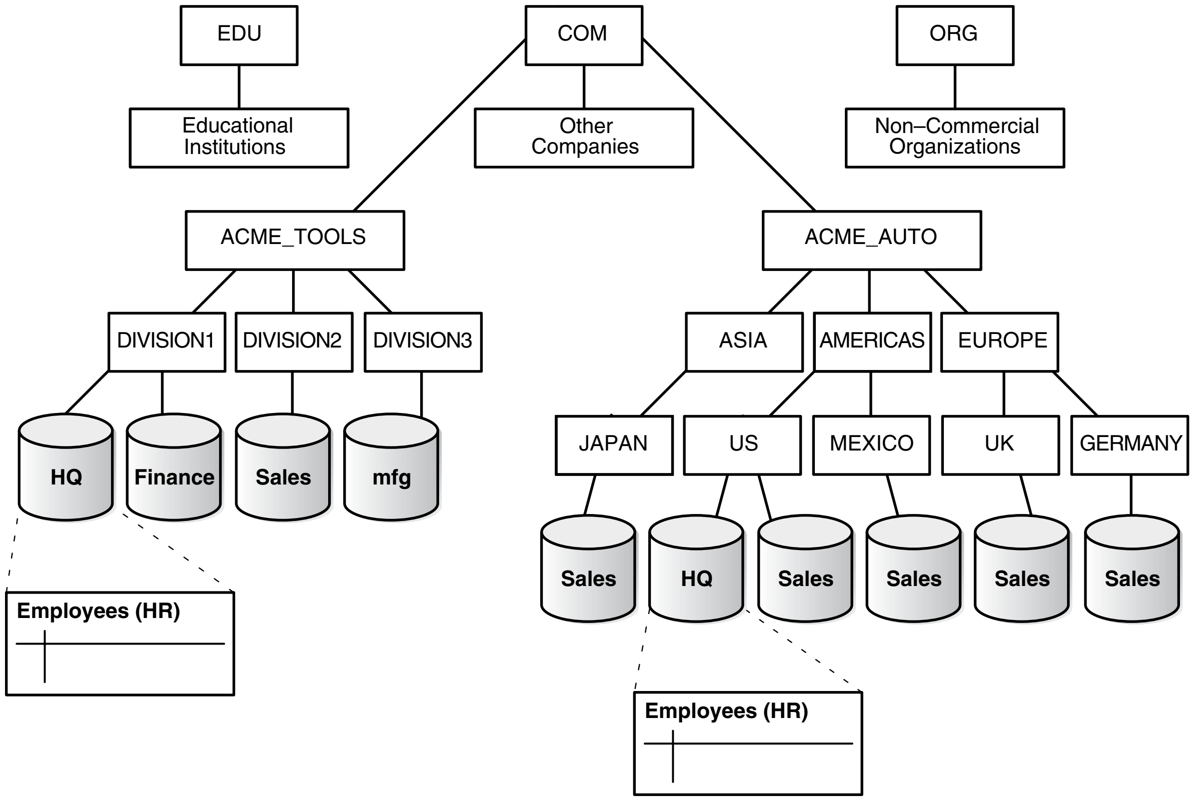
- "Users of Database Links" on page 29-11 for an explanation of database link users
- "Viewing Information About Database Links" for an explanation of how to hide passwords from non-administrative users

Global Database Names in Database Links

To understand how a database link works, you must first understand what a global database name is. Each database in a distributed database is uniquely identified by its global database name. The database forms a global database name by prefixing the database network domain, specified by the `DB_DOMAIN` initialization parameter at database creation, with the individual database name, specified by the `DB_NAME` initialization parameter.

For example, Figure 29–4 illustrates a representative hierarchical arrangement of databases throughout a network.

Figure 29–4 Hierarchical Arrangement of Networked Databases



The name of a database is formed by starting at the leaf of the tree and following a path to the root. For example, the `mfg` database is in `division3` of the `acme_tools` branch of the `com` domain. The global database name for `mfg` is created by concatenating the nodes in the tree as follows:

- `mfg.division3.acme_tools.com`

While several databases can share an individual name, each database must have a unique global database name. For example, the network domains `us.americas.acme_auto.com` and `uk.europe.acme_auto.com` each contain a `sales` database. The global database naming system distinguishes the `sales` database in the `americas` division from the `sales` database in the `europe` division as follows:

- `sales.us.americas.acme_auto.com`
- `sales.uk.europe.acme_auto.com`

See Also: "Managing Global Names in a Distributed System" on page 30-1 to learn how to specify and change global database names

Names for Database Links

Typically, a database link has the same name as the global database name of the remote database that it references. For example, if the global database name of a database is `sales.us.oracle.com`, then the database link is also called `sales.us.oracle.com`.

When you set the initialization parameter `GLOBAL_NAMES` to `TRUE`, the database ensures that the name of the database link is the same as the global database name of the remote database. For example, if the global database name for `hq` is `hq.acme.com`, and `GLOBAL_NAMES` is `TRUE`, then the link name must be called `hq.acme.com`. Note that the database checks the domain part of the global database name as stored in the data dictionary, *not* the `DB_DOMAIN` setting in the initialization parameter file (see "Changing the Domain in a Global Database Name" on page 30-3).

If you set the initialization parameter `GLOBAL_NAMES` to `FALSE`, then you are not required to use global naming. You can then name the database link whatever you want. For example, you can name a database link to `hq.acme.com` as `foo`.

Note: Oracle recommends that you use global naming because many useful features, including Replication, require global naming.

After you have enabled global naming, database links are essentially transparent to users of a distributed database because the name of a database link is the same as the global name of the database to which the link points. For example, the following statement creates a database link in the local database to remote database `sales`:

```
CREATE PUBLIC DATABASE LINK sales.division3.acme.com USING 'sales1';
```

See Also: *Oracle Database Reference* for more information about specifying the initialization parameter `GLOBAL_NAMES`

Types of Database Links

Oracle Database lets you create **private**, **public**, and **global** database links. These basic link types differ according to which users are allowed access to the remote database:

Type	Owner	Description
Private	User who created the link. View ownership data through: ■ `DBA_DB_LINKS` ■ `ALL_DB_LINKS` ■ `USER_DB_LINKS`	Creates link in a specific schema of the local database. Only the owner of a private database link or PL/SQL subprograms in the schema can use this link to access database objects in the corresponding remote database.
Public	User called PUBLIC. View ownership data through views shown for private database links.	Creates a database-wide link. All users and PL/SQL subprograms in the database can use the link to access database objects in the corresponding remote database.
Global	User called PUBLIC. View ownership data through views shown for private database links.	Creates a network-wide link. When an Oracle network uses a directory server, the directory server automatically create and manages global database links (as net service names) for every Oracle Database in the network. Users and PL/SQL subprograms in any database can use a global link to access objects in the corresponding remote database. **Note**: In earlier releases of Oracle Database, a global database link referred to a database link that was registered with an Oracle Names server. The use of an Oracle Names server has been deprecated. In this document, global database links refer to the use of net service names from the directory server.

Determining the type of database links to employ in a distributed database depends on the specific requirements of the applications using the system. Consider these features when making your choice:

Type of Link	Features
Private database link	This link is more secure than a public or global link, because only the owner of the private link, or subprograms within the same schema, can use the link to access the remote database.
Public database link	When many users require an access path to a remote Oracle Database, you can create a single public database link for all users in a database.
Global database link	When an Oracle network uses a directory server, an administrator can conveniently manage global database links for all databases in the system. Database link management is centralized and simple.

See Also:

- "Specifying Link Types" on page 30-7 to learn how to create different types of database links
- "Viewing Information About Database Links" on page 30-16 to learn how to access information about links

Users of Database Links

When creating the link, you determine which user should connect to the remote database to access the data. The following table explains the differences among the categories of users involved in database links:

User Type	Description	Sample Link Creation Syntax
Connected user	A local user accessing a database link in which no fixed username and password have been specified. If `SYSTEM` accesses a public link in a query, then the connected user is `SYSTEM`, and the database connects to the `SYSTEM` schema in the remote database. **Note:** A connected user does not have to be the user who created the link, but is any user who is accessing the link.	`CREATE PUBLIC DATABASE LINK hq USING 'hq';`
Current user	A global user in a `CURRENT_USER` database link. The global user must be authenticated by an X.509 certificate (an SSL-authenticated enterprise user) or a password (a password-authenticated enterprise user), and be a user on both databases involved in the link. Current user links are an aspect of the Oracle Advanced Security option. See *Oracle Database Advanced Security Administrator's Guide* for information about global security	`CREATE PUBLIC DATABASE LINK hq CONNECT TO CURRENT_USER using 'hq';`
Fixed user	A user whose username/password is part of the link definition. If a link includes a fixed user, the fixed user's username and password are used to connect to the remote database.	`CREATE PUBLIC DATABASE LINK hq CONNECT TO jane IDENTIFIED BY doe USING 'hq';`

See Also: "Specifying Link Users" on page 30-8 to learn how to specify users when creating links

Connected User Database Links

Connected user links have no connect string associated with them. The advantage of a connected user link is that a user referencing the link connects to the remote database as the same user, and credentials don't have to be stored in the link definition in the data dictionary.

Connected user links have some disadvantages. Because these links require users to have accounts and privileges on the remote databases to which they are attempting to connect, they require more privilege administration for administrators. Also, giving users more privileges than they need violates the fundamental security concept of least privilege: users should only be given the privileges they need to perform their jobs.

The ability to use a connected user database link depends on several factors, chief among them whether the user is authenticated by the database using a password, or externally authenticated by the operating system or a network authentication service. If the user is externally authenticated, then the ability to use a connected user link also depends on whether the remote database accepts remote authentication of users, which is set by the `REMOTE_OS_AUTHENT` initialization parameter.

The `REMOTE_OS_AUTHENT` parameter operates as follows:

REMOTE_OS_AUTHENT Value	Consequences
`TRUE` for the remote database	An externally-authenticated user can connect to the remote database using a connected user database link.
`FALSE` for the remote database	An externally-authenticated user cannot connect to the remote database using a connected user database link unless a secure protocol or a network authentication service supported by the Oracle Advanced Security option is used.

Note: The `REMOTE_OS_AUTHENT` initialization parameter is deprecated. It is retained for backward compatibility only.

Fixed User Database Links

A benefit of a fixed user link is that it connects a user in a primary database to a remote database with the security context of the user specified in the connect string. For example, local user `joe` can create a public database link in `joe`'s schema that specifies the fixed user `scott` with password `tiger`. If `jane` uses the fixed user link in a query, then `jane` is the user on the local database, but she connects to the remote database as `scott/tiger`.

Fixed user links have a username and password associated with the connect string. The username and password are stored with other link information in data dictionary tables.

Current User Database Links

Current user database links make use of a global user. A global user must be authenticated by an X.509 certificate or a password, and be a user on both databases involved in the link.

The user invoking the `CURRENT_USER` link does not have to be a global user. For example, if `jane` is authenticated (not as a global user) by password to the Accounts Payable database, she can access a stored procedure to retrieve data from the `hq` database. The procedure uses a current user database link, which connects her to `hq` as global user `scott`. User `scott` is a global user and authenticated through a certificate over SSL, but `jane` is not.

Note that current user database links have these consequences:

- If the current user database link is *not* accessed from within a stored object, then the current user is the same as the connected user accessing the link. For example, if `scott` issues a `SELECT` statement through a current user link, then the current user is `scott`.
- When executing a stored object such as a procedure, view, or trigger that accesses a database link, the current user is the user that *owns* the stored object, and not the user that *calls* the object. For example, if `jane` calls procedure `scott.p` (created by `scott`), and a current user link appears *within* the called procedure, then `scott` is the current user of the link.
- If the stored object is an invoker-rights function, procedure, or package, then the invoker's authorization ID is used to connect as a remote user. For example, if user `jane` calls procedure `scott.p` (an invoker-rights procedure created by `scott`), and the link appears inside procedure `scott.p`, then `jane` is the current user.
- You cannot connect to a database as an enterprise user and then use a current user link in a stored procedure that exists in a shared, global schema. For example, if user `jane` accesses a stored procedure in the shared schema `guest` on database `hq`, she cannot use a current user link in this schema to log on to a remote database.

See Also:

- "Distributed Database Security" on page 29-17 for more information about security issues relating to database links
- *Oracle Database Advanced Security Administrator's Guide*
- *Oracle Database PL/SQL Language Reference* for more information about invoker-rights functions, procedures, or packages.

Creation of Database Links: Examples

Create database links using the `CREATE DATABASE LINK` statement. The table gives examples of SQL statements that create database links in a local database to the remote `sales.us.americas.acme_auto.com` database:

SQL Statement	Connects To Database	Connects As	Link Type
`CREATE DATABASE LINK sales.us.americas.acme_auto.com USING 'sales_us';`	`sales` using net service name `sales_us`	Connected user	Private connected user
`CREATE DATABASE LINK foo CONNECT TO CURRENT_USER USING 'am_sls';`	`sales` using service name `am_sls`	Current global user	Private current user
`CREATE DATABASE LINK sales.us.americas.acme_auto.com CONNECT TO scott IDENTIFIED BY tiger USING 'sales_us';`	`sales` using net service name `sales_us`	`scott` using password `tiger`	Private fixed user
`CREATE PUBLIC DATABASE LINK sales CONNECT TO scott IDENTIFIED BY tiger USING 'rev';`	`sales` using net service name `rev`	`scott` using password `tiger`	Public fixed user

SQL Statement	Connects To Database	Connects As	Link Type
`CREATE SHARED PUBLIC DATABASE LINK sales.us.americas.acme_auto.com CONNECT TO scott IDENTIFIED BY tiger AUTHENTICATED BY anupam IDENTIFIED BY bhide USING 'sales';`	`sales` using net service name `sales`	`scott` using password `tiger`, authenticated as `anupam` using password `bhide`	Shared public fixed user

See Also:

- "Creating Database Links" on page 30-6 to learn how to create link
- *Oracle Database SQL Language Reference* for information about the `CREATE DATABASE LINK` statement syntax

Schema Objects and Database Links

After you have created a database link, you can execute SQL statements that access objects on the remote database. For example, to access remote object `emp` using database link `foo`, you can issue:

```
SELECT * FROM emp@foo;
```

You must also be authorized in the remote database to access specific remote objects.

Constructing properly formed object names using database links is an essential aspect of data manipulation in distributed systems.

Naming of Schema Objects Using Database Links

Oracle Database uses the global database name to name the schema objects globally using the following scheme:

`schema.schema_object@global_database_name`

where:

- *`schema`* is a collection of logical structures of data, or schema objects. A schema is owned by a database user and has the same name as that user. Each user owns a single schema.
- *`schema_object`* is a logical data structure like a table, index, view, synonym, procedure, package, or a database link.
- *`global_database_name`* is the name that uniquely identifies a remote database. This name must be the same as the concatenation of the remote database initialization parameters `DB_NAME` and `DB_DOMAIN`, unless the parameter `GLOBAL_NAMES` is set to `FALSE`, in which case any name is acceptable.

For example, using a database link to database `sales.division3.acme.com`, a user or application can reference remote data as follows:

```
SELECT * FROM scott.emp@sales.division3.acme.com;  # emp table in scott's schema
SELECT loc FROM scott.dept@sales.division3.acme.com;
```

If `GLOBAL_NAMES` is set to `FALSE`, then you can use any name for the link to `sales.division3.acme.com`. For example, you can call the link `foo`. Then, you can access the remote database as follows:

```
SELECT name FROM scott.emp@foo;  # link name different from global name
```

Authorization for Accessing Remote Schema Objects

To access a remote schema object, you must be granted access to the remote object in the remote database. Further, to perform any updates, inserts, or deletes on the remote object, you must be granted the `SELECT` privilege on the object, along with the `UPDATE`, `INSERT`, or `DELETE` privilege. Unlike when accessing a local object, the `SELECT` privilege is necessary for accessing a remote object because the database has no remote describe capability. The database must do a `SELECT *` on the remote object in order to determine its structure.

Synonyms for Schema Objects

Oracle Database lets you create synonyms so that you can hide the database link name from the user. A synonym allows access to a table on a remote database using the same syntax that you would use to access a table on a local database. For example, assume you issue the following query against a table in a remote database:

```
SELECT * FROM emp@hq.acme.com;
```

You can create the synonym `emp` for `emp@hq.acme.com` so that you can issue the following query instead to access the same data:

```
SELECT * FROM emp;
```

See Also: "Using Synonyms to Create Location Transparency" on page 30-20 to learn how to create synonyms for objects specified using database links

Schema Object Name Resolution

To resolve application references to schema objects (a process called **name resolution**), the database forms object names hierarchically. For example, the database guarantees that each schema within a database has a unique name, and that within a schema each object has a unique name. As a result, a schema object name is always unique within the database. Furthermore, the database resolves application references to the local name of the object.

In a distributed database, a schema object such as a table is accessible to all applications in the system. The database extends the hierarchical naming model with global database names to effectively create **global object names** and resolve references to the schema objects in a distributed database system. For example, a query can reference a remote table by specifying its fully qualified name, including the database in which it resides.

For example, assume that you connect to the local database as user `SYSTEM`:

```
CONNECT SYSTEM/password@sales1
```

You then issue the following statements using database link `hq.acme.com` to access objects in the `scott` and `jane` schemas on remote database `hq`:

```
SELECT * FROM scott.emp@hq.acme.com;
INSERT INTO jane.accounts@hq.acme.com (acc_no, acc_name, balance)
  VALUES (5001, 'BOWER', 2000);
UPDATE jane.accounts@hq.acme.com
  SET balance = balance + 500;
DELETE FROM jane.accounts@hq.acme.com
  WHERE acc_name = 'BOWER';
```

Database Link Restrictions

You *cannot* perform the following operations using database links:

- Grant privileges on remote objects
- Execute `DESCRIBE` operations on some remote objects. The following remote objects, however, do support `DESCRIBE` operations:
  - Tables
  - Views
  - Procedures
  - Functions
- Analyze remote objects
- Define or enforce referential integrity
- Grant roles to users in a remote database
- Obtain nondefault roles on a remote database. For example, if `jane` connects to the local database and executes a stored procedure that uses a fixed user link connecting as `scott`, `jane` receives `scott`'s default roles on the remote database. Jane cannot issue `SET ROLE` to obtain a nondefault role.
- Execute hash query joins that use shared server connections
- Use a current user link without authentication through SSL, password, or NT native authentication

Distributed Database Administration

The following sections explain some of the topics relating to database management in an Oracle Database distributed database system:

- Site Autonomy
- Distributed Database Security
- Auditing Database Links
- Administration Tools

See Also:

- Chapter 30, "Managing a Distributed Database" to learn how to administer homogenous systems
- *Oracle Database Heterogeneous Connectivity Administrator's Guide* to learn about heterogeneous services concepts

Site Autonomy

Site autonomy means that each server participating in a distributed database is administered independently from all other databases. Although several databases can work together, each database is a separate repository of data that is managed individually. Some of the benefits of site autonomy in an Oracle Database distributed database include:

- Nodes of the system can mirror the logical organization of companies or groups that need to maintain independence.

- Local administrators control corresponding local data. Therefore, each database administrator's domain of responsibility is smaller and more manageable.
- Independent failures are less likely to disrupt other nodes of the distributed database. No single database failure need halt all distributed operations or be a performance bottleneck.
- Administrators can recover from isolated system failures independently from other nodes in the system.
- A data dictionary exists for each local database. A global catalog is not necessary to access local data.
- Nodes can upgrade software independently.

Although Oracle Database permits you to manage each database in a distributed database system independently, you should not ignore the global requirements of the system. For example, you may need to:

- Create additional user accounts in each database to support the links that you create to facilitate server-to-server connections.
- Set additional initialization parameters such as `COMMIT_POINT_STRENGTH`, and `OPEN_LINKS`.

Distributed Database Security

The database supports all of the security features that are available with a non-distributed database environment for distributed database systems, including:

- Password authentication for users and roles
- Some types of external authentication for users and roles including:
  - Kerberos version 5 for connected user links
  - DCE for connected user links
- Login packet encryption for client-to-server and server-to-server connections

The following sections explain some additional topics to consider when configuring an Oracle Database distributed database system:

- Authentication Through Database Links
- Authentication Without Passwords
- Supporting User Accounts and Roles
- Centralized User and Privilege Management
- Data Encryption

See Also: *Oracle Database Advanced Security Administrator's Guide* for more information about external authentication

Authentication Through Database Links

Database links are either private or public, **authenticated** or **non-authenticated**. You create public links by specifying the `PUBLIC` keyword in the link creation statement. For example, you can issue:

```
CREATE PUBLIC DATABASE LINK foo USING 'sales';
```

You create authenticated links by specifying the `CONNECT TO` clause, `AUTHENTICATED BY` clause, or both clauses together in the database link creation statement. For example, you can issue:

```
CREATE DATABASE LINK sales CONNECT TO scott IDENTIFIED BY tiger USING 'sales';
CREATE SHARED PUBLIC DATABASE LINK sales CONNECT TO mick IDENTIFIED BY jagger
     AUTHENTICATED BY david IDENTIFIED BY bowie USING 'sales';
```

This table describes how users access the remote database through the link:

Link Type	Authenticated	Security Access
Private	No	When connecting to the remote database, the database uses security information (userid/password) taken from the local session. Hence, the link is a connected user database link. Passwords must be synchronized between the two databases.
Private	Yes	The userid/password is taken from the link definition rather than from the local session context. Hence, the link is a fixed user database link. This configuration allows passwords to be different on the two databases, but the local database link password must match the remote database password.
Public	No	Works the same as a private nonauthenticated link, except that all users can reference this pointer to the remote database.
Public	Yes	All users on the local database can access the remote database and all use the same userid/password to make the connection.

Authentication Without Passwords

When using a connected user or current user database link, you can use an external authentication source such as Kerberos to obtain **end-to-end security**. In end-to-end authentication, credentials are passed from server to server and can be authenticated by a database server belonging to the same domain. For example, if `jane` is authenticated externally on a local database, and wants to use a connected user link to connect as herself to a remote database, the local server passes the security ticket to the remote database.

Supporting User Accounts and Roles

In a distributed database system, you must carefully plan the user accounts and roles that are necessary to support applications using the system. Note that:

- The user accounts necessary to establish server-to-server connections must be available in all databases of the distributed database system.
- The roles necessary to make available application privileges to distributed database application users must be present in all databases of the distributed database system.

As you create the database links for the nodes in a distributed database system, determine which user accounts and roles each site needs to support server-to-server connections that use the links.

In a distributed environment, users typically require access to many network services. When you must configure separate authentications for each user to access each network service, security administration can become unwieldy, especially for large systems.

> **See Also:** "Creating Database Links" on page 30-6 for more information about the user accounts that must be available to support different types of database links in the system

Centralized User and Privilege Management

The database provides different ways for you to manage the users and privileges involved in a distributed system. For example, you have these options:

- Enterprise user management. You can create global users who are authenticated through SSL or by using passwords, then manage these users and their privileges in a directory through an independent enterprise directory service.
- Network authentication service. This common technique simplifies security management for distributed environments. You can use the Oracle Advanced Security option to enhance Oracle Net and the security of an Oracle Database distributed database system. Windows NT native authentication is an example of a non-Oracle authentication solution.

> **See Also:**
>
> - *Oracle Database Advanced Security Administrator's Guide*
> - *Oracle Database Enterprise User Security Administrator's Guide*

Schema-Dependent Global Users One option for centralizing user and privilege management is to create the following:

- A global user in a centralized directory
- A user in every database that the global user must connect to

For example, you can create a global user called `fred` with the following SQL statement:

```
CREATE USER fred IDENTIFIED GLOBALLY AS 'CN=fred adams,O=Oracle,C=England';
```

This solution allows a single global user to be authenticated by a centralized directory.

The schema-dependent global user solution has the consequence that you must create a user called `fred` on every database that this user must access. Because most users need permission to access an application schema but do not need their own schemas, the creation of a separate account in each database for every global user creates significant overhead. Because of this problem, the database also supports schema-independent users, which are global users that an access a single, generic schema in every database.

Schema-Independent Global Users The database supports functionality that allows a global user to be centrally managed by an enterprise directory service. Users who are managed in the directory are called **enterprise users**. This directory contains information about:

- Which databases in a distributed system an enterprise user can access
- Which role on each database an enterprise user can use
- Which schema on each database an enterprise user can connect to

The administrator of each database is not required to create a global user account for each enterprise user on each database to which the enterprise user needs to connect.

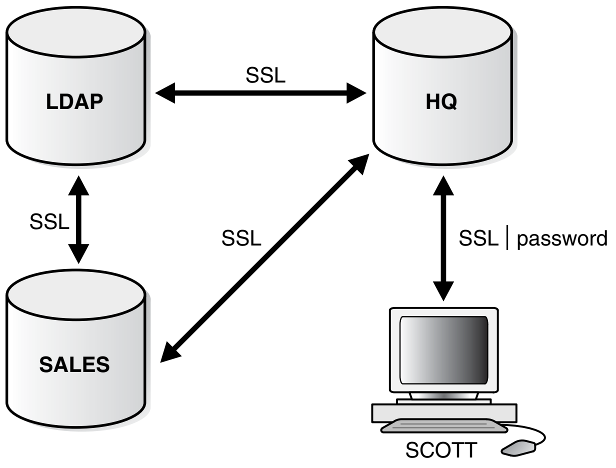
Instead, multiple enterprise users can connect to the same database schema, called a **shared schema**.

Note: You cannot access a current user database link in a shared schema.

For example, suppose `jane`, `bill`, and `scott` all use a human resources application. The `hq` application objects are all contained in the `guest` schema on the `hq` database. In this case, you can create a local global user account to be used as a shared schema. This global username, that is, shared schema name, is `guest`. `jane`, `bill`, and `scott` are all created as enterprise users in the directory service. They are also mapped to the `guest` schema in the directory, and can be assigned different authorizations in the `hq` application.

Figure 29–5 illustrates an example of global user security using the enterprise directory service:

Figure 29–5 Global User Security



Assume that the enterprise directory service contains the following information on enterprise users for `hq` and `sales`:

Database	Role	Schema	Enterprise Users
`tb`	`clerk1`	`guest`	`bill` `scott`
`sales`	`clerk2`	`guest`	`jane` `scott`

Also, assume that the local administrators for `hq` and `sales` have issued statements as follows:

Database	CREATE Statements

`hq`	`CREATE USER guest IDENTIFIED GLOBALLY AS '';`
	`CREATE ROLE clerk1 GRANT select ON emp;`
	`CREATE PUBLIC DATABASE LINK sales_link CONNECT AS CURRENT_USER USING 'sales';`

Database	CREATE Statements

`sales`	`CREATE USER guest IDENTIFIED GLOBALLY AS '';`
	`CREATE ROLE clerk2 GRANT select ON dept;`

Assume that enterprise user `scott` requests a connection to local database `hq` in order to execute a distributed transaction involving `sales`. The following steps occur (not necessarily in this exact order):

1. Enterprise user `scott` is authenticated using SSL or a password.
2. User `scott` issues the following statement:

   ```
   SELECT e.ename, d.loc
   FROM emp e, dept@sales_link d
   WHERE e.deptno=d.deptno;
   ```

3. Databases `hq` and `sales` mutually authenticate one another using SSL.
4. `Database hq` queries the enterprise directory service to determine whether enterprise user `scott` has access to `hq`, and discovers `scott` can access local schema `guest` using role `clerk1`.
5. Database `sales` queries the enterprise directory service to determine whether enterprise user `scott` has access to `sales`, and discovers `scott` can access local schema `guest` using role `clerk2`.
6. Enterprise user `scott` logs into `sales` to schema `guest` with role `clerk2` and issues a `SELECT` to obtain the required information and transfer it to `hq`.
7. Database `hq` receives the requested data from `sales` and returns it to the client `scott`.

See Also: *Oracle Database Enterprise User Security Administrator's Guide* for more information about enterprise user security

Data Encryption

The Oracle Advanced Security option also enables Oracle Net and related products to use network data encryption and checksumming so that data cannot be read or altered. It protects data from unauthorized viewing by using the RSA Data Security RC4 or the Data Encryption Standard (DES) encryption algorithm.

To ensure that data has not been modified, deleted, or replayed during transmission, the security services of the Oracle Advanced Security option can generate a cryptographically secure message digest and include it with each packet sent across the network.

See Also: *Oracle Database Advanced Security Administrator's Guide* for more information about these and other features of the Oracle Advanced Security option

Auditing Database Links

You must always perform auditing operations locally. That is, if a user acts in a local database and accesses a remote database through a database link, the local actions are audited in the local database, and the remote actions are audited in the remote database, provided appropriate audit options are set in the respective databases.

The remote database cannot determine whether a successful connect request and subsequent SQL statements come from another server or from a locally connected client. For example, assume the following:

- Fixed user link `hq.acme.com` connects local user `jane` to the remote `hq` database as remote user `scott`.
- User `scott` is audited on the remote database.

Actions performed during the remote database session are audited as if `scott` were connected locally to `hq` and performing the same actions there. You must set audit options in the remote database to capture the actions of the username--in this case, `scott` on the `hq` database--embedded in the link if the desired effect is to audit what `jane` is doing in the remote database.

Note: You can audit the global username for global users.

You cannot set local auditing options on remote objects. Therefore, you cannot audit use of a database link, although access to remote objects can be audited on the remote database.

Administration Tools

The database administrator has several choices for tools to use when managing an Oracle Database distributed database system:

- Enterprise Manager
- Third-Party Administration Tools
- SNMP Support

Enterprise Manager

Enterprise Manager is the Oracle Database administration tool that provides a graphical user interface (GUI). Enterprise Manager provides administrative functionality for distributed databases through an easy-to-use interface. You can use Enterprise Manager to:

- Administer multiple databases. You can use Enterprise Manager to administer a single database or to simultaneously administer multiple databases.
- Centralize database administration tasks. You can administer both local and remote databases running on any Oracle Database platform in any location worldwide. In addition, these Oracle Database platforms can be connected by any network protocols supported by Oracle Net.
- Dynamically execute SQL, PL/SQL, and Enterprise Manager commands. You can use Enterprise Manager to enter, edit, and execute statements. Enterprise Manager also maintains a history of statements executed.

  Thus, you can reexecute statements without retyping them, a particularly useful feature if you need to execute lengthy statements repeatedly in a distributed database system.
- Manage security features such as global users, global roles, and the enterprise directory service.

Third-Party Administration Tools

Currently more than 60 companies produce more than 150 products that help manage Oracle Databases and networks, providing a truly open environment.

SNMP Support

Besides its network administration capabilities, Oracle **Simple Network Management Protocol** (*SNMP*) support allows an Oracle Database server to be located and queried by any SNMP-based network management system. SNMP is the accepted standard underlying many popular network management systems such as:

- HP OpenView
- Digital POLYCENTER Manager on NetView
- IBM NetView/6000
- Novell NetWare Management System
- SunSoft SunNet Manager

Transaction Processing in a Distributed System

A transaction is a logical unit of work constituted by one or more SQL statements executed by a single user. A transaction begins with the user's first executable SQL statement and ends when it is committed or rolled back by that user.

A **remote transaction** contains only statements that access a single remote node. A **distributed transaction** contains statements that access more than one node.

The following sections define important concepts in transaction processing and explain how transactions access data in a distributed database:

- Remote SQL Statements
- Distributed SQL Statements
- Shared SQL for Remote and Distributed Statements
- Remote Transactions
- Distributed Transactions
- Two-Phase Commit Mechanism
- Database Link Name Resolution
- Schema Object Name Resolution

Remote SQL Statements

A **remote query** statement is a query that selects information from one or more remote tables, all of which reside at the same remote node. For example, the following query accesses data from the `dept` table in the `scott` schema of the remote `sales` database:

```
SELECT * FROM scott.dept@sales.us.americas.acme_auto.com;
```

A **remote update** statement is an update that modifies data in one or more tables, all of which are located at the same remote node. For example, the following query updates the `dept` table in the `scott` schema of the remote `sales` database:

```
UPDATE scott.dept@mktng.us.americas.acme_auto.com
  SET loc = 'NEW YORK'
  WHERE deptno = 10;
```

Note: A remote update can include a subquery that retrieves data from one or more remote nodes, but because the update happens at only a single remote node, the statement is classified as a remote update.

Distributed SQL Statements

A **distributed query** statement retrieves information from two or more nodes. For example, the following query accesses data from the local database as well as the remote `sales` database:

```
SELECT ename, dname
  FROM scott.emp e, scott.dept@sales.us.americas.acme_auto.com d
  WHERE e.deptno = d.deptno;
```

A **distributed update** statement modifies data on two or more nodes. A distributed update is possible using a PL/SQL subprogram unit such as a procedure or trigger that includes two or more remote updates that access data on different nodes. For example, the following PL/SQL program unit updates tables on the local database and the remote `sales` database:

```
BEGIN
  UPDATE scott.dept@sales.us.americas.acme_auto.com
    SET loc = 'NEW YORK'
    WHERE deptno = 10;
  UPDATE scott.emp
    SET deptno = 11
    WHERE deptno = 10;
END;
COMMIT;
```

The database sends statements in the program to the remote nodes, and their execution succeeds or fails as a unit.

Shared SQL for Remote and Distributed Statements

The mechanics of a remote or distributed statement using shared SQL are essentially the same as those of a local statement. The SQL text must match, and the referenced objects must match. If available, shared SQL areas can be used for the local and remote handling of any statement or decomposed query.

See Also: *Oracle Database Concepts* for more information about shared SQL

Remote Transactions

A remote transaction contains one or more remote statements, all of which reference a single remote node. For example, the following transaction contains two statements, each of which accesses the remote `sales` database:

```
UPDATE scott.dept@sales.us.americas.acme_auto.com
  SET loc = 'NEW YORK'
  WHERE deptno = 10;
UPDATE scott.emp@sales.us.americas.acme_auto.com
  SET deptno = 11
  WHERE deptno = 10;
COMMIT;
```

Distributed Transactions

A distributed transaction is a transaction that includes one or more statements that, individually or as a group, update data on two or more distinct nodes of a distributed database. For example, this transaction updates the local database and the remote `sales` database:

```
UPDATE scott.dept@sales.us.americas.acme_auto.com
  SET loc = 'NEW YORK'
  WHERE deptno = 10;
UPDATE scott.emp
  SET deptno = 11
  WHERE deptno = 10;
COMMIT;
```

Note: If all statements of a transaction reference only a single remote node, the transaction is remote, not distributed.

Two-Phase Commit Mechanism

A database must guarantee that all statements in a transaction, distributed or non-distributed, either commit or roll back as a unit. The effects of an ongoing transaction should be invisible to all other transactions at all nodes; this transparency should be true for transactions that include any type of operation, including queries, updates, or remote procedure calls.

The general mechanisms of transaction control in a non-distributed database are discussed in the *Oracle Database Concepts*. In a distributed database, the database must coordinate transaction control with the same characteristics over a network and maintain data consistency, even if a network or system failure occurs.

The database **two-phase commit** mechanism guarantees that *all* database servers participating in a distributed transaction either all commit or all roll back the statements in the transaction. A two-phase commit mechanism also protects implicit DML operations performed by integrity constraints, remote procedure calls, and triggers.

See Also: Chapter 32, "Distributed Transactions Concepts" for more information about the Oracle Database two-phase commit mechanism

Database Link Name Resolution

A **global object name** is an object specified using a database link. The essential components of a global object name are:

- Object name
- Database name
- Domain

The following table shows the components of an explicitly specified global database object name:

Statement	Object	Database	Domain
`SELECT * FROM joan.dept@sales.acme.com`	`dept`	`sales`	`acme.com`

Statement	Object	Database	Domain
`SELECT * FROM emp@mktg.us.acme.com`	`emp`	`mktg`	`us.acme.com`

Whenever a SQL statement includes a reference to a global object name, the database searches for a database link with a name that matches the database name specified in the global object name. For example, if you issue the following statement:

```
SELECT * FROM scott.emp@orders.us.acme.com;
```

The database searches for a database link called `orders.us.acme.com`. The database performs this operation to determine the path to the specified remote database.

The database always searches for matching database links in the following order:

1. Private database links in the schema of the user who issued the SQL statement.
2. Public database links in the local database.
3. Global database links (only if a directory server is available).

Name Resolution When the Global Database Name Is Complete

Assume that you issue the following SQL statement, which specifies a complete global database name:

```
SELECT * FROM emp@prod1.us.oracle.com;
```

In this case, both the database name (`prod1`) and domain components (`us.oracle.com`) are specified, so the database searches for private, public, and global database links. The database searches only for links that match the specified global database name.

Name Resolution When the Global Database Name Is Partial

If any part of the domain is specified, the database assumes that a complete global database name is specified. If a SQL statement specifies a partial global database name (that is, only the database component is specified), the database appends the value in the `DB_DOMAIN` initialization parameter to the value in the `DB_NAME` initialization parameter to construct a complete name. For example, assume you issue the following statements:

```
CONNECT scott/tiger@locdb
SELECT * FROM scott.emp@orders;
```

If the network domain for `locdb` is `us.acme.com`, then the database appends this domain to `orders` to construct the complete global database name of `orders.us.acme.com`. The database searches for database links that match only the constructed global name. If a matching link is not found, the database returns an error and the SQL statement cannot execute.

Name Resolution When No Global Database Name Is Specified

If a global object name references an object in the local database and a database link name is *not* specified using the @ symbol, then the database automatically detects that the object is local and does not search for or use database links to resolve the object reference. For example, assume that you issue the following statements:

```
CONNECT scott/tiger@locdb
SELECT * from scott.emp;
```

Because the second statement does not specify a global database name using a database link connect string, the database does not search for database links.

Terminating the Search for Name Resolution

The database does not necessarily stop searching for matching database links when it finds the first match. The database must search for matching private, public, and network database links until it determines a complete path to the remote database (both a remote account and service name).

The first match determines the remote schema as illustrated in the following table:

User Operation	Database Response	Example
Do *not* specify the `CONNECT` clause	Uses a connected user database link	`CREATE DATABASE LINK k1 USING 'prod'`
Do specify the `CONNECT TO ... IDENTIFIED BY` clause	Uses a fixed user database link	`CREATE DATABASE LINK k2 CONNECT TO scott IDENTIFIED BY tiger USING 'prod'`
Specify the `CONNECT TO CURRENT_USER` clause	Uses a current user database link	`CREATE DATABASE LINK k3 CONNECT TO CURRENT_USER USING 'prod'`
Do *not* specify the `USING` clause	Searches until it finds a link specifying a database string. If matching database links are found and a string is never identified, the database returns an error.	`CREATE DATABASE LINK k4 CONNECT TO CURRENT_USER`

After the database determines a complete path, it creates a remote session, assuming that an identical connection is not already open on behalf of the same local session. If a session already exists, the database reuses it.

Schema Object Name Resolution

After the local Oracle Database connects to the specified remote database on behalf of the local user that issued the SQL statement, object resolution continues as if the remote user had issued the associated SQL statement. The first match determines the remote schema according to the following rules:

Type of Link Specified	Location of Object Resolution
A fixed user database link	Schema specified in the link creation statement
A connected user database link	Connected user's remote schema
A current user database link	Current user's schema

If the database cannot find the object, then it checks public objects of the remote database. If it cannot resolve the object, then the established remote session remains but the SQL statement cannot execute and returns an error.

The following are examples of global object name resolution in a distributed database system. For all the following examples, assume that:

Example of Global Object Name Resolution: Complete Object Name

This example illustrates how the database resolves a complete global object name and determines the appropriate path to the remote database using both a private and public database link. For this example, assume the following:

- The remote database is named `sales.division3.acme.com`.
- The local database is named `hq.division3.acme.com`.
- A directory server (and therefore, global database links) is not available.
- A remote table `emp` is contained in the schema `tsmith`.

Consider the following statements issued by `scott` at the local database:

```
CONNECT scott/tiger@hq

CREATE PUBLIC DATABASE LINK sales.division3.acme.com
CONNECT TO guest IDENTIFIED BY network
  USING 'dbstring';
```

Later, `JWARD` connects and issues the following statements:

```
CONNECT jward/bronco@hq

CREATE DATABASE LINK sales.division3.acme.com
  CONNECT TO tsmith IDENTIFIED BY radio;

UPDATE tsmith.emp@sales.division3.acme.com
  SET deptno = 40
  WHERE deptno = 10;
```

The database processes the final statement as follows:

1. The database determines that a complete global object name is referenced in `jward`'s `UPDATE` statement. Therefore, the system begins searching in the local database for a database link with a matching name.
2. The database finds a matching private database link in the schema `jward`. Nevertheless, the private database link `jward.sales.division3.acme.com` does not indicate a complete path to the remote `sales` database, only a remote account. Therefore, the database now searches for a matching public database link.
3. The database finds the public database link in `scott`'s schema. From this public database link, the database takes the service name `dbstring`.
4. Combined with the remote account taken from the matching private fixed user database link, the database determines a complete path and proceeds to establish a connection to the remote `sales` database as user `tsmith/radio`.
5. The remote database can now resolve the object reference to the `emp` table. The database searches in the `tsmith` schema and finds the referenced `emp` table.
6. The remote database completes the execution of the statement and returns the results to the local database.

Example of Global Object Name Resolution: Partial Object Name

This example illustrates how the database resolves a partial global object name and determines the appropriate path to the remote database using both a private and public database link.

For this example, assume that:

- The remote database is named `sales.division3.acme.com`.
- The local database is named `hq.division3.acme.com`.
- A directory server (and therefore, global database links) is not available.
- A table `emp` on the remote database `sales` is contained in the schema `tsmith`, but not in schema `scott`.
- A public synonym named `emp` resides at remote database `sales` and points to `tsmith.emp` in the remote database `sales`.
- The public database link in "Example of Global Object Name Resolution: Complete Object Name" on page 29-28 is already created on local database `hq`:

  ```
  CREATE PUBLIC DATABASE LINK sales.division3.acme.com
    CONNECT TO guest IDENTIFIED BY network
    USING 'dbstring';
  ```

Consider the following statements issued at local database `hq`:

```
CONNECT scott/tiger@hq

CREATE DATABASE LINK sales.division3.acme.com;

DELETE FROM emp@sales
  WHERE empno = 4299;
```

The database processes the final `DELETE` statement as follows:

1. The database notices that a partial global object name is referenced in `scott`'s `DELETE` statement. It expands it to a complete global object name using the domain of the local database as follows:

   ```
   DELETE FROM emp@sales.division3.acme.com
     WHERE empno = 4299;
   ```

2. The database searches the local database for a database link with a matching name.
3. The database finds a matching *private* connected user link in the schema `scott`, but the private database link indicates no path at all. The database uses the connected username/password as the remote account portion of the path and then searches for and finds a matching *public* database link:

   ```
   CREATE PUBLIC DATABASE LINK sales.division3.acme.com
     CONNECT TO guest IDENTIFIED BY network
     USING 'dbstring';
   ```

4. The database takes the database net service name `dbstring` from the public database link. At this point, the database has determined a complete path.
5. The database connects to the remote database as `scott/tiger` and searches for and does not find an object named `emp` in the schema `scott`.
6. The remote database searches for a public synonym named `emp` and finds it.
7. The remote database executes the statement and returns the results to the local database.

Global Name Resolution in Views, Synonyms, and Procedures

A view, synonym, or PL/SQL program unit (for example, a procedure, function, or trigger) can reference a remote schema object by its global object name. If the global object name is complete, then the database stores the definition of the object without expanding the global object name. If the name is partial, however, the database expands the name using the domain of the local database name.

The following table explains when the database completes the expansion of a partial global object name for views, synonyms, and program units:

User Operation	Database Response
Create a view	Does *not* expand partial global names. The data dictionary stores the exact text of the defining query. Instead, the database expands a partial global object name each time a statement that uses the view is parsed.
Create a synonym	Expands partial global names. The definition of the synonym stored in the data dictionary includes the expanded global object name.
Compile a program unit	Expands partial global names.

What Happens When Global Names Change

Global name changes can affect views, synonyms, and procedures that reference remote data using partial global object names. If the global name of the referenced database changes, views and procedures may try to reference a nonexistent or incorrect database. On the other hand, synonyms do not expand database link names at runtime, so they do not change.

Scenarios for Global Name Changes

For example, consider two databases named `sales.uk.acme.com` and `hq.uk.acme.com`. Also, assume that the `sales` database contains the following view and synonym:

```
CREATE VIEW employee_names AS
        SELECT ename FROM scott.emp@hr;

CREATE SYNONYM employee FOR scott.emp@hr;
```

The database expands the `employee` synonym definition and stores it as:

`scott.emp@hr.uk.acme.com`

Scenario 1: Both Databases Change Names First, consider the situation where both the Sales and Human Resources departments are relocated to the United States. Consequently, the corresponding global database names are both changed as follows:

- `sales.uk.acme.com` becomes `sales.us.acme.com`
- `hq.uk.acme.com` becomes `hq.us.acme.com`

The following table describes query expansion before and after the change in global names:

Query on `sales`	Expansion Before Change	Expansion After Change
`SELECT * FROM employee_names`	`SELECT * FROM scott.emp@hr.uk.acme.com`	`SELECT * FROM scott.emp@hr.us.acme.com`
`SELECT * FROM employee`	`SELECT * FROM scott.emp@hr.uk.acme.com`	`SELECT * FROM scott.emp@hr.uk.acme.com`

Scenario 2: One Database Changes Names Now consider that only the Sales department is moved to the United States; Human Resources remains in the UK. Consequently, the corresponding global database names are both changed as follows:

- `sales.uk.acme.com` becomes `sales.us.acme.com`
- `hq.uk.acme.com` is not changed

The following table describes query expansion before and after the change in global names:

Query on `sales`	Expansion Before Change	Expansion After Change
`SELECT * FROM employee_names`	`SELECT * FROM scott.emp@hr.uk.acme.com`	`SELECT * FROM scott.emp@hr.us.acme.com`
`SELECT * FROM employee`	`SELECT * FROM scott.emp@hr.uk.acme.com`	`SELECT * FROM scott.emp@hr.uk.acme.com`

In this case, the defining query of the `employee_names` view expands to a nonexistent global database name. On the other hand, the `employee` synonym continues to reference the correct database, `hq.uk.acme.com`.

Distributed Database Application Development

Application development in a distributed system raises issues that are not applicable in a non-distributed system. This section contains the following topics relevant for distributed application development:

- Transparency in a Distributed Database System
- Remote Procedure Calls (RPCs)
- Distributed Query Optimization

> **See Also:** Chapter 31, "Developing Applications for a Distributed Database System" to learn how to develop applications for distributed systems

Transparency in a Distributed Database System

With minimal effort, you can develop applications that make an Oracle Database distributed database system transparent to users that work with the system. The goal of transparency is to make a distributed database system appear as though it is a single Oracle Database. Consequently, the system does not burden developers and users of the system with complexities that would otherwise make distributed database application development challenging and detract from user productivity.

The following sections explain more about transparency in a distributed database system.

Location Transparency

An Oracle Database distributed database system has features that allow application developers and administrators to hide the physical location of database objects from applications and users. **Location transparency** exists when a user can universally refer to a database object such as a table, regardless of the node to which an application connects. Location transparency has several benefits, including:

- Access to remote data is simple, because database users do not need to know the physical location of database objects.
- Administrators can move database objects with no impact on end-users or existing database applications.

Typically, administrators and developers use synonyms to establish location transparency for the tables and supporting objects in an application schema. For example, the following statements create synonyms in a database for tables in another, remote database.

```
CREATE PUBLIC SYNONYM emp
  FOR scott.emp@sales.us.americas.acme_auto.com;
CREATE PUBLIC SYNONYM dept
  FOR scott.dept@sales.us.americas.acme_auto.com;
```

Now, rather than access the remote tables with a query such as:

```
SELECT ename, dname
  FROM scott.emp@sales.us.americas.acme_auto.com e,
       scott.dept@sales.us.americas.acme_auto.com d
  WHERE e.deptno = d.deptno;
```

An application can issue a much simpler query that does not have to account for the location of the remote tables.

```
SELECT ename, dname
  FROM emp e, dept d
  WHERE e.deptno = d.deptno;
```

In addition to synonyms, developers can also use views and stored procedures to establish location transparency for applications that work in a distributed database system.

SQL and COMMIT Transparency

The Oracle Database distributed database architecture also provides query, update, and transaction transparency. For example, standard SQL statements such as `SELECT`, `INSERT`, `UPDATE`, and `DELETE` work just as they do in a non-distributed database environment. Additionally, applications control transactions using the standard SQL statements `COMMIT`, `SAVEPOINT`, and `ROLLBACK`. There is no requirement for complex programming or other special operations to provide distributed transaction control.

- The statements in a single transaction can reference any number of local or remote tables.
- The database guarantees that all nodes involved in a distributed transaction take the same action: they either all commit or all roll back the transaction.
- If a network or system failure occurs during the commit of a distributed transaction, the transaction is automatically and transparently resolved globally. Specifically, when the network or system is restored, the nodes either all commit or all roll back the transaction.

Internal to the database, each committed transaction has an associated **system change number** (**SCN**) to uniquely identify the changes made by the statements within that transaction. In a distributed database, the SCNs of communicating nodes are coordinated when:

- A connection is established using the path described by one or more database links.

- A distributed SQL statement is executed.
- A distributed transaction is committed.

Among other benefits, the coordination of SCNs among the nodes of a distributed database system allows global distributed read-consistency at both the statement and transaction level. If necessary, global distributed time-based recovery can also be completed.

Replication Transparency

The database also provide many features to transparently replicate data among the nodes of the system. For more information about Oracle Database replication features, see *Oracle Database Advanced Replication*.

Remote Procedure Calls (RPCs)

Developers can code PL/SQL packages and procedures to support applications that work with a distributed database. Applications can make local procedure calls to perform work at the local database and **remote procedure calls** (**RPCs**) to perform work at a remote database.

When a program calls a remote procedure, the local server passes all procedure parameters to the remote server in the call. For example, the following PL/SQL program unit calls the packaged procedure `del_emp` located at the remote `sales` database and passes it the parameter 1257:

```
BEGIN
  emp_mgmt.del_emp@sales.us.americas.acme_auto.com(1257);
END;
```

In order for the RPC to succeed, the called procedure must exist at the remote site, and the user being connected to must have the proper privileges to execute the procedure.

When developing packages and procedures for distributed database systems, developers must code with an understanding of what program units should do at remote locations, and how to return the results to a calling application.

Distributed Query Optimization

Distributed query optimization is an Oracle Database feature that reduces the amount of data transfer required between sites when a transaction retrieves data from remote tables referenced in a distributed SQL statement.

Distributed query optimization uses cost-based optimization to find or generate SQL expressions that extract only the necessary data from remote tables, process that data at a remote site or sometimes at the local site, and send the results to the local site for final processing. This operation reduces the amount of required data transfer when compared to the time it takes to transfer all the table data to the local site for processing.

Using various cost-based optimizer hints such as `DRIVING_SITE`, `NO_MERGE`, and `INDEX`, you can control where Oracle Database processes the data and how it accesses the data.

> **See Also:** "Using Cost-Based Optimization" on page 31-4 for more information about cost-based optimization

Character Set Support for Distributed Environments

Oracle Database supports environments in which clients, Oracle Database servers, and non-Oracle Database servers use different character sets. NCHAR support is provided for heterogeneous environments. You can set a variety of National Language Support (NLS) and Heterogeneous Services (HS) environment variables and initialization parameters to control data conversion between different character sets.

Character settings are defined by the following NLS and HS parameters:

Parameters	Environment	Defined For
NLS_LANG (environment variable)	Client-Server	Client
NLS_LANGUAGE NLS_CHARACTERSET NLS_TERRITORY	Client-Server Not Heterogeneous Distributed Heterogeneous Distributed	Oracle Database server
HS_LANGUAGE	Heterogeneous Distributed	Non-Oracle Database server Transparent gateway
NLS_NCHAR (environment variable) HS_NLS_NCHAR	Heterogeneous Distributed	Oracle Database server Transparent gateway

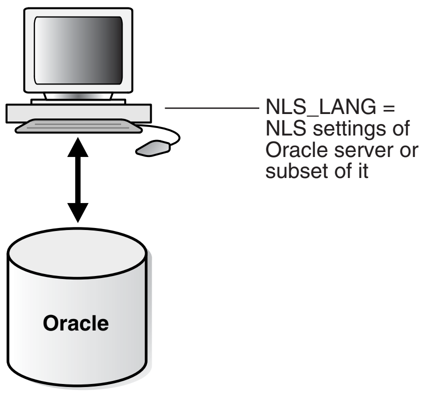
See Also:

- *Oracle Database Globalization Support Guide* for information about NLS parameters
- *Oracle Database Heterogeneous Connectivity Administrator's Guide* for information about HS parameters

Client/Server Environment

In a client/server environment, set the client character set to be the same as or a subset of the Oracle Database server character set, as illustrated in Figure 29–6.

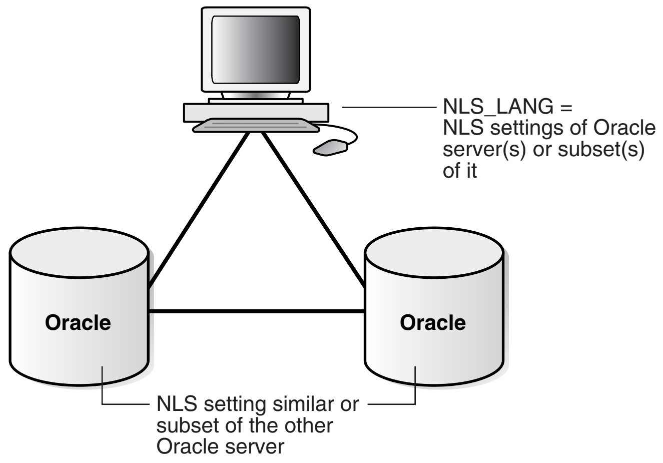
Figure 29–6 NLS Parameter Settings in a Client/Server Environment



Homogeneous Distributed Environment

In a non-heterogeneous environment, the client and server character sets should be either the same as or subsets of the main server character set, as illustrated in Figure 29–7:

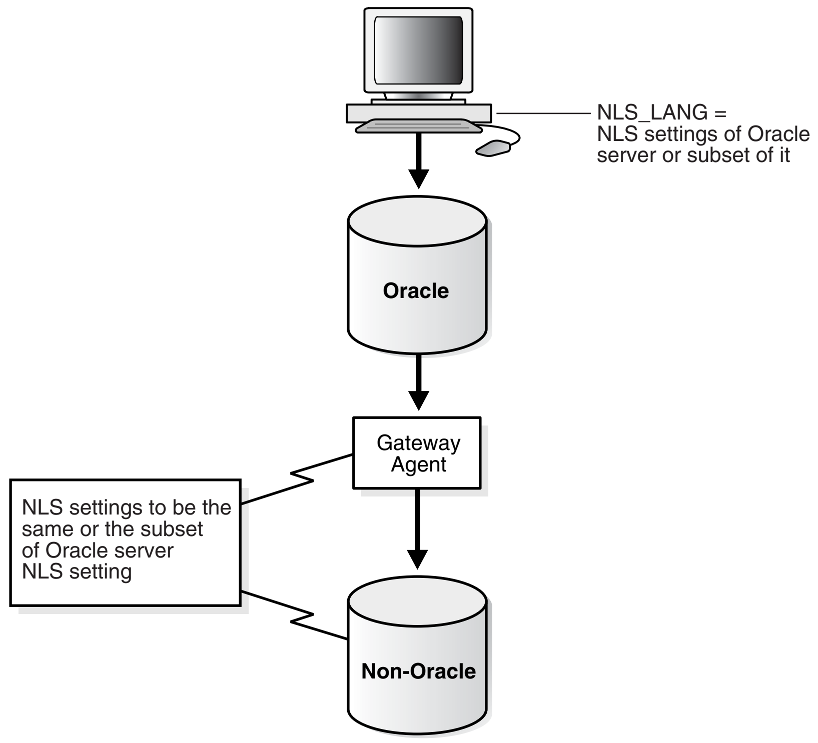
Figure 29–7 NLS Parameter Settings in a Homogeneous Environment


NLS_LANG =
NLS settings of Oracle server(s) or subset(s) of it
Oracle
Oracle
NLS setting similar or subset of the other Oracle server

Heterogeneous Distributed Environment

In a heterogeneous environment, the globalization support parameter settings of the client, the transparent gateway, and the non-Oracle Database data source should be either the same or a subset of the database server character set as illustrated in Figure 29–8. Transparent gateways have full globalization support.

Figure 29–8 NLS Parameter Settings in a Heterogeneous Environment


NLS_LANG =
NLS settings of Oracle server or subset of it
Oracle
Gateway Agent
NLS settings to be the same or the subset of Oracle server NLS setting
Non-Oracle

In a heterogeneous environment, only transparent gateways built with HS technology support complete `NCHAR` capabilities. Whether a specific transparent gateway supports `NCHAR` depends on the non-Oracle Database data source it is targeting. For information on how a particular transparent gateway handles `NCHAR` support, consult the system-specific transparent gateway documentation.

> **See Also:** *Oracle Database Heterogeneous Connectivity Administrator's Guide* for more detailed information about Heterogeneous Services

30 Managing a Distributed Database

This chapter describes how to manage and maintain a distributed database system and contains the following topics:

- Managing Global Names in a Distributed System
- Creating Database Links
- Using Shared Database Links
- Managing Database Links
- Viewing Information About Database Links
- Creating Location Transparency
- Managing Statement Transparency
- Managing a Distributed Database: Examples

Managing Global Names in a Distributed System

In a distributed database system, each database should have a unique **global database name**. Global database names uniquely identify a database in the system. A primary administration task in a distributed system is managing the creation and alteration of global database names.

This section contains the following topics:

- Understanding How Global Database Names Are Formed
- Determining Whether Global Naming Is Enforced
- Viewing a Global Database Name
- Changing the Domain in a Global Database Name
- Changing a Global Database Name: Scenario

Understanding How Global Database Names Are Formed

A global database name is formed from two components: a database name and a domain. The database name and the domain name are determined by the following initialization parameters at database creation:

Component	Parameter	Requirements	Example
Database name	`DB_NAME`	Must be eight characters or less.	`sales`

Component	Parameter	Requirements	Example
Domain containing the database	`DB_DOMAIN`	Must follow standard Internet conventions. Levels in domain names must be separated by dots and the order of domain names is from leaf to root, left to right.	`us.acme.com`

These are examples of valid global database names:

DB_NAME	DB_DOMAIN	Global Database Name
`sales`	`au.oracle.com`	`sales.au.oracle.com`
`sales`	`us.oracle.com`	`sales.us.oracle.com`
`mktg`	`us.oracle.com`	`mktg.us.oracle.com`
`payroll`	`nonprofit.org`	`payroll.nonprofit.org`

The `DB_DOMAIN` initialization parameter is only important at database creation time when it is used, together with the `DB_NAME` parameter, to form the database global name. At this point, the database global name is stored in the data dictionary. You must change the global name using an `ALTER DATABASE` statement, *not* by altering the `DB_DOMAIN` parameter in the initialization parameter file. It is good practice, however, to change the `DB_DOMAIN` parameter to reflect the change in the domain name before the next database startup.

Determining Whether Global Naming Is Enforced

The name that you give to a link on the local database depends on whether the remote database that you want to access enforces global naming. If the remote database enforces global naming, then you must use the remote database global database name as the name of the link. For example, if you are connected to the local `hq` server and want to create a link to the remote `mfg` database, and `mfg` enforces global naming, then you must use the `mfg` global database name as the link name.

You can also use service names as part of the database link name. For example, if you use the service names `sn1` and `sn2` to connect to database `hq.acme.com`, and `hq` enforces global naming, then you can create the following link names to `hq`:

- `HQ.ACME.COM@SN1`
- `HQ.ACME.COM@SN2`

See Also: "Using Connection Qualifiers to Specify Service Names Within Link Names" on page 30-10 for more information about using services names in link names

To determine whether global naming on a database is enforced on a database, either examine the database initialization parameter file or query the `V$PARAMETER` view. For example, to see whether global naming is enforced on `mfg`, you could start a session on `mfg` and then create and execute the following `globalnames.sql` script (sample output included):

```
COL NAME FORMAT A12
COL VALUE FORMAT A6
SELECT NAME, VALUE FROM V$PARAMETER
```

```
   WHERE NAME = 'global_names'
/

SQL> @globalnames

NAME         VALUE
------------ ------
global_names FALSE
```

Viewing a Global Database Name

Use the data dictionary view `GLOBAL_NAME` to view the database global name. For example, issue the following:

```
SELECT * FROM GLOBAL_NAME;

GLOBAL_NAME
-------------------------------------------------------------------------------
SALES.AU.ORACLE.COM
```

Changing the Domain in a Global Database Name

Use the `ALTER DATABASE` statement to change the domain in a database global name. Note that after the database is created, changing the initialization parameter `DB_DOMAIN` has no effect on the global database name or on the resolution of database link names.

The following example shows the syntax for the renaming statement, where *database* is a database name and *domain* is the network domain:

```
ALTER DATABASE RENAME GLOBAL_NAME TO database.domain;
```

Use the following procedure to change the domain in a global database name:

1. Determine the current global database name. For example, issue:

   ```
   SELECT * FROM GLOBAL_NAME;

   GLOBAL_NAME
   ----------------------------------------------------------------------------
   SALES.AU.ORACLE.COM
   ```

2. Rename the global database name using an `ALTER DATABASE` statement. For example, enter:

   ```
   ALTER DATABASE RENAME GLOBAL_NAME TO sales.us.oracle.com;
   ```

3. Query the `GLOBAL_NAME` table to check the new name. For example, enter:

   ```
   SELECT * FROM GLOBAL_NAME;

   GLOBAL_NAME
   ----------------------------------------------------------------------------
   SALES.US.ORACLE.COM
   ```

Changing a Global Database Name: Scenario

In this scenario, you change the domain part of the global database name of the local database. You also create database links using partially specified global names to test how Oracle Database resolves the names. You discover that the database resolves the partial names using the domain part of the current global database name of the local database, not the value for the initialization parameter DB_DOMAIN.

1. You connect to SALES.US.ACME.COM and query the GLOBAL_NAME data dictionary view to determine the current database global name:

   ```
   CONNECT SYSTEM/password@sales.us.acme.com
   SELECT * FROM GLOBAL_NAME;

   GLOBAL_NAME
   ----------------------------------------------------------------------------
   SALES.US.ACME.COM
   ```

2. You query the V$PARAMETER view to determine the current setting for the DB_DOMAIN initialization parameter:

   ```
   SELECT NAME, VALUE FROM V$PARAMETER WHERE NAME = 'db_domain';

   NAME       VALUE
   ---------  -----------
   db_domain  US.ACME.COM
   ```

3. You then create a database link to a database called hq, using only a partially-specified global name:

   ```
   CREATE DATABASE LINK hq USING 'sales';
   ```

   The database expands the global database name for this link by appending the domain part of the global database name of the *local* database to the name of the database specified in the link.

4. You query USER_DB_LINKS to determine which domain name the database uses to resolve the partially specified global database name:

   ```
   SELECT DB_LINK FROM USER_DB_LINKS;

   DB_LINK
   ------------------
   HQ.US.ACME.COM
   ```

   This result indicates that the domain part of the global database name of the local database is us.acme.com. The database uses this domain in resolving partial database link names when the database link is created.

5. Because you have received word that the sales database will move to Japan, you rename the sales database to sales.jp.acme.com:

   ```
   ALTER DATABASE RENAME GLOBAL_NAME TO sales.jp.acme.com;
   SELECT * FROM GLOBAL_NAME;

   GLOBAL_NAME
   ----------------------------------------------------------------------------
   SALES.JP.ACME.COM
   ```

6. You query V$PARAMETER again and discover that the value of DB_DOMAIN is *not* changed, although you renamed the domain part of the global database name:

   ```
   SELECT NAME, VALUE FROM V$PARAMETER
     WHERE NAME = 'db_domain';

   NAME       VALUE
   ---------  -----------
   db_domain  US.ACME.COM
   ```

This result indicates that the value of the DB_DOMAIN initialization parameter is independent of the ALTER DATABASE RENAME GLOBAL_NAME statement. The ALTER DATABASE statement determines the domain of the global database name, not the DB_DOMAIN initialization parameter (although it is good practice to alter DB_DOMAIN to reflect the new domain name).

7. You create another database link to database supply, and then query USER_DB_LINKS to see how the database resolves the domain part of the global database name of supply:

```
CREATE DATABASE LINK supply USING 'supply';
SELECT DB_LINK FROM USER_DB_LINKS;

DB_LINK
------------------
HQ.US.ACME.COM
SUPPLY.JP.ACME.COM
```

   This result indicates that the database resolves the partially specified link name by using the domain jp.acme.com. This domain is used when the link is created because it is the domain part of the global database name of the local database. The database does *not* use the DB_DOMAIN initialization parameter setting when resolving the partial link name.

8. You then receive word that your previous information was faulty: sales will be in the ASIA.JP.ACME.COM domain, not the JP.ACME.COM domain. Consequently, you rename the global database name as follows:

```
ALTER DATABASE RENAME GLOBAL_NAME TO sales.asia.jp.acme.com;
SELECT * FROM GLOBAL_NAME;

GLOBAL_NAME
----------------------------------------------------------------------------
SALES.ASIA.JP.ACME.COM
```

9. You query V$PARAMETER to again check the setting for the parameter DB_DOMAIN:

```
SELECT NAME, VALUE FROM V$PARAMETER
  WHERE NAME = 'db_domain';

NAME        VALUE
----------  -----------
db_domain   US.ACME.COM
```

   The result indicates that the domain setting in the parameter file is exactly the same as it was before you issued *either* of the ALTER DATABASE RENAME statements.

10. Finally, you create a link to the warehouse database and again query USER_DB_LINKS to determine how the database resolves the partially-specified global name:

```
CREATE DATABASE LINK warehouse USING 'warehouse';
SELECT DB_LINK FROM USER_DB_LINKS;

DB_LINK
------------------
HQ.US.ACME.COM
SUPPLY.JP.ACME.COM
```

```
WAREHOUSE.ASIA.JP.ACME.COM
```

Again, you see that the database uses the domain part of the global database name of the local database to expand the partial link name during link creation.

Note: In order to correct the `supply` database link, it must be dropped and re-created.

See Also: *Oracle Database Reference* for more information about specifying the `DB_NAME` and `DB_DOMAIN` initialization parameters

Creating Database Links

To support application access to the data and schema objects throughout a distributed database system, you must create all necessary database links. This section contains the following topics:

- Obtaining Privileges Necessary for Creating Database Links
- Specifying Link Types
- Specifying Link Users
- Using Connection Qualifiers to Specify Service Names Within Link Names

Obtaining Privileges Necessary for Creating Database Links

A database link is a pointer in the local database that lets you access objects on a remote database. To create a private database link, you must have been granted the proper privileges. The following table illustrates which privileges are required on which database for which type of link:

Privilege	**Database**	**Required For**
`CREATE DATABASE LINK`	Local	Creation of a private database link.
`CREATE PUBLIC DATABASE LINK`	Local	Creation of a public database link.
`CREATE SESSION`	Remote	Creation of any type of database link.

To see which privileges you currently have available, query `ROLE_SYS_PRIVS`. For example, you could create and execute the following `privs.sql` script (sample output included):

```
SELECT DISTINCT PRIVILEGE AS "Database Link Privileges"
FROM ROLE_SYS_PRIVS
WHERE PRIVILEGE IN ( 'CREATE SESSION','CREATE DATABASE LINK',
                     'CREATE PUBLIC DATABASE LINK')
/

SQL> @privs

Database Link Privileges
----------------------------------------
CREATE DATABASE LINK
CREATE PUBLIC DATABASE LINK
CREATE SESSION
```

Specifying Link Types

When you create a database link, you must decide who will have access to it. The following sections describe how to create the three basic types of links:

- Creating Private Database Links
- Creating Public Database Links
- Creating Global Database Links

Creating Private Database Links

To create a private database link, specify the following (where *link_name* is the global database name or an arbitrary link name):

```
CREATE DATABASE LINK link_name ...;
```

Following are examples of private database links:

SQL Statement	Result
`CREATE DATABASE LINK supply.us.acme.com;`	A private link using the global database name to the remote `supply` database. The link uses the userid/password of the connected user. So if `scott` (identified by `tiger`) uses the link in a query, the link establishes a connection to the remote database as `scott/tiger`.
`CREATE DATABASE LINK link_2 CONNECT TO jane IDENTIFIED BY doe USING 'us_supply';`	A private fixed user link called link_2 to the database with service name us_supply. The link connects to the remote database with the userid/password of jane/doe regardless of the connected user.
`CREATE DATABASE LINK link_1 CONNECT TO CURRENT_USER USING 'us_supply';`	A private link called `link_1` to the database with service name `us_supply`. The link uses the userid/password of the current user to log onto the remote database. **Note:** The current user may not be the same as the connected user, and must be a global user on both databases involved in the link (see "Users of Database Links" on page 29-11). Current user links are part of the Oracle Advanced Security option.

See Also: *Oracle Database SQL Language Reference* for `CREATE DATABASE LINK` syntax

Creating Public Database Links

To create a public database link, use the keyword `PUBLIC` (where *link_name* is the global database name or an arbitrary link name):

```
CREATE PUBLIC DATABASE LINK link_name ...;
```

Following are examples of public database links:

SQL Statement	Result
`CREATE PUBLIC DATABASE LINK supply.us.acme.com;`	A public link to the remote `supply` database. The link uses the userid/password of the connected user. So if `scott` (identified by `tiger`) uses the link in a query, the link establishes a connection to the remote database as `scott/tiger`.
`CREATE PUBLIC DATABASE LINK pu_link CONNECT TO CURRENT_USER USING 'supply';`	A public link called `pu_link` to the database with service name `supply`. The link uses the userid/password of the current user to log onto the remote database. **Note:** The current user may not be the same as the connected user, and must be a global user on both databases involved in the link (see "Users of Database Links" on page 29-11).
`CREATE PUBLIC DATABASE LINK sales.us.acme.com CONNECT TO jane IDENTIFIED BY doe;`	A public fixed user link to the remote `sales` database. The link connects to the remote database with the userid/password of `jane/doe`.

See Also: *Oracle Database SQL Language Reference* for `CREATE PUBLIC DATABASE LINK` syntax

Creating Global Database Links

In earlier releases, you defined **global database links** in the Oracle Names server. The Oracle Names server has been deprecated. Now, you can use a directory server in which databases are identified by net service names. In this document these are what are referred to as global database links.

See the *Oracle Database Net Services Administrator's Guide* to learn how to create directory entries that act as global database links.

Specifying Link Users

A database link defines a communication path from one database to another. When an application uses a database link to access a remote database, Oracle Database establishes a database session in the remote database on behalf of the local application request.

When you create a private or public database link, you can determine which schema on the remote database the link will establish connections to by creating fixed user, current user, and connected user database links.

Creating Fixed User Database Links

To create a **fixed user database link**, you embed the credentials (in this case, a username and password) required to access the remote database in the definition of the link:

```
CREATE DATABASE LINK ... CONNECT TO username IDENTIFIED BY password ...;
```

Following are examples of fixed user database links:

SQL Statement	Result
`CREATE PUBLIC DATABASE LINK supply.us.acme.com CONNECT TO scott AS tiger;`	A public link using the global database name to the remote `supply` database. The link connects to the remote database with the userid/password `scott/tiger`.
`CREATE DATABASE LINK foo CONNECT TO jane IDENTIFIED BY doe USING 'finance';`	A private fixed user link called `foo` to the database with service name `finance`. The link connects to the remote database with the userid/password `jane/doe`.

When an application uses a fixed user database link, the local server always establishes a connection to a fixed remote schema in the remote database. The local server also sends the fixed user's credentials across the network when an application uses the link to access the remote database.

Creating Connected User and Current User Database Links

Connected user and current user database links do not include credentials in the definition of the link. The credentials used to connect to the remote database can change depending on the user that references the database link and the operation performed by the application.

Note: For many distributed applications, you do not want a user to have privileges in a remote database. One simple way to achieve this result is to create a procedure that contains a fixed user or current user database link within it. In this way, the user accessing the procedure temporarily assumes someone else's privileges.

For an extended conceptual discussion of the distinction between connected users and current users, see "Users of Database Links" on page 29-11.

Creating a Connected User Database Link To create a connected user database link, omit the `CONNECT TO` clause. The following syntax creates a connected user database link, where *dblink* is the name of the link and *net_service_name* is an optional connect string:

```
CREATE [SHARED] [PUBLIC] DATABASE LINK dblink ... [USING 'net_service_name'];
```

For example, to create a connected user database link, use the following syntax:

```
CREATE DATABASE LINK sales.division3.acme.com USING 'sales';
```

Creating a Current User Database Link To create a current user database link, use the `CONNECT TO CURRENT_USER` clause in the link creation statement. Current user links are only available through the Oracle Advanced Security option.

The following syntax creates a current user database link, where *dblink* is the name of the link and *net_service_name* is an optional connect string:

```
CREATE [SHARED] [PUBLIC] DATABASE LINK dblink CONNECT TO CURRENT_USER
[USING 'net_service_name'];
```

For example, to create a connected user database link to the `sales` database, you might use the following syntax:

```
CREATE DATABASE LINK sales CONNECT TO CURRENT_USER USING 'sales';
```

Note: To use a current user database link, the current user must be a global user on both databases involved in the link.

See Also: *Oracle Database SQL Language Reference* for more syntax information about creating database links

Using Connection Qualifiers to Specify Service Names Within Link Names

In some situations, you may want to have several database links of the same type (for example, public) that point to the same remote database, yet establish connections to the remote database using different communication pathways. Some cases in which this strategy is useful are:

- A remote database is part of an Oracle Real Application Clusters configuration, so you define several public database links at your local node so that connections can be established to specific instances of the remote database.
- Some clients connect to the Oracle Database server using TCP/IP while others use DECNET.

To facilitate such functionality, the database lets you create a database link with an optional service name in the database link name. When creating a database link, a service name is specified as the trailing portion of the database link name, separated by an `@` sign, as in `@sales`. This string is called a **connection qualifier**.

For example, assume that remote database `hq.acme.com` is managed in a Oracle Real Application Clusters environment. The `hq` database has two instances named `hq_1` and `hq_2`. The local database can contain the following public database links to define pathways to the remote instances of the `hq` database:

```
CREATE PUBLIC DATABASE LINK hq.acme.com@hq_1
  USING 'string_to_hq_1';
CREATE PUBLIC DATABASE LINK hq.acme.com@hq_2
  USING 'string_to_hq_2';
CREATE PUBLIC DATABASE LINK hq.acme.com
  USING 'string_to_hq';
```

Notice in the first two examples that a service name is simply a part of the database link name. The text of the service name does not necessarily indicate how a connection is to be established; this information is specified in the service name of the `USING` clause. Also notice that in the third example, a service name is not specified as part of the link name. In this case, just as when a service name is specified as part of the link name, the instance is determined by the `USING` string.

To use a service name to specify a particular instance, include the service name at the end of the global object name:

```
SELECT * FROM scott.emp@hq.acme.com@hq_1
```

Note that in this example, there are two @ symbols.

Using Shared Database Links

Every application that references a remote server using a standard database link establishes a connection between the local database and the remote database. Many users running applications simultaneously can cause a high number of connections between the local and remote databases.

Shared database links enable you to limit the number of network connections required between the local server and the remote server.

This section contains the following topics:

- Determining Whether to Use Shared Database Links
- Creating Shared Database Links
- Configuring Shared Database Links

See Also: "What Are Shared Database Links?" on page 29-7 for a conceptual overview of shared database links

Determining Whether to Use Shared Database Links

Look carefully at your application and shared server configuration to determine whether to use shared links. A simple guideline is to use shared database links when the number of users accessing a database link is expected to be much larger than the number of server processes in the local database.

The following table illustrates three possible configurations involving database links:

Link Type	Server Mode	Consequences
Nonshared	Dedicated/shared server	If your application uses a standard public database link, and 100 users simultaneously require a connection, then 100 direct network connections to the remote database are required.
Shared	Shared server	If 10 shared server processes exist in the local shared server mode database, then 100 users that use the same database link require 10 or fewer network connections to the remote server. Each local shared server process may only need one connection to the remote server.
Shared	Dedicated	If 10 clients connect to a local dedicated server, and each client has 10 sessions on the same connection (thus establishing 100 sessions overall), and each session references the same remote database, then only 10 connections are needed. With a nonshared database link, 100 connections are needed.

Shared database links are not useful in all situations. Assume that only one user accesses the remote server. If this user defines a shared database link and 10 shared server processes exist in the local database, then this user can require up to 10 network connections to the remote server. Because the user can use each shared server process, each process can establish a connection to the remote server.

Clearly, a nonshared database link is preferable in this situation because it requires only one network connection. Shared database links lead to more network connections in single-user scenarios, so use shared links only when many users need to use the same link. Typically, shared links are used for public database links, but can also be used for private database links when many clients access the same local schema (and therefore the same private database link).

Note: In a multitiered environment, there is a restriction that if you use a shared database link to connect to a remote database, then that remote database cannot link to another database with a database link that cannot be migrated. That link must use a shared server, or it must be another shared database link.

Creating Shared Database Links

To create a shared database link, use the keyword `SHARED` in the `CREATE DATABASE LINK` statement:

```
CREATE SHARED DATABASE LINK dblink_name
[CONNECT TO username IDENTIFIED BY password]|[CONNECT TO CURRENT_USER]
AUTHENTICATED BY schema_name IDENTIFIED BY password
[USING 'service_name'];
```

Whenever you use the keyword `SHARED`, the clause `AUTHENTICATED BY` is required. The schema specified in the `AUTHENTICATED BY` clause must exist in the remote database and must be granted at least the `CREATE SESSION` privilege. The credentials of this schema can be considered the authentication method between the local database and the remote database. These credentials are required to protect the remote shared server processes from clients that masquerade as a database link user and attempt to gain unauthorized access to information.

After a connection is made with a shared database link, operations on the remote database proceed with the privileges of the `CONNECT TO` user or `CURRENT_USER`, not the `AUTHENTICATED BY` schema.

The following example creates a fixed user, shared link to database `sales`, connecting as `scott` and authenticated as `linkuser`:

```
CREATE SHARED DATABASE LINK link2sales
CONNECT TO scott IDENTIFIED BY tiger
AUTHENTICATED BY linkuser IDENTIFIED BY ostrich
USING 'sales';
```

See Also: *Oracle Database SQL Language Reference* for information about the `CREATE DATABASE LINK` statement

Configuring Shared Database Links

You can configure shared database links in the following ways:

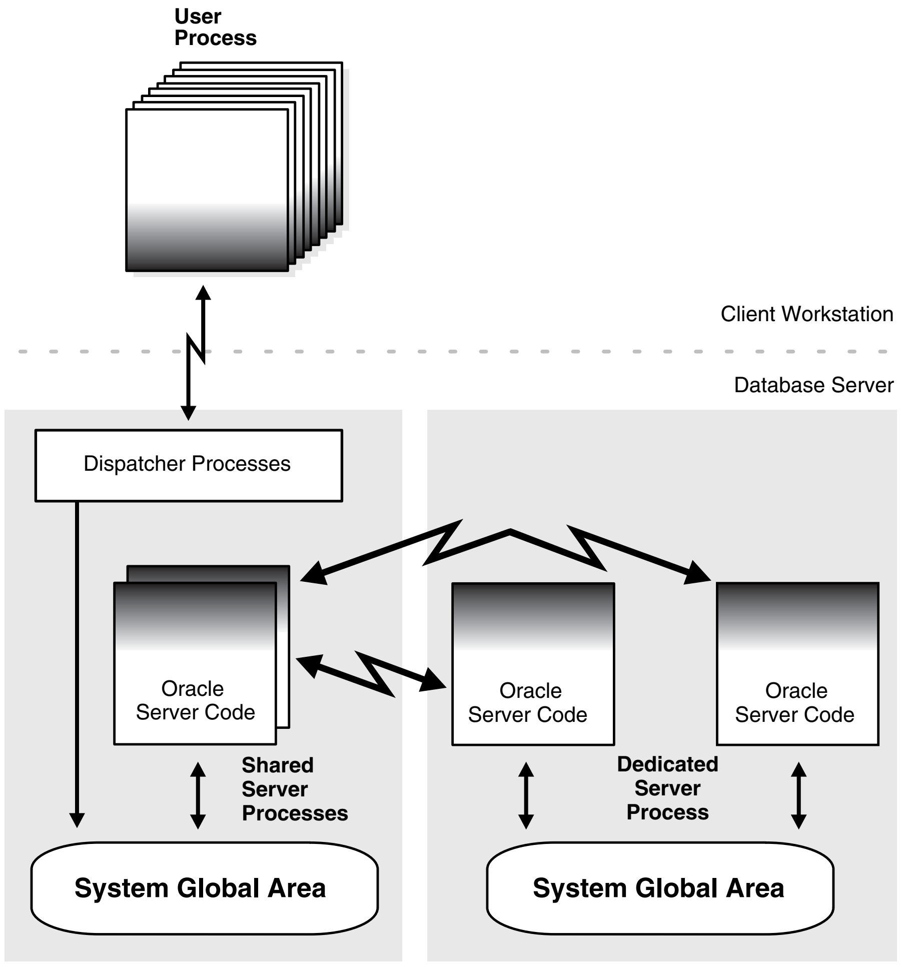
- Creating Shared Links to Dedicated Servers
- Creating Shared Links to Shared Servers

Creating Shared Links to Dedicated Servers

In the configuration illustrated in Figure 30–1, a shared server process in the local server owns a dedicated remote server process. The advantage is that a direct network transport exists between the local shared server and the remote dedicated server. A disadvantage is that extra back-end server processes are needed.

Note: The remote server can either be a shared server or dedicated server. There is a dedicated connection between the local and remote servers. When the remote server is a shared server, you can force a dedicated server connection by using the (`SERVER=DEDICATED`) clause in the definition of the service name.

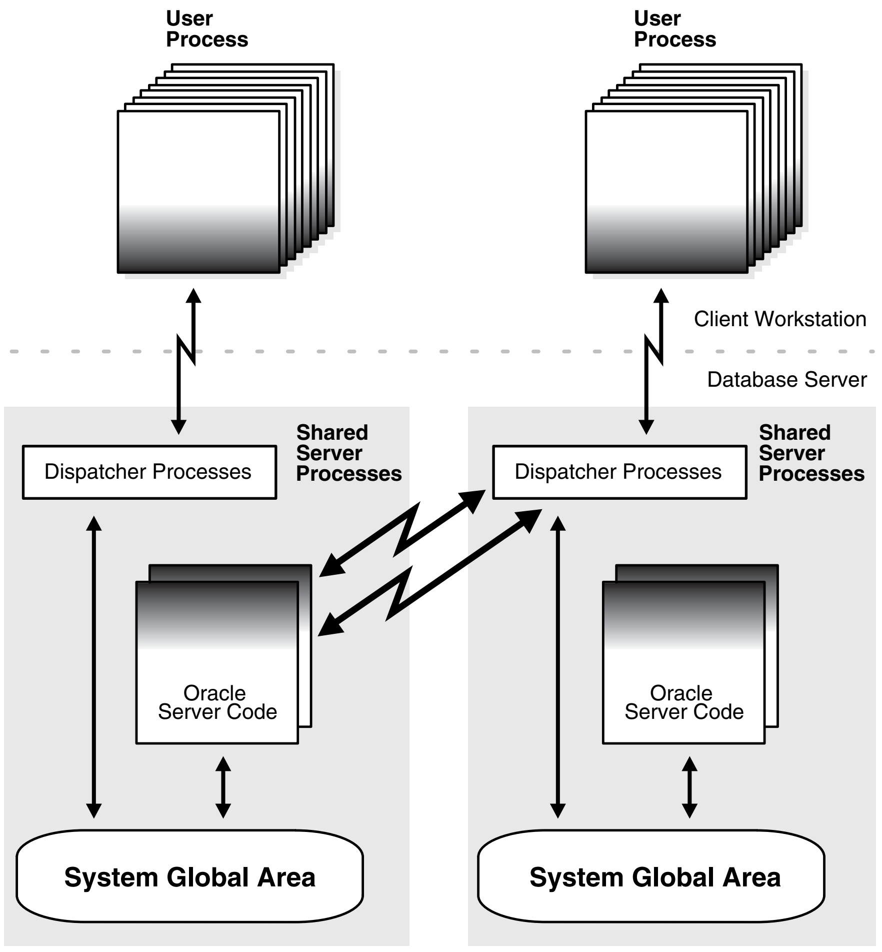
Figure 30–1 A Shared Database Link to Dedicated Server Processes



Creating Shared Links to Shared Servers

The configuration illustrated in Figure 30–2 uses shared server processes on the remote server. This configuration eliminates the need for more dedicated servers, but requires the connection to go through the dispatcher on the remote server. Note that both the local and the remote server must be configured as shared servers.

Figure 30–2 Shared Database Link to Shared Server



See Also: *Oracle Database Net Services Administrator's Guide* for information about the shared server option

Managing Database Links

This section contains the following topics:

- Closing Database Links
- Dropping Database Links
- Limiting the Number of Active Database Link Connections

Closing Database Links

If you access a database link in a session, then the link remains open until you close the session. A link is open in the sense that a process is active on each of the remote databases accessed through the link. This situation has the following consequences:

- If 20 users open sessions and access the same public link in a local database, then 20 database link connections are open.
- If 20 users open sessions and each user accesses a private link, then 20 database link connections are open.

- If one user starts a session and accesses 20 different links, then 20 database link connections are open.

After you close a session, the links that were active in the session are automatically closed. You may have occasion to close the link manually. For example, close links when:

- The network connection established by a link is used infrequently in an application.
- The user session must be terminated.

If you want to close a link, issue the following statement, where *linkname* refers to the name of the link:

```
ALTER SESSION CLOSE DATABASE LINK linkname;
```

Note that this statement only closes the links that are active in your current session.

Dropping Database Links

You can drop a database link just as you can drop a table or view. If the link is private, then it must be in your schema. If the link is public, then you must have the `DROP PUBLIC DATABASE LINK` system privilege.

The statement syntax is as follows, where *dblink* is the name of the link:

```
DROP [PUBLIC] DATABASE LINK dblink;
```

Procedure for Dropping a Private Database Link

1. Connect to the local database using SQL*Plus. For example, enter:

   ```
   CONNECT scott/tiger@local_db
   ```

2. Query `USER_DB_LINKS` to view the links that you own. For example, enter:

   ```
   SELECT DB_LINK FROM USER_DB_LINKS;

   DB_LINK
   -----------------------------------
   SALES.US.ORACLE.COM
   MKTG.US.ORACLE.COM
   2 rows selected.
   ```

3. Drop the desired link using the `DROP DATABASE LINK` statement. For example, enter:

   ```
   DROP DATABASE LINK sales.us.oracle.com;
   ```

Procedure for Dropping a Public Database Link

1. Connect to the local database as a user with the `DROP PUBLIC DATABASE LINK` privilege. For example, enter:

   ```
   CONNECT SYSTEM/password@local_db AS SYSDBA
   ```

2. Query `DBA_DB_LINKS` to view the public links. For example, enter:

   ```
   SELECT DB_LINK FROM USER_DB_LINKS
     WHERE OWNER = 'PUBLIC';

   DB_LINK
   -----------------------------------
   ```

```
DBL1.US.ORACLE.COM
SALES.US.ORACLE.COM
INST2.US.ORACLE.COM
RMAN2.US.ORACLE.COM
4 rows selected.
```

3. Drop the desired link using the `DROP PUBLIC DATABASE LINK` statement. For example, enter:

```
DROP PUBLIC DATABASE LINK sales.us.oracle.com;
```

Limiting the Number of Active Database Link Connections

You can limit the number of connections from a user process to remote databases using the static initialization parameter `OPEN_LINKS`. This parameter controls the number of remote connections that a single user session can use concurrently in distributed transactions.

Note the following considerations for setting this parameter:

- The value should be greater than or equal to the number of databases referred to in a single SQL statement that references multiple databases.
- Increase the value if several distributed databases are accessed over time. Thus, if you regularly access three databases, set `OPEN_LINKS` to 3 or greater.
- The default value for `OPEN_LINKS` is 4. If `OPEN_LINKS` is set to 0, then no distributed transactions are allowed.

See Also: *Oracle Database Reference* for more information about the `OPEN_LINKS` initialization parameter

Viewing Information About Database Links

The data dictionary of each database stores the definitions of all the database links in the database. You can use data dictionary tables and views to gain information about the links. This section contains the following topics:

- Determining Which Links Are in the Database
- Determining Which Link Connections Are Open

Determining Which Links Are in the Database

The following views show the database links that have been defined at the local database and stored in the data dictionary:

View	Purpose
`DBA_DB_LINKS`	Lists all database links in the database.
`ALL_DB_LINKS`	Lists all database links accessible to the connected user.
`USER_DB_LINKS`	Lists all database links owned by the connected user.

These data dictionary views contain the same basic information about database links, with some exceptions:

Column	Which Views?	Description
OWNER	All except USER_*	The user who created the database link. If the link is public, then the user is listed as PUBLIC.
DB_LINK	All	The name of the database link.
USERNAME	All	If the link definition includes a fixed user, then this column displays the username of the fixed user. If there is no fixed user, the column is NULL.
PASSWORD	Only USER_*	Not used. Maintained for backward compatibility only.
HOST	All	The net service name used to connect to the remote database.
CREATED	All	Creation time of the database link.

Any user can query USER_DB_LINKS to determine which database links are available to that user. Only those with additional privileges can use the ALL_DB_LINKS or DBA_DB_LINKS view.

The following script queries the DBA_DB_LINKS view to access link information:

```
COL OWNER FORMAT a10
COL USERNAME FORMAT A8 HEADING "USER"
COL DB_LINK FORMAT A30
COL HOST FORMAT A7 HEADING "SERVICE"
SELECT * FROM DBA_DB_LINKS
/
```

Here, the script is invoked and the resulting output is shown:

```
SQL>@link_script

OWNER      DB_LINK                        USER     SERVICE CREATED
---------- ------------------------------ -------- ------- ----------
SYS        TARGET.US.ACME.COM             SYS      inst1   23-JUN-99
PUBLIC     DBL1.UK.ACME.COM               BLAKE    ora51   23-JUN-99
PUBLIC     RMAN2.US.ACME.COM                       inst2   23-JUN-99
PUBLIC     DEPT.US.ACME.COM                        inst2   23-JUN-99
JANE       DBL.UK.ACME.COM                BLAKE    ora51   23-JUN-99
SCOTT      EMP.US.ACME.COM                SCOTT    inst2   23-JUN-99
6 rows selected.
```

Determining Which Link Connections Are Open

You may find it useful to determine which database link connections are currently open in your session. Note that if you connect as SYSDBA, you cannot query a view to determine all the links open for all sessions; you can only access the link information in the session within which you are working.

The following views show the database link connections that are currently open in your current session:

View	Purpose
V$DBLINK	Lists all open database links in your session, that is, all database links with the IN_TRANSACTION column set to YES.
GV$DBLINK	Lists all open database links in your session along with their corresponding instances. This view is useful in an Oracle Real Application Clusters configuration.

These data dictionary views contain the same basic information about database links, with one exception:

Column	Which Views?	Description
DB_LINK	All	The name of the database link.
OWNER_ID	All	The owner of the database link.
LOGGED_ON	All	Whether the database link is currently logged on.
HETEROGENEOUS	All	Whether the database link is homogeneous (NO) or heterogeneous (YES).
PROTOCOL	All	The communication protocol for the database link.
OPEN_CURSORS	All	Whether cursors are open for the database link.
IN_TRANSACTION	All	Whether the database link is accessed in a transaction that has not yet been committed or rolled back.
UPDATE_SENT	All	Whether there was an update on the database link.
COMMIT_POINT_STRENGTH	All	The commit point strength of the transactions using the database link.
INST_ID	GV$DBLINK only	The instance from which the view information was obtained.

For example, you can create and execute the script below to determine which links are open (sample output included):

```
COL DB_LINK FORMAT A25
COL OWNER_ID FORMAT 99999 HEADING "OWNID"
COL LOGGED_ON FORMAT A5 HEADING "LOGON"
COL HETEROGENEOUS FORMAT A5 HEADING "HETER"
COL PROTOCOL FORMAT A8
COL OPEN_CURSORS FORMAT 999 HEADING "OPN_CUR"
COL IN_TRANSACTION FORMAT A3 HEADING "TXN"
COL UPDATE_SENT FORMAT A6 HEADING "UPDATE"
COL COMMIT_POINT_STRENGTH FORMAT 99999 HEADING "C_P_S"

SELECT * FROM V$DBLINK
/

SQL> @dblink

DB_LINK                   OWNID LOGON HETER PROTOCOL OPN_CUR TXN UPDATE  C_P_S
------------------------- ------ ----- ----- -------- ------- --- ------ ------
INST2.ACME.COM                 0 YES   YES   UNKN           0 YES YES       255
```

Creating Location Transparency

After you have configured the necessary database links, you can use various tools to hide the distributed nature of the database system from users. In other words, users can access remote objects as if they were local objects. The following sections explain how to hide distributed functionality from users:

- Using Views to Create Location Transparency
- Using Synonyms to Create Location Transparency

- Using Procedures to Create Location Transparency

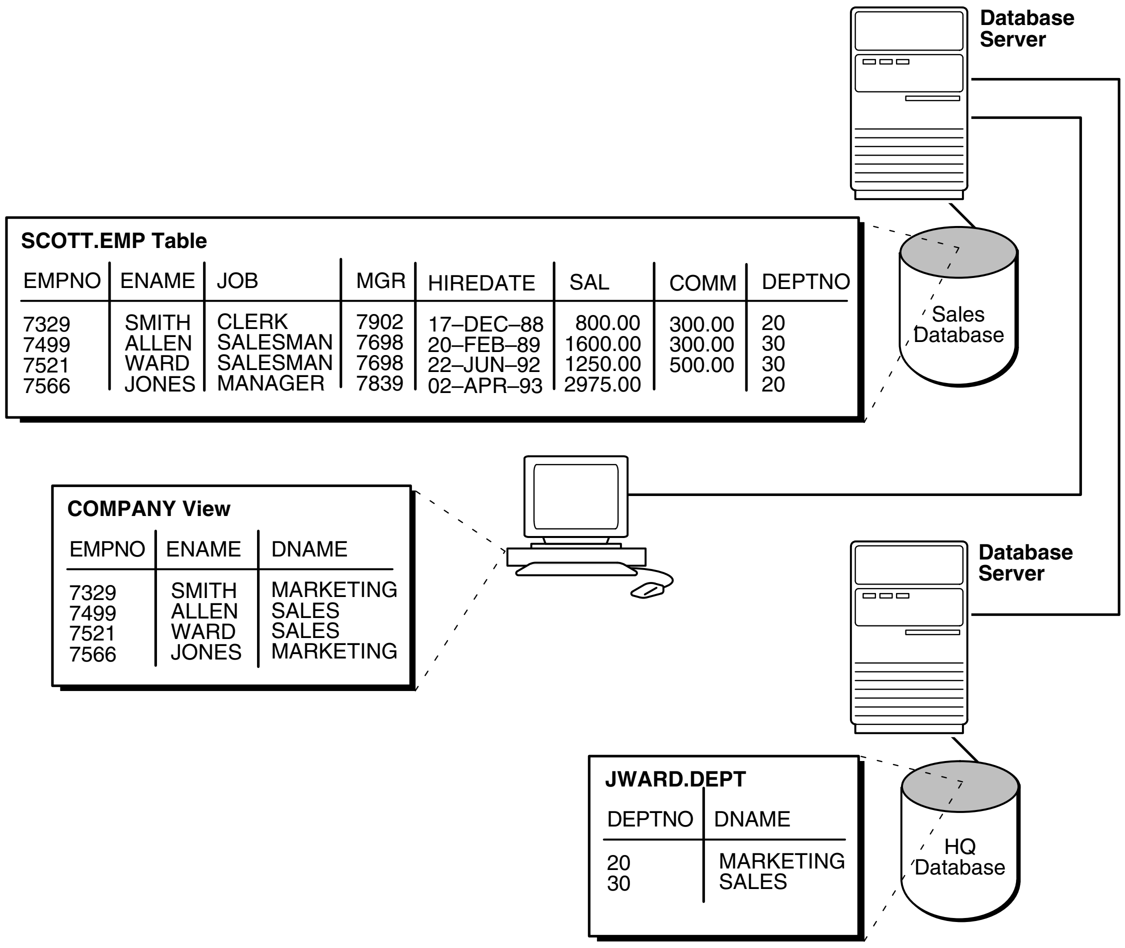
Using Views to Create Location Transparency

Local views can provide location transparency for local and remote tables in a distributed database system.

For example, assume that table `emp` is stored in a local database and table `dept` is stored in a remote database. To make these tables transparent to users of the system, you can create a view in the local database that joins local and remote data:

```
CREATE VIEW company AS
   SELECT a.empno, a.ename, b.dname
   FROM scott.emp a, jward.dept@hq.acme.com b
   WHERE a.deptno = b.deptno;
```

Figure 30–3 Views and Location Transparency



SCOTT.EMP Table

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
7329	SMITH	CLERK	7902	17–DEC–88	800.00	300.00	20
7499	ALLEN	SALESMAN	7698	20–FEB–89	1600.00	300.00	30
7521	WARD	SALESMAN	7698	22–JUN–92	1250.00	500.00	30
7566	JONES	MANAGER	7839	02–APR–93	2975.00		20

COMPANY View

EMPNO	ENAME	DNAME
7329	SMITH	MARKETING
7499	ALLEN	SALES
7521	WARD	SALES
7566	JONES	MARKETING

JWARD.DEPT

DEPTNO	DNAME
20	MARKETING
30	SALES

When users access this view, they do not need to know where the data is physically stored, or if data from more than one table is being accessed. Thus, it is easier for them to get required information. For example, the following query provides data from both the local and remote database table:

```
SELECT * FROM company;
```

The owner of the local view can grant only those object privileges on the local view that have been granted by the remote user. (The remote user is implied by the type of database link). This is similar to privilege management for views that reference local data.

Using Synonyms to Create Location Transparency

Synonyms are useful in both distributed and non-distributed environments because they hide the identity of the underlying object, including its location in a distributed database system. If you must rename or move the underlying object, you only need to redefine the synonym; applications based on the synonym continue to function normally. Synonyms also simplify SQL statements for users in a distributed database system.

Creating Synonyms

You can create synonyms for the following:

- Tables
- Types
- Views
- Materialized views
- Sequences
- Procedures
- Functions
- Packages

All synonyms are schema objects that are stored in the data dictionary of the database in which they are created. To simplify remote table access through database links, a synonym can allow single-word access to remote data, hiding the specific object name and the location from users of the synonym.

The syntax to create a synonym is:

```
CREATE [PUBLIC] synonym_name
FOR [schema.]object_name[@database_link_name];
```

where:

- `PUBLIC` is a keyword specifying that this synonym is available to all users. Omitting this parameter makes a synonym private, and usable only by the creator. Public synonyms can be created only by a user with `CREATE PUBLIC SYNONYM` system privilege.
- *`synonym_name`* specifies the alternate object name to be referenced by users and applications.
- *`schema`* specifies the schema of the object specified in *`object_name`*. Omitting this parameter uses the schema of the creator as the schema of the object.
- *`object_name`* specifies either a table, view, sequence, materialized view, type, procedure, function or package as appropriate.
- *`database_link_name`* specifies the database link identifying the remote database and schema in which the object specified in *`object_name`* is located.

A synonym must be a uniquely named object for its schema. If a schema contains a schema object and a public synonym exists with the same name, then the database always finds the schema object when the user that owns the schema references that name.

Example: Creating a Public Synonym

Assume that in every database in a distributed database system, a public synonym is defined for the `scott.emp` table stored in the `hq` database:

```
CREATE PUBLIC SYNONYM emp FOR scott.emp@hq.acme.com;
```

You can design an employee management application without regard to where the application is used because the location of the table `scott.emp@hq.acme.com` is hidden by the public synonyms. SQL statements in the application access the table by referencing the public synonym `emp`.

Furthermore, if you move the `emp` table from the `hq` database to the `hr` database, then you only need to change the public synonyms on the nodes of the system. The employee management application continues to function properly on all nodes.

Managing Privileges and Synonyms

A synonym is a reference to an actual object. A user who has access to a synonym for a particular schema object must also have privileges on the underlying schema object itself. For example, if the user attempts to access a synonym but does not have privileges on the table it identifies, an error occurs indicating that the table or view does not exist.

Assume `scott` creates local synonym `emp` as an alias for remote object `scott.emp@sales.acme.com. scott` *cannot* grant object privileges on the synonym to another local user. `scott` cannot grant local privileges for the synonym because this operation amounts to granting privileges for the remote `emp` table on the `sales` database, which is not allowed. This behavior is different from privilege management for synonyms that are aliases for local tables or views.

Therefore, you cannot manage local privileges when synonyms are used for location transparency. Security for the base object is controlled entirely at the remote node. For example, user `admin` cannot grant object privileges for the `emp_syn` synonym.

Unlike a database link referenced in a view or procedure definition, a database link referenced in a synonym is resolved by first looking for a private link owned by the schema in effect at the time the reference to the synonym is parsed. Therefore, to ensure the desired object resolution, it is especially important to specify the schema of the underlying object in the definition of a synonym.

Using Procedures to Create Location Transparency

PL/SQL program units called **procedures** can provide location transparency. You have these options:

- Using Local Procedures to Reference Remote Data
- Using Local Procedures to Call Remote Procedures
- Using Local Synonyms to Reference Remote Procedures

Using Local Procedures to Reference Remote Data

Procedures or functions (either standalone or in packages) can contain SQL statements that reference remote data. For example, consider the procedure created by the following statement:

```
CREATE PROCEDURE fire_emp (enum NUMBER) AS
```

```
BEGIN
  DELETE FROM emp@hq.acme.com
  WHERE empno = enum;
END;
```

When a user or application calls the `fire_emp` procedure, it is not apparent that a remote table is being modified.

A second layer of location transparency is possible when the statements in a procedure indirectly reference remote data using local procedures, views, or synonyms. For example, the following statement defines a local synonym:

```
CREATE SYNONYM emp FOR emp@hq.acme.com;
```

Given this synonym, you can create the `fire_emp` procedure using the following statement:

```
CREATE PROCEDURE fire_emp (enum NUMBER) AS
BEGIN
  DELETE FROM emp WHERE empno = enum;
END;
```

If you rename or move the table `emp@hq`, then you only need to modify the local synonym that references the table. None of the procedures and applications that call the procedure require modification.

Using Local Procedures to Call Remote Procedures

You can use a local procedure to call a remote procedure. The remote procedure can then execute the required DML. For example, assume that `scott` connects to `local_db` and creates the following procedure:

```
CONNECT scott/tiger@local_db

CREATE PROCEDURE fire_emp (enum NUMBER)
AS
BEGIN
  EXECUTE term_emp@hq.acme.com;
END;
```

Now, assume that `scott` connects to the remote database and creates the remote procedure:

```
CONNECT scott/tiger@hq.acme.com

CREATE PROCEDURE term_emp (enum NUMBER)
AS
BEGIN
  DELETE FROM emp WHERE empno = enum;
END;
```

When a user or application connected to `local_db` calls the `fire_emp` procedure, this procedure in turn calls the remote `term_emp` procedure on `hq.acme.com`.

Using Local Synonyms to Reference Remote Procedures

For example, `scott` connects to the local `sales.acme.com` database and creates the following procedure:

```
CREATE PROCEDURE fire_emp (enum NUMBER) AS
BEGIN
DELETE FROM emp@hq.acme.com
```

```
WHERE empno = enum;
END;
```

User peggy then connects to the supply.acme.com database and creates the following synonym for the procedure that scott created on the remote sales database:

```
SQL> CONNECT peggy/hill@supply
SQL> CREATE PUBLIC SYNONYM emp FOR scott.fire_emp@sales.acme.com;
```

A local user on supply can use this synonym to execute the procedure on sales.

Managing Procedures and Privileges

Assume a local procedure includes a statement that references a remote table or view. The owner of the local procedure can grant the execute privilege to any user, thereby giving that user the ability to execute the procedure and, indirectly, access remote data.

In general, procedures aid in security. Privileges for objects referenced within a procedure do not need to be explicitly granted to the calling users.

Managing Statement Transparency

The database allows the following standard DML statements to reference remote tables:

- SELECT (queries)
- INSERT
- UPDATE
- DELETE
- SELECT...FOR UPDATE (not always supported in Heterogeneous Systems)
- LOCK TABLE

Queries including joins, aggregates, subqueries, and SELECT...FOR UPDATE can reference any number of local and remote tables and views. For example, the following query joins information from two remote tables:

```
SELECT e.empno, e.ename, d.dname
  FROM scott.emp@sales.division3.acme.com e, jward.dept@hq.acme.com d
  WHERE e.deptno = d.deptno;
```

In a homogeneous environment, UPDATE, INSERT, DELETE, and LOCK TABLE statements can reference both local and remote tables. No programming is necessary to update remote data. For example, the following statement inserts new rows into the remote table emp in the scott.sales schema by selecting rows from the emp table in the jward schema in the local database:

```
INSERT INTO scott.emp@sales.division3.acme.com
  SELECT * FROM jward.emp;
```

Restrictions for Statement Transparency:

Several restrictions apply to statement transparency.

- Data manipulation language statements that update objects on a remote non-Oracle Database system cannot reference any objects on the local Oracle Database. For example, a statement such as the following will cause an error to be raised:

```
INSERT INTO remote_table@link as SELECT * FROM local_table;
```

- Within a single SQL statement, all referenced `LONG` and `LONG RAW` columns, sequences, updated tables, and locked tables must be located at the same node.
- The database does not allow remote DDL statements (for example, `CREATE`, `ALTER`, and `DROP`) in homogeneous systems except through remote execution of procedures of the `DBMS_SQL` package, as in this example:

  ```
  DBMS_SQL.PARSE@link_name(crs, 'drop table emp', v7);
  ```

  Note that in Heterogeneous Systems, a pass-through facility lets you execute DDL.
- The `LIST CHAINED ROWS` clause of an `ANALYZE` statement cannot reference remote tables.
- In a distributed database system, the database always evaluates environmentally-dependent SQL functions such as `SYSDATE`, `USER`, `UID`, and `USERENV` with respect to the local server, no matter where the statement (or portion of a statement) executes.

  Note: Oracle Database supports the `USERENV` function for queries only.

- A number of performance restrictions relate to access of remote objects:
  - Remote views do not have statistical data.
  - Queries on partitioned tables may not be optimized.
  - No more than 20 indexes are considered for a remote table.
  - No more than 20 columns are used for a composite index.
- There is a restriction in the Oracle Database implementation of distributed read consistency that can cause one node to be in the past with respect to another node. In accordance with read consistency, a query may end up retrieving consistent, but out-of-date data. See "Managing Read Consistency" on page 33-19 to learn how to manage this problem.

  See Also: *Oracle Database PL/SQL Packages and Types Reference* for more information about the `DBMS_SQL` package

Managing a Distributed Database: Examples

This section presents examples illustrating management of database links:

- Example 1: Creating a Public Fixed User Database Link
- Example 2: Creating a Public Fixed User Shared Database Link
- Example 3: Creating a Public Connected User Database Link
- Example 4: Creating a Public Connected User Shared Database Link
- Example 5: Creating a Public Current User Database Link

Example 1: Creating a Public Fixed User Database Link

The following statements connect to the local database as `jane` and create a public fixed user database link to database `sales` for `scott`. The database is accessed through its net service name `sldb`:

```
CONNECT jane/doe@local

CREATE PUBLIC DATABASE LINK sales.division3.acme.com
  CONNECT TO scott IDENTIFIED BY tiger
  USING 'sldb';
```

After executing these statements, any user connected to the local database can use the `sales.division3.acme.com` database link to connect to the remote database. Each user connects to the schema `scott` in the remote database.

To access the table `emp` table in `scott`'s remote schema, a user can issue the following SQL query:

```
SELECT * FROM emp@sales.division3.acme.com;
```

Note that each application or user session creates a separate connection to the common account on the server. The connection to the remote database remains open for the duration of the application or user session.

Example 2: Creating a Public Fixed User Shared Database Link

The following example connects to the local database as `dana` and creates a public link to the `sales` database (using its net service name `sldb`). The link allows a connection to the remote database as `scott` and authenticates this user as `scott`:

```
CONNECT dana/sculley@local

CREATE SHARED PUBLIC DATABASE LINK sales.division3.acme.com
  CONNECT TO scott IDENTIFIED BY tiger
  AUTHENTICATED BY scott IDENTIFIED BY tiger
  USING 'sldb';
```

Now, any user connected to the local shared server can use this database link to connect to the remote `sales` database through a shared server process. The user can then query tables in the `scott` schema.

In the preceding example, each local shared server can establish one connection to the remote server. Whenever a local shared server process needs to access the remote server through the `sales.division3.acme.com` database link, the local shared server process reuses established network connections.

Example 3: Creating a Public Connected User Database Link

The following example connects to the local database as `larry` and creates a public link to the database with the net service name `sldb`:

```
CONNECT larry/oracle@local

CREATE PUBLIC DATABASE LINK redwood
  USING 'sldb';
```

Any user connected to the local database can use the `redwood` database link. The connected user in the local database who uses the database link determines the remote schema.

If `scott` is the connected user and uses the database link, then the database link connects to the remote schema `scott`. If `fox` is the connected user and uses the database link, then the database link connects to remote schema `fox`.

The following statement fails for local user `fox` in the local database when the remote schema `fox` cannot resolve the `emp` schema object. That is, if the `fox` schema in the `sales.division3.acme.com` does not have `emp` as a table, view, or (public) synonym, an error will be returned.

```
CONNECT fox/mulder@local

SELECT * FROM emp@redwood;
```

Example 4: Creating a Public Connected User Shared Database Link

The following example connects to the local database as `neil` and creates a shared, public link to the `sales` database (using its net service name `sldb`). The user is authenticated by the userid/password of `crazy/horse`. The following statement creates a public, connected user, shared database link:

```
CONNECT neil/young@local

CREATE SHARED PUBLIC DATABASE LINK sales.division3.acme.com
  AUTHENTICATED BY crazy IDENTIFIED BY horse
  USING 'sldb';
```

Each user connected to the local server can use this shared database link to connect to the remote database and query the tables in the corresponding remote schema.

Each local, shared server process establishes one connection to the remote server. Whenever a local server process needs to access the remote server through the `sales.division3.acme.com` database link, the local process reuses established network connections, even if the connected user is a different user.

If this database link is used frequently, eventually every shared server in the local database will have a remote connection. At this point, no more physical connections are needed to the remote server, even if new users use this shared database link.

Example 5: Creating a Public Current User Database Link

The following example connects to the local database as the connected user and creates a public link to the `sales` database (using its net service name `sldb`). The following statement creates a public current user database link:

```
CONNECT bart/simpson@local

CREATE PUBLIC DATABASE LINK sales.division3.acme.com
  CONNECT TO CURRENT_USER
  USING 'sldb';
```

Note: To use this link, the current user must be a global user.

The consequences of this database link are as follows:

Assume `scott` creates local procedure `fire_emp` that deletes a row from the remote `emp` table, and grants execute privilege on `fire_emp` to `ford`.

```
CONNECT scott/tiger@local_db
```

```
CREATE PROCEDURE fire_emp (enum NUMBER)
AS
BEGIN
   DELETE FROM emp@sales.division3.acme.com
   WHERE empno=enum;
END;

GRANT EXECUTE ON fire_emp TO ford;
```

Now, assume that `ford` connects to the local database and runs `scott`'s procedure:

```
CONNECT ford/fairlane@local_db

EXECUTE PROCEDURE scott.fire_emp (enum 10345);
```

When `ford` executes the procedure `scott.fire_emp`, the procedure runs under `scott`'s privileges. Because a current user database link is used, the connection is established to `scott`'s remote schema, not `ford`'s remote schema. Note that `scott` must be a global user while `ford` does not have to be a global user.

Note: If a connected user database link were used instead, the connection would be to `ford`'s remote schema. For more information about invoker rights and privileges, see the *Oracle Database PL/SQL Language Reference*.

You can accomplish the same result by using a fixed user database link to `scott`'s remote schema.

31 Developing Applications for a Distributed Database System

This chapter describes considerations important when developing an application to run in a distributed database system. It contains the following topics:

- Managing the Distribution of Application Data
- Controlling Connections Established by Database Links
- Maintaining Referential Integrity in a Distributed System
- Tuning Distributed Queries
- Handling Errors in Remote Procedures

> **See Also:** *Oracle Database Advanced Application Developer's Guide* for more information about application development in an Oracle Database environment

Managing the Distribution of Application Data

In a distributed database environment, coordinate with the database administrator to determine the best location for the data. Some issues to consider are:

- Number of transactions posted from each location
- Amount of data (portion of table) used by each node
- Performance characteristics and reliability of the network
- Speed of various nodes, capacities of disks
- Importance of a node or link when it is unavailable
- Need for referential integrity among tables

Controlling Connections Established by Database Links

When a global object name is referenced in a SQL statement or remote procedure call, database links establish a connection to a session in the remote database on behalf of the local user. The remote connection and session are only created if the connection has not already been established previously for the local user session.

The connections and sessions established to remote databases persist for the duration of the local user's session, unless the application or user explicitly terminates them. Note that when you issue a `SELECT` statement across a database link, a transaction lock is placed on the undo segments. To rerelease the segment, you must issue a `COMMIT` or `ROLLBACK` statement.

Terminating remote connections established using database links is useful for disconnecting high cost connections that are no longer required by the application. You can terminate a remote connection and session using the `ALTER SESSION` statement with the `CLOSE DATABASE LINK` clause. For example, assume you issue the following transactions:

```
SELECT * FROM emp@sales;
COMMIT;
```

The following statement terminates the session in the remote database pointed to by the `sales` database link:

```
ALTER SESSION CLOSE DATABASE LINK sales;
```

To close a database link connection in your user session, you must have the `ALTER SESSION` system privilege.

Note: Before closing a database link, first close all cursors that use the link and then end your current transaction if it uses the link.

See Also: *Oracle Database SQL Language Reference* for more information about the `ALTER SESSION` statement

Maintaining Referential Integrity in a Distributed System

If a part of a distributed statement fails, for example, due to an integrity constraint violation, the database returns error number `ORA-02055`. Subsequent statements or procedure calls return error number `ORA-02067` until a `ROLLBACK` or `ROLLBACK TO SAVEPOINT` is issued.

Design your application to check for any returned error messages that indicate that a portion of the distributed update has failed. If you detect a failure, you should roll back the entire transaction before allowing the application to proceed.

The database does not permit declarative referential integrity constraints to be defined across nodes of a distributed system. In other words, a declarative referential integrity constraint on one table cannot specify a foreign key that references a primary or unique key of a remote table. Nevertheless, you can maintain parent/child table relationships across nodes using triggers.

If you decide to define referential integrity across the nodes of a distributed database using triggers, be aware that network failures can limit the accessibility of not only the parent table, but also the child table. For example, assume that the child table is in the `sales` database and the parent table is in the `hq` database. If the network connection between the two databases fails, some DML statements against the child table (those that insert rows into the child table or update a foreign key value in the child table) cannot proceed because the referential integrity triggers must have access to the parent table in the `hq` database.

See Also: *Oracle Database PL/SQL Language Reference* for more information about using triggers to enforce referential integrity

Tuning Distributed Queries

The local Oracle Database server breaks the distributed query into a corresponding number of remote queries, which it then sends to the remote nodes for execution. The remote nodes execute the queries and send the results back to the local node. The local node then performs any necessary post-processing and returns the results to the user or application.

You have several options for designing your application to optimize query processing. This section contains the following topics:

- Using Collocated Inline Views
- Using Cost-Based Optimization
- Using Hints
- Analyzing the Execution Plan

Using Collocated Inline Views

The most effective way of optimizing distributed queries is to access the remote databases as little as possible and to retrieve only the required data.

For example, assume you reference five remote tables from two different remote databases in a distributed query and have a complex filter (for example, `WHERE r1.salary + r2.salary > 50000`). You can improve the performance of the query by rewriting the query to access the remote databases once and to apply the filter at the remote site. This rewrite causes less data to be transferred to the query execution site.

Rewriting your query to access the remote database once is achieved by using collocated inline views. The following terms need to be defined:

- **Collocated**

  Two or more tables located in the same database.

- **Inline view**

  A `SELECT` statement that is substituted for a table in a parent `SELECT` statement. The embedded `SELECT` statement, shown within the parentheses is an example of an inline view:

  ```
  SELECT e.empno,e.ename,d.deptno,d.dname
     FROM (SELECT empno, ename from
           emp@orc1.world) e, dept d;
  ```

- **Collocated inline view**

  An inline view that selects data from multiple tables from a single database only. It reduces the amount of times that the remote database is accessed, improving the performance of a distributed query.

Oracle recommends that you form your distributed query using collocated inline views to increase the performance of your distributed query. Oracle Database cost-based optimization can transparently rewrite many of your distributed queries to take advantage of the performance gains offered by collocated inline views.

Using Cost-Based Optimization

In addition to rewriting your queries with collocated inline views, the cost-based optimization method optimizes distributed queries according to the gathered statistics of the referenced tables and the computations performed by the optimizer.

For example, cost-based optimization analyzes the following query. The example assumes that table statistics are available. Note that it analyzes the query inside a `CREATE TABLE` statement:

```
CREATE TABLE AS (
                 SELECT l.a, l.b, r1.c, r1.d, r1.e, r2.b, r2.c
                 FROM local l, remote1 r1, remote2 r2
                    WHERE l.c = r.c
                    AND r1.c = r2.c
                    AND r.e > 300
                );
```

and rewrites it as:

```
CREATE TABLE AS (
                 SELECT l.a, l.b, v.c, v.d, v.e
                 FROM (
                        SELECT r1.c, r1.d, r1.e, r2.b, r2.c
                         FROM remote1 r1, remote2 r2
                         WHERE r1.c = r2.c
                         AND r1.e > 300
                      ) v, local l
                 WHERE l.c = r1.c
                );
```

The alias `v` is assigned to the inline view, which can then be referenced as a table in the preceding `SELECT` statement. Creating a collocated inline view reduces the amount of queries performed at a remote site, thereby reducing costly network traffic.

How Does Cost-Based Optimization Work?

The main task of optimization is to rewrite a distributed query to use collocated inline views. This optimization is performed in three steps:

1. All mergeable views are merged.
2. Optimizer performs collocated query block test.
3. Optimizer rewrites query using collocated inline views.

After the query is rewritten, it is executed and the data set is returned to the user.

While cost-based optimization is performed transparently to the user, it is unable to improve the performance of several distributed query scenarios. Specifically, if your distributed query contains any of the following, cost-based optimization is not effective:

- Aggregates
- Subqueries
- Complex SQL

If your distributed query contains one of these elements, see "Using Hints" on page 31-6 to learn how you can modify your query and use hints to improve the performance of your distributed query.

Setting Up Cost-Based Optimization

After you have set up your system to use cost-based optimization to improve the performance of distributed queries, the operation is transparent to the user. In other words, the optimization occurs automatically when the query is issued.

You need to complete the following tasks to set up your system to take advantage of cost-based optimization:

- Setting Up the Environment
- Analyzing Tables

Setting Up the Environment To enable cost-based optimization, set the `OPTIMIZER_MODE` initialization parameter to `CHOOSE` or `COST`. You can set this parameter by:

- Modifying the `OPTIMIZER_MODE` parameter in the initialization parameter file
- Setting it at session level by issuing an `ALTER SESSION` statement

Issue one of the following statements to set the `OPTIMIZER_MODE` initialization parameter at the session level:

```
ALTER SESSION OPTIMIZER_MODE = CHOOSE;
ALTER SESSION OPTIMIZER_MODE = COST;
```

See Also: *Oracle Database Performance Tuning Guide* for information on setting the `OPTIMIZER_MODE` initialization parameter in the parameter file and for configuring your system to use a cost-based optimization method

Analyzing Tables For cost-based optimization to select the most efficient path for a distributed query, you must provide accurate statistics for the tables involved. You do this using the `DBMS_STATS` package or the `ANALYZE` statement.

Note: You must connect locally with respect to the tables when executing the `DBMS_STATS` procedure or `ANALYZE` statement. For example, you cannot execute the following:

```
ANALYZE TABLE remote@remote.com COMPUTE STATISTICS;
```

You must first connect to the remote site and then execute the preceding `ANALYZE` statement, or the equivalent `DBMS_STATS` procedure.

The following `DBMS_STATS` procedures enable the gathering of certain classes of optimizer statistics:

- `GATHER_INDEX_STATS`
- `GATHER_TABLE_STATS`
- `GATHER_SCHEMA_STATS`
- `GATHER_DATABASE_STATS`

For example, assume that distributed transactions routinely access the `scott.dept` table. To ensure that the cost-based optimizer is still picking the best plan, execute the following:

```
BEGIN
   DBMS_STATS.GATHER_TABLE_STATS ('scott', 'dept');
END;
```

See Also:

- *Oracle Database Performance Tuning Guide* for information about generating statistics
- *Oracle Database PL/SQL Packages and Types Reference* for additional information on using the `DBMS_STATS` package

Using Hints

If a statement is not sufficiently optimized, then you can use hints to extend the capability of cost-based optimization. Specifically, if you write your own query to utilize collocated inline views, instruct the cost-based optimizer not to rewrite your distributed query.

Additionally, if you have special knowledge about the database environment (such as statistics, load, network and CPU limitations, distributed queries, and so forth), you can specify a hint to guide cost-based optimization. For example, if you have written your own optimized query using collocated inline views that are based on your knowledge of the database environment, specify the `NO_MERGE` hint to prevent the optimizer from rewriting your query.

This technique is especially helpful if your distributed query contains an aggregate, subquery, or complex SQL. Because this type of distributed query cannot be rewritten by the optimizer, specifying `NO_MERGE` causes the optimizer to skip the steps described in "How Does Cost-Based Optimization Work?" on page 31-4.

The `DRIVING_SITE` hint lets you define a remote site to act as the query execution site. In this way, the query executes on the remote site, which then returns the data to the local site. This hint is especially helpful when the remote site contains the majority of the data.

See Also: *Oracle Database Performance Tuning Guide* for more information about using hints

Using the NO_MERGE Hint

The `NO_MERGE` hint prevents the database from merging an inline view into a potentially non-collocated SQL statement (see "Using Hints" on page 31-6). This hint is embedded in the `SELECT` statement and can appear either at the beginning of the `SELECT` statement with the inline view as an argument or in the query block that defines the inline view.

```
/* with argument */

SELECT /*+NO_MERGE(v)*/ t1.x, v.avg_y
   FROM t1, (SELECT x, AVG(y) AS avg_y FROM t2 GROUP BY x) v,
   WHERE t1.x = v.x AND t1.y = 1;

/* in query block */

SELECT t1.x, v.avg_y
   FROM t1, (SELECT /*+NO_MERGE*/ x, AVG(y) AS avg_y FROM t2 GROUP BY x) v,
   WHERE t1.x = v.x AND t1.y = 1;
```

Typically, you use this hint when you have developed an optimized query based on your knowledge of your database environment.

Using the DRIVING_SITE Hint

The `DRIVING_SITE` hint lets you specify the site where the query execution is performed. It is best to let cost-based optimization determine where the execution should be performed, but if you prefer to override the optimizer, you can specify the execution site manually.

Following is an example of a `SELECT` statement with a `DRIVING_SITE` hint:

```
SELECT /*+DRIVING_SITE(dept)*/ * FROM emp, dept@remote.com
   WHERE emp.deptno = dept.deptno;
```

Analyzing the Execution Plan

An important aspect to tuning distributed queries is analyzing the execution plan. The feedback that you receive from your analysis is an important element to testing and verifying your database. Verification becomes especially important when you want to compare plans. For example, comparing the execution plan for a distributed query optimized by cost-based optimization to a plan for a query manually optimized using hints, collocated inline views, and other techniques.

See Also: *Oracle Database Performance Tuning Guide* for detailed information about execution plans, the `EXPLAIN PLAN` statement, and how to interpret the results

Preparing the Database to Store the Plan

Before you can view the execution plan for the distributed query, prepare the database to store the execution plan. You can perform this preparation by executing a script. Execute the following script to prepare your database to store an execution plan:

```
SQL> @UTLXPLAN.SQL
```

Note: The `utlxplan.sql` file can be found in the `$ORACLE_HOME/rdbms/admin` directory.

After you execute `utlxplan.sql`, a table, `PLAN_TABLE`, is created in the current schema to temporarily store the execution plan.

Generating the Execution Plan

After you have prepared the database to store the execution plan, you are ready to view the plan for a specified query. Instead of directly executing a SQL statement, append the statement to the `EXPLAIN PLAN FOR` clause. For example, you can execute the following:

```
EXPLAIN PLAN FOR
   SELECT d.dname
   FROM dept d
      WHERE d.deptno
      IN (SELECT deptno
          FROM emp@orc2.world
          GROUP BY deptno
          HAVING COUNT (deptno) >3
          )
/
```

Viewing the Execution Plan

After you have executed the preceding SQL statement, the execution plan is stored temporarily in the `PLAN_TABLE` that you created earlier. To view the results of the execution plan, execute the following script:

```
@UTLXPLS.SQL
```

Note: The `utlxpls.sql` can be found in the `$ORACLE_HOME/rdbms/admin` directory.

Executing the `utlxpls.sql` script displays the execution plan for the `SELECT` statement that you specified. The results are formatted as follows:

```
Plan Table
-------------------------------------------------------------------------------
| Operation                 |  Name     |  Rows | Bytes|  Cost  | Pstart| Pstop |
-------------------------------------------------------------------------------
| SELECT STATEMENT          |           |       |      |        |       |       |
|  NESTED LOOPS             |           |       |      |        |       |       |
|   VIEW                    |           |       |      |        |       |       |
|    REMOTE                 |           |       |      |        |       |       |
|   TABLE ACCESS BY INDEX RO|DEPT       |       |      |        |       |       |
|    INDEX UNIQUE SCAN      |PK_DEPT    |       |      |        |       |       |
-------------------------------------------------------------------------------
```

If you are manually optimizing distributed queries by writing your own collocated inline views or using hints, it is best to generate an execution plan before and after your manual optimization. With both execution plans, you can compare the effectiveness of your manual optimization and make changes as necessary to improve the performance of the distributed query.

To view the SQL statement that will be executed at the remote site, execute the following select statement:

```
SELECT OTHER
FROM PLAN_TABLE
   WHERE operation = 'REMOTE';
```

Following is sample output:

```
SELECT DISTINCT "A1"."DEPTNO" FROM "EMP" "A1"
   GROUP BY "A1"."DEPTNO" HAVING COUNT("A1"."DEPTNO")>3
```

Note: If you are having difficulty viewing the entire contents of the `OTHER` column, execute the following SQL*Plus command:

```
SET LONG 9999999
```

Handling Errors in Remote Procedures

When the database executes a procedure locally or at a remote location, four types of exceptions can occur:

- PL/SQL user-defined exceptions, which must be declared using the keyword `EXCEPTION`
- PL/SQL predefined exceptions such as the `NO_DATA_FOUND` keyword
- SQL errors such as `ORA-00900` and `ORA-02015`

- Application exceptions generated using the `RAISE_APPLICATION_ERROR`() procedure

When using local procedures, you can trap these messages by writing an exception handler such as the following

```
BEGIN
  ...
EXCEPTION
   WHEN ZERO_DIVIDE THEN
   /* ... handle the exception */
END;
```

Notice that the `WHEN` clause requires an exception name. If the exception does not have a name, for example, exceptions generated with `RAISE_APPLICATION_ERROR`, you can assign one using `PRAGMA_EXCEPTION_INIT`. For example:

```
DECLARE
  null_salary EXCEPTION;
  PRAGMA EXCEPTION_INIT(null_salary, -20101);
BEGIN
  ...
  RAISE_APPLICATION_ERROR(-20101, 'salary is missing');
...
EXCEPTION
  WHEN null_salary THEN
  ...
END;
```

When calling a remote procedure, exceptions can be handled by an exception handler in the local procedure. The remote procedure must return an error number to the local, calling procedure, which then handles the exception as shown in the previous example. Note that PL/SQL user-defined exceptions always return `ORA-06510` to the local procedure.

Therefore, it is not possible to distinguish between two different user-defined exceptions based on the error number. All other remote exceptions can be handled in the same manner as local exceptions.

> **See Also:** *Oracle Database PL/SQL Language Reference* for more information about PL/SQL procedures

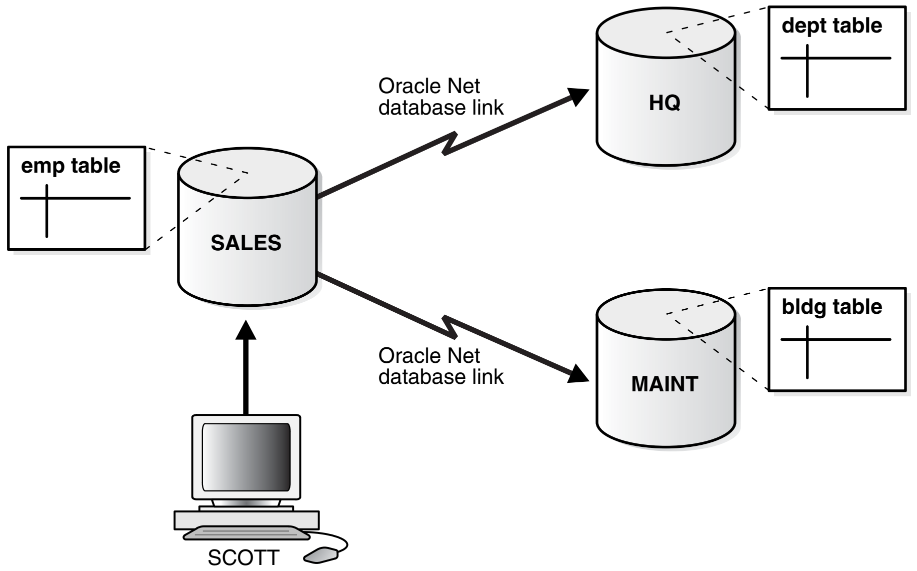
32 Distributed Transactions Concepts

This chapter describes what distributed transactions are and how Oracle Database maintains their integrity. The following topics are contained in this chapter:

What Are Distributed Transactions?

A **distributed transaction** includes one or more statements that, individually or as a group, update data on two or more distinct nodes of a distributed database. For example, assume the database configuration depicted in Figure 32–1:

Figure 32–1 Distributed System



The following distributed transaction executed by `scott` updates the local `sales` database, the remote `hq` database, and the remote `maint` database:

```
UPDATE scott.dept@hq.us.acme.com
  SET loc = 'REDWOOD SHORES'
  WHERE deptno = 10;
UPDATE scott.emp
  SET deptno = 11
  WHERE deptno = 10;
UPDATE scott.bldg@maint.us.acme.com
  SET room = 1225
  WHERE room = 1163;
COMMIT;
```

Note: If all statements of a transaction reference only a single remote node, then the transaction is remote, not distributed.

There are two types of permissible operations in distributed transactions:

- DML and DDL Transactions
- Transaction Control Statements

DML and DDL Transactions

The following are the DML and DDL operations supported in a distributed transaction:

- `CREATE TABLE AS SELECT`
- `DELETE`
- `INSERT` (default and direct load)
- `LOCK TABLE`
- `SELECT`
- `SELECT FOR UPDATE`

You can execute DML and DDL statements in parallel, and `INSERT` direct load statements serially, but note the following restrictions:

- All remote operations must be `SELECT` statements.
- These statements must not be clauses in another distributed transaction.
- If the table referenced in the *table_expression_clause* of an `INSERT`, `UPDATE`, or `DELETE` statement is remote, then execution is serial rather than parallel.
- You cannot perform remote operations after issuing parallel DML/DDL or direct load `INSERT`.
- If the transaction begins using XA or OCI, it executes serially.
- No loopback operations can be performed on the transaction originating the parallel operation. For example, you cannot reference a remote object that is actually a synonym for a local object.
- If you perform a distributed operation other than a `SELECT` in the transaction, no DML is parallelized.

Transaction Control Statements

The following are the supported transaction control statements:

- `COMMIT`
- `ROLLBACK`

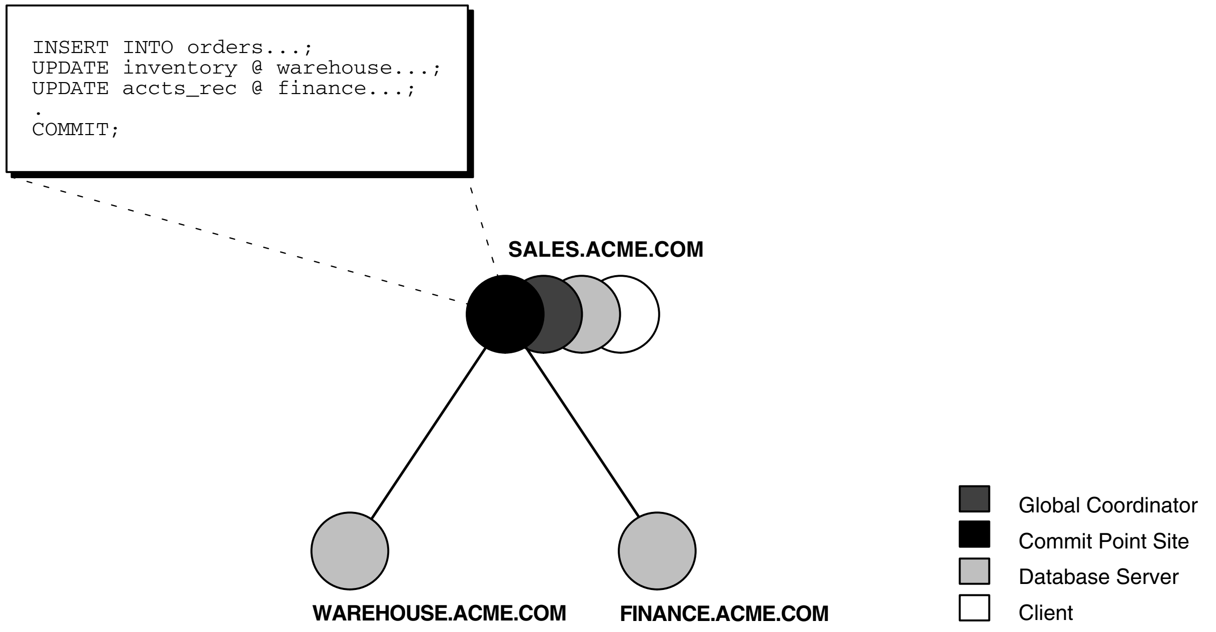
- `SAVEPOINT`

See Also: *Oracle Database SQL Language Reference* for more information about these SQL statements

Session Trees for Distributed Transactions

As the statements in a distributed transaction are issued, the database defines a **session tree** of all nodes participating in the transaction. A session tree is a hierarchical model that describes the relationships among sessions and their roles. Figure 32–2 illustrates a session tree:

Figure 32–2 Example of a Session Tree



```
INSERT INTO orders...;
UPDATE inventory @ warehouse...;
UPDATE accts_rec @ finance...;
.
COMMIT;
```

All nodes participating in the session tree of a distributed transaction assume one or more of the following roles:

Role	Description
Client	A node that references information in a database belonging to a different node.
Database server	A node that receives a request for information from another node.
Global coordinator	The node that originates the distributed transaction.
Local coordinator	A node that is forced to reference data on other nodes to complete its part of the transaction.
Commit point site	The node that commits or rolls back the transaction as instructed by the global coordinator.

The role a node plays in a distributed transaction is determined by:

- Whether the transaction is local or remote
- The **commit point strength** of the node ("Commit Point Site" on page 32-5)

- Whether all requested data is available at a node, or whether other nodes need to be referenced to complete the transaction
- Whether the node is read-only

Clients

A node acts as a client when it references information from a database on another node. The referenced node is a database server. In Figure 32–2, the node `sales` is a client of the nodes that host the `warehouse` and `finance` databases.

Database Servers

A database server is a node that hosts a database from which a client requests data.

In Figure 32–2, an application at the `sales` node initiates a distributed transaction that accesses data from the `warehouse` and `finance` nodes. Therefore, `sales.acme.com` has the role of client node, and `warehouse` and `finance` are both database servers. In this example, `sales` is a database server *and* a client because the application also modifies data in the `sales` database.

Local Coordinators

A node that must reference data on other nodes to complete its part in the distributed transaction is called a local coordinator. In Figure 32–2, `sales` is a local coordinator because it coordinates the nodes it directly references: `warehouse` and `finance.` The node `sales` also happens to be the global coordinator because it coordinates all the nodes involved in the transaction.

A local coordinator is responsible for coordinating the transaction among the nodes it communicates directly with by:

- Receiving and relaying transaction status information to and from those nodes
- Passing queries to those nodes
- Receiving queries from those nodes and passing them on to other nodes
- Returning the results of queries to the nodes that initiated them

Global Coordinator

The node where the distributed transaction originates is called the global coordinator. The database application issuing the distributed transaction is directly connected to the node acting as the global coordinator. For example, in Figure 32–2, the transaction issued at the node `sales` references information from the database servers `warehouse` and `finance`. Therefore, `sales.acme.com` is the global coordinator of this distributed transaction.

The global coordinator becomes the parent or root of the session tree. The global coordinator performs the following operations during a distributed transaction:

- Sends all of the distributed transaction SQL statements, remote procedure calls, and so forth to the directly referenced nodes, thus forming the session tree
- Instructs all directly referenced nodes other than the commit point site to prepare the transaction
- Instructs the commit point site to initiate the global commit of the transaction if all nodes prepare successfully

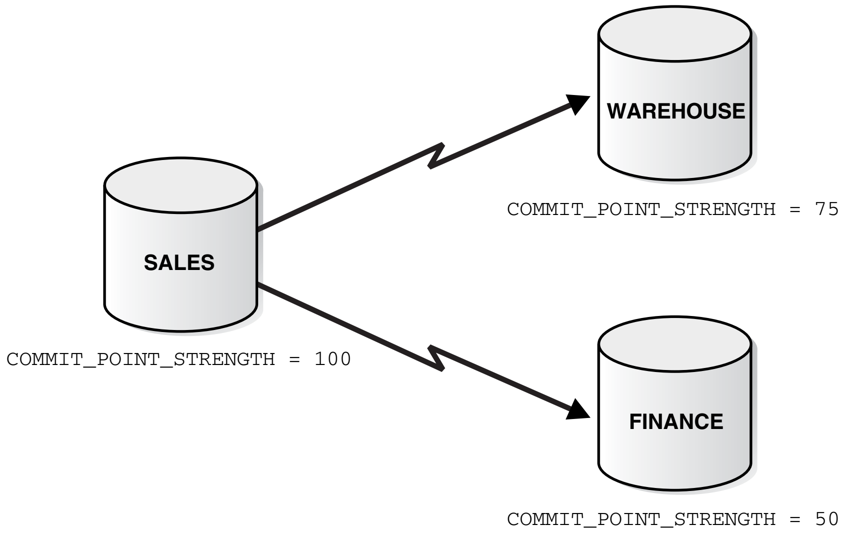
- Instructs all nodes to initiate a global rollback of the transaction if there is an abort response

Commit Point Site

The job of the commit point site is to initiate a commit or roll back operation as instructed by the global coordinator. The system administrator always designates one node to be the commit point site in the session tree by assigning all nodes a commit point strength. The node selected as commit point site should be the node that stores the most critical data.

Figure 32–3 illustrates an example of distributed system, with `sales` serving as the commit point site:

Figure 32–3 Commit Point Site


WAREHOUSE
COMMIT_POINT_STRENGTH = 75
SALES
COMMIT_POINT_STRENGTH = 100
FINANCE
COMMIT_POINT_STRENGTH = 50

The commit point site is distinct from all other nodes involved in a distributed transaction in these ways:

- The commit point site never enters the prepared state. Consequently, if the commit point site stores the most critical data, this data never remains in-doubt, even if a failure occurs. In failure situations, failed nodes remain in a prepared state, holding necessary locks on data until in-doubt transactions are resolved.
- The commit point site commits before the other nodes involved in the transaction. In effect, the outcome of a distributed transaction at the commit point site determines whether the transaction at all nodes is committed or rolled back: the other nodes follow the lead of the commit point site. The global coordinator ensures that all nodes complete the transaction in the same manner as the commit point site.

How a Distributed Transaction Commits

A distributed transaction is considered committed after all non-commit-point sites are prepared, and the transaction has been actually committed at the commit point site. The redo log at the commit point site is updated as soon as the distributed transaction is committed at this node.

Because the commit point log contains a record of the commit, the transaction is considered committed even though some participating nodes may still be only in the prepared state and the transaction not yet actually committed at these nodes. In the same way, a distributed transaction is considered *not* committed if the commit has not been logged at the commit point site.

Commit Point Strength

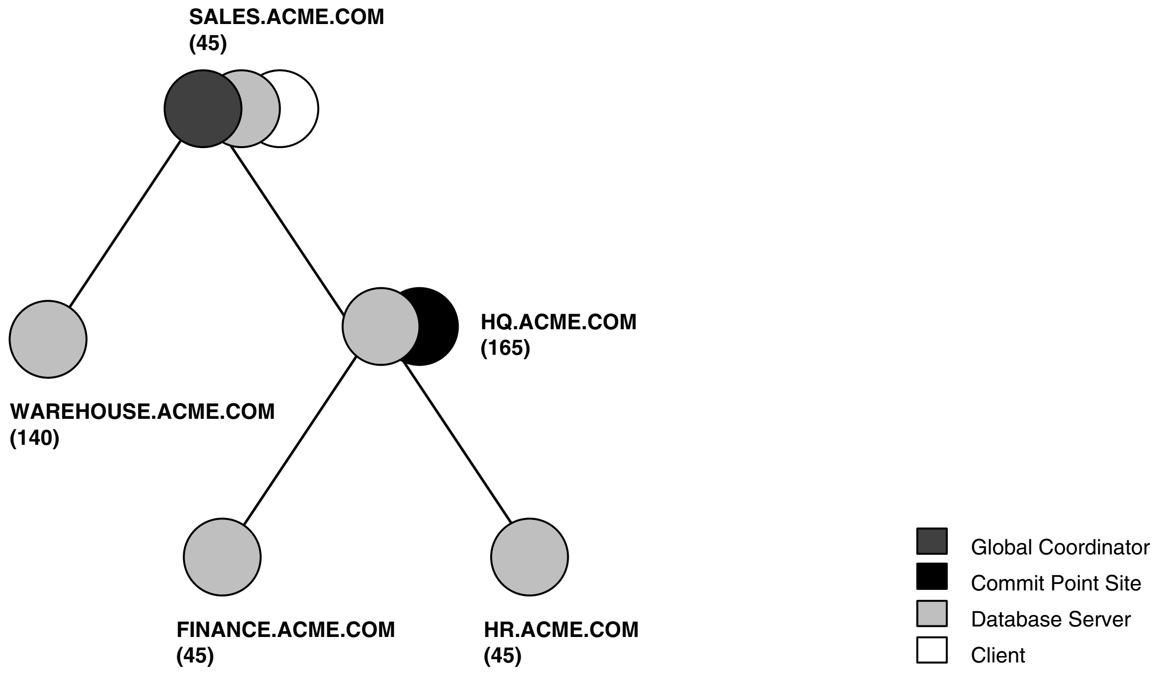
Every database server must be assigned a commit point strength. If a database server is referenced in a distributed transaction, the value of its commit point strength determines which role it plays in the two-phase commit. Specifically, the commit point strength determines whether a given node is the commit point site in the distributed transaction and thus commits before all of the other nodes. This value is specified using the initialization parameter `COMMIT_POINT_STRENGTH`. This section explains how the database determines the commit point site.

The commit point site, which is determined at the beginning of the prepare phase, is selected only from the nodes participating in the transaction. The following sequence of events occurs:

1. Of the nodes directly referenced by the global coordinator, the database selects the node with the highest commit point strength as the commit point site.
2. The initially-selected node determines if any of the nodes from which it has to obtain information for this transaction has a higher commit point strength.
3. Either the node with the highest commit point strength directly referenced in the transaction or one of its servers with a higher commit point strength becomes the commit point site.
4. After the final commit point site has been determined, the global coordinator sends prepare responses to all nodes participating in the transaction.

Figure 32–4 shows in a sample session tree the commit point strengths of each node (in parentheses) and shows the node chosen as the commit point site:

Figure 32–4 Commit Point Strengths and Determination of the Commit Point Site



The following conditions apply when determining the commit point site:

- A read-only node cannot be the commit point site.
- If multiple nodes directly referenced by the global coordinator have the same commit point strength, then the database designates one of these as the commit point site.
- If a distributed transaction ends with a rollback, then the prepare and commit phases are not needed. Consequently, the database never determines a commit point site. Instead, the global coordinator sends a `ROLLBACK` statement to all nodes and ends the processing of the distributed transaction.

As Figure 32–4 illustrates, the commit point site and the global coordinator can be different nodes of the session tree. The commit point strength of each node is communicated to the coordinators when the initial connections are made. The coordinators retain the commit point strengths of each node they are in direct communication with so that commit point sites can be efficiently selected during two-phase commits. Therefore, it is not necessary for the commit point strength to be exchanged between a coordinator and a node each time a commit occurs.

See Also:

- "Specifying the Commit Point Strength of a Node" on page 33-1 to learn how to set the commit point strength of a node
- *Oracle Database Reference* for more information about the initialization parameter `COMMIT_POINT_STRENGTH`

Two-Phase Commit Mechanism

Unlike a transaction on a local database, a distributed transaction involves altering data on multiple databases. Consequently, distributed transaction processing is more complicated, because the database must coordinate the committing or rolling back of the changes in a transaction as a self-contained unit. In other words, the entire transaction commits, or the entire transaction rolls back.

The database ensures the integrity of data in a distributed transaction using the **two-phase commit mechanism**. In the **prepare phase**, the initiating node in the transaction asks the other participating nodes to promise to commit or roll back the transaction. During the **commit phase**, the initiating node asks all participating nodes to commit the transaction. If this outcome is not possible, then all nodes are asked to roll back.

All participating nodes in a distributed transaction should perform the same action: they should either all commit or all perform a rollback of the transaction. The database automatically controls and monitors the commit or rollback of a distributed transaction and maintains the integrity of the **global database** (the collection of databases participating in the transaction) using the two-phase commit mechanism. This mechanism is completely transparent, requiring no programming on the part of the user or application developer.

The commit mechanism has the following distinct phases, which the database performs automatically whenever a user commits a distributed transaction:

Phase	Description
Prepare phase	The initiating node, called the **global coordinator**, asks participating nodes other than the commit point site to promise to commit or roll back the transaction, even if there is a failure. If any node cannot prepare, the transaction is rolled back.

Phase	Description
Commit phase	If all participants respond to the coordinator that they are prepared, then the coordinator asks the commit point site to commit. After it commits, the coordinator asks all other nodes to commit the transaction.
Forget phase	The global coordinator forgets about the transaction.

This section contains the following topics:

- Prepare Phase
- Commit Phase
- Forget Phase

Prepare Phase

The first phase in committing a distributed transaction is the prepare phase. In this phase, the database does not actually commit or roll back the transaction. Instead, all nodes referenced in a distributed transaction (except the commit point site, described in the "Commit Point Site" on page 32-5) are told to prepare to commit. By preparing, a node:

- Records information in the redo logs so that it can subsequently either commit or roll back the transaction, regardless of intervening failures
- Places a distributed lock on modified tables, which prevents reads

When a node responds to the global coordinator that it is prepared to commit, the prepared node *promises* to either commit or roll back the transaction later, but does not make a unilateral decision on whether to commit or roll back the transaction. The promise means that if an instance failure occurs at this point, the node can use the redo records in the online log to recover the database back to the prepare phase.

Note: Queries that start after a node has prepared cannot access the associated locked data until all phases complete. The time is insignificant unless a failure occurs (see "Deciding How to Handle In-Doubt Transactions" on page 33-5).

Types of Responses in the Prepare Phase

When a node is told to prepare, it can respond in the following ways:

Response	Meaning
Prepared	Data on the node has been modified by a statement in the distributed transaction, and the node has successfully prepared.
Read-only	No data on the node has been, or can be, modified (only queried), so no preparation is necessary.
Abort	The node cannot successfully prepare.

Prepared Response When a node has successfully prepared, it issues a **prepared message**. The message indicates that the node has records of the changes in the online log, so it is prepared either to commit or perform a rollback. The message also guarantees that locks held for the transaction can survive a failure.

Read-Only Response When a node is asked to prepare, and the SQL statements affecting the database do not change any data on the node, the node responds with a **read-only message**. The message indicates that the node will not participate in the commit phase.

There are three cases in which all or part of a distributed transaction is read-only:

Case	Conditions	Consequence
Partially read-only	Any of the following occurs: ■ Only queries are issued at one or more nodes. ■ No data is changed. ■ Changes rolled back due to triggers firing or constraint violations.	The read-only nodes recognize their status when asked to prepare. They give their local coordinators a read-only response. Thus, the commit phase completes faster because the database eliminates read-only nodes from subsequent processing.
Completely read-only with prepare phase	All of following occur: ■ No data changes. ■ Transaction is *not* started with `SET TRANSACTION READ ONLY` statement.	All nodes recognize that they are read-only during prepare phase, so no commit phase is required. The global coordinator, not knowing whether all nodes are read-only, must still perform the prepare phase.
Completely read-only without two-phase commit	All of following occur: ■ No data changes. ■ Transaction *is* started with `SET TRANSACTION READ ONLY` statement.	Only queries are allowed in the transaction, so global coordinator does not have to perform two-phase commit. Changes by other transactions do not degrade global transaction-level read consistency because of global SCN coordination among nodes. The transaction does not use undo segments.

Note that if a distributed transaction is set to read-only, then it does not use undo segments. If many users connect to the database and their transactions are *not* set to `READ ONLY`, then they allocate undo space even if they are only performing queries.

Abort Response When a node cannot successfully prepare, it performs the following actions:

1. Releases resources currently held by the transaction and rolls back the local portion of the transaction.
2. Responds to the node that referenced it in the distributed transaction with an abort message.

These actions then propagate to the other nodes involved in the distributed transaction so that they can roll back the transaction and guarantee the integrity of the data in the global database. This response enforces the primary rule of a distributed transaction: *all nodes involved in the transaction either all commit or all roll back the transaction at the same logical time*.

Steps in the Prepare Phase

To complete the prepare phase, each node excluding the commit point site performs the following steps:

1. The node requests that its **descendants**, that is, the nodes subsequently referenced, prepare to commit.

2. The node checks to see whether the transaction changes data on itself or its descendants. If there is no change to the data, then the node skips the remaining steps and returns a read-only response (see "Read-Only Response" on page 32-9).
3. The node allocates the resources it needs to commit the transaction if data is changed.
4. The node saves redo records corresponding to changes made by the transaction to its redo log.
5. The node guarantees that locks held for the transaction are able to survive a failure.
6. The node responds to the initiating node with a prepared response (see "Prepared Response" on page 32-8) or, if its attempt or the attempt of one of its descendents to prepare was unsuccessful, with an abort response (see "Abort Response" on page 32-9).

These actions guarantee that the node can subsequently commit or roll back the transaction on the node. The prepared nodes then wait until a `COMMIT` or `ROLLBACK` request is received from the global coordinator.

After the nodes are prepared, the distributed transaction is said to be **in-doubt** (see "In-Doubt Transactions" on page 32-11).It retains in-doubt status until all changes are either committed or rolled back.

Commit Phase

The second phase in committing a distributed transaction is the commit phase. Before this phase occurs, *all* nodes other than the commit point site referenced in the distributed transaction have guaranteed that they are prepared, that is, they have the necessary resources to commit the transaction.

Steps in the Commit Phase

The commit phase consists of the following steps:

1. The global coordinator instructs the commit point site to commit.
2. The commit point site commits.
3. The commit point site informs the global coordinator that it has committed.
4. The global and local coordinators send a message to all nodes instructing them to commit the transaction.
5. At each node, the database commits the local portion of the distributed transaction and releases locks.
6. At each node, the database records an additional redo entry in the local redo log, indicating that the transaction has committed.
7. The participating nodes notify the global coordinator that they have committed.

When the commit phase is complete, the data on all nodes of the distributed system is consistent.

Guaranteeing Global Database Consistency

Each committed transaction has an associated system change number (SCN) to uniquely identify the changes made by the SQL statements within that transaction. The SCN functions as an internal timestamp that uniquely identifies a committed version of the database.

In a distributed system, the SCNs of communicating nodes are coordinated when all of the following actions occur:

- A connection occurs using the path described by one or more database links
- A distributed SQL statement executes
- A distributed transaction commits

Among other benefits, the coordination of SCNs among the nodes of a distributed system ensures global read-consistency at both the statement and transaction level. If necessary, global time-based recovery can also be completed.

During the prepare phase, the database determines the highest SCN at all nodes involved in the transaction. The transaction then commits with the high SCN at the commit point site. The commit SCN is then sent to all prepared nodes with the commit decision.

> **See Also:** "Managing Read Consistency" on page 33-19 for information about managing time lag issues in read consistency

Forget Phase

After the participating nodes notify the commit point site that they have committed, the commit point site can forget about the transaction. The following steps occur:

1. After receiving notice from the global coordinator that all nodes have committed, the commit point site erases status information about this transaction.
2. The commit point site informs the global coordinator that it has erased the status information.
3. The global coordinator erases its own information about the transaction.

In-Doubt Transactions

The two-phase commit mechanism ensures that all nodes either commit or perform a rollback together. What happens if any of the three phases fails because of a system or network error? The transaction becomes in-doubt.

Distributed transactions can become in-doubt in the following ways:

- A server machine running Oracle Database software crashes
- A network connection between two or more Oracle Databases involved in distributed processing is disconnected
- An unhandled software error occurs

The RECO process automatically resolves in-doubt transactions when the machine, network, or software problem is resolved. Until RECO can resolve the transaction, the data is locked for both reads and writes. The database blocks reads because it cannot determine which version of the data to display for a query.

This section contains the following topics:

- Automatic Resolution of In-Doubt Transactions
- Manual Resolution of In-Doubt Transactions
- Relevance of System Change Numbers for In-Doubt Transactions

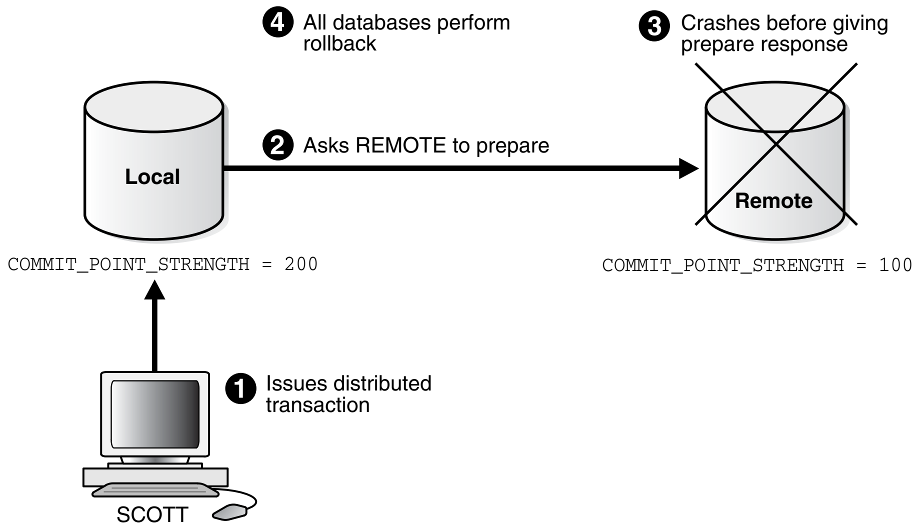
Automatic Resolution of In-Doubt Transactions

In the majority of cases, the database resolves the in-doubt transaction automatically. Assume that there are two nodes, `local` and `remote`, in the following scenarios. The local node is the commit point site. User `scott` connects to `local` and executes and commits a distributed transaction that updates `local` and `remote`.

Failure During the Prepare Phase

Figure 32–5 illustrates the sequence of events when there is a failure during the prepare phase of a distributed transaction:

Figure 32–5 Failure During Prepare Phase


4 All databases perform rollback
3 Crashes before giving prepare response
Local
2 Asks REMOTE to prepare
Remote
COMMIT_POINT_STRENGTH = 200
COMMIT_POINT_STRENGTH = 100
1 Issues distributed transaction
SCOTT

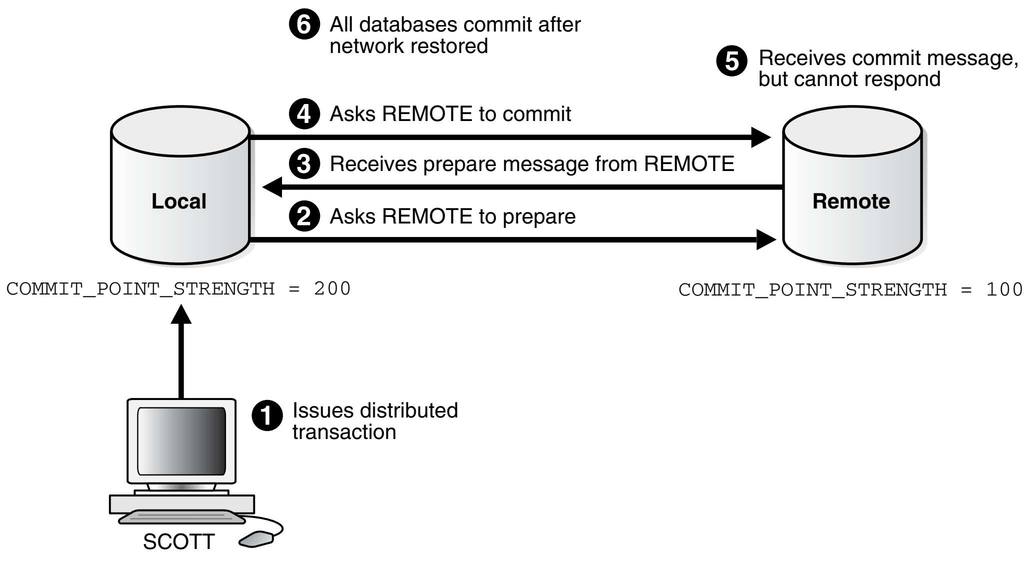
The following steps occur:

1. User `SCOTT` connects to `Local` and executes a distributed transaction.
2. The global coordinator, which in this example is also the commit point site, requests all databases other than the commit point site to promise to commit or roll back when told to do so.
3. The `remote` database crashes before issuing the prepare response back to `local`.
4. The transaction is ultimately rolled back on each database by the RECO process when the remote site is restored.

Failure During the Commit Phase

Figure 32–6 illustrates the sequence of events when there is a failure during the commit phase of a distributed transaction:

Figure 32–6 Failure During Commit Phase


6 All databases commit after network restored
5 Receives commit message, but cannot respond
4 Asks REMOTE to commit
3 Receives prepare message from REMOTE
2 Asks REMOTE to prepare
Local
Remote
COMMIT_POINT_STRENGTH = 200
COMMIT_POINT_STRENGTH = 100
1 Issues distributed transaction
SCOTT

The following steps occur:

1. User `Scott` connects to `local` and executes a distributed transaction.
2. The global coordinator, which in this case is also the commit point site, requests all databases other than the commit point site to promise to commit or roll back when told to do so.
3. The commit point site receives a prepared message from `remote` saying that it will commit.
4. The commit point site commits the transaction locally, then sends a commit message to `remote` asking it to commit.
5. The `remote` database receives the commit message, but cannot respond because of a network failure.
6. The transaction is ultimately committed on the remote database by the RECO process after the network is restored.

See Also: "Deciding How to Handle In-Doubt Transactions" on page 33-5 for a description of failure situations and how the database resolves intervening failures during two-phase commit

Manual Resolution of In-Doubt Transactions

You should only need to resolve an in-doubt transaction in the following cases:

- The in-doubt transaction has locks on critical data or undo segments.
- The cause of the machine, network, or software failure cannot be repaired quickly.

Resolution of in-doubt transactions can be complicated. The procedure requires that you do the following:

- Identify the transaction identification number for the in-doubt transaction.
- Query the `DBA_2PC_PENDING` and `DBA_2PC_NEIGHBORS` views to determine whether the databases involved in the transaction have committed.
- If necessary, force a commit using the `COMMIT FORCE` statement or a rollback using the `ROLLBACK FORCE` statement.

See Also: The following sections explain how to resolve in-doubt transactions:

- "Deciding How to Handle In-Doubt Transactions" on page 33-5
- "Manually Overriding In-Doubt Transactions" on page 33-8

Relevance of System Change Numbers for In-Doubt Transactions

A **system change number** (SCN) is an internal timestamp for a committed version of the database. The Oracle Database server uses the SCN clock value to guarantee transaction consistency. For example, when a user commits a transaction, the database records an SCN for this commit in the redo log.

The database uses SCNs to coordinate distributed transactions among different databases. For example, the database uses SCNs in the following way:

1. An application establishes a connection using a database link.
2. The distributed transaction commits with the highest global SCN among all the databases involved.
3. The commit global SCN is sent to all databases involved in the transaction.

SCNs are important for distributed transactions because they function as a synchronized commit timestamp of a transaction, even if the transaction fails. If a transaction becomes in-doubt, an administrator can use this SCN to coordinate changes made to the global database. The global SCN for the transaction commit can also be used to identify the transaction later, for example, in distributed recovery.

Distributed Transaction Processing: Case Study

In this scenario, a company has separate Oracle Database servers, `sales.acme.com` and `warehouse.acme.com`. As users insert sales records into the `sales` database, associated records are being updated at the `warehouse` database.

This case study of distributed processing illustrates:

- The definition of a session tree
- How a commit point site is determined
- When prepare messages are sent
- When a transaction actually commits
- What information is stored locally about the transaction

Stage 1: Client Application Issues DML Statements

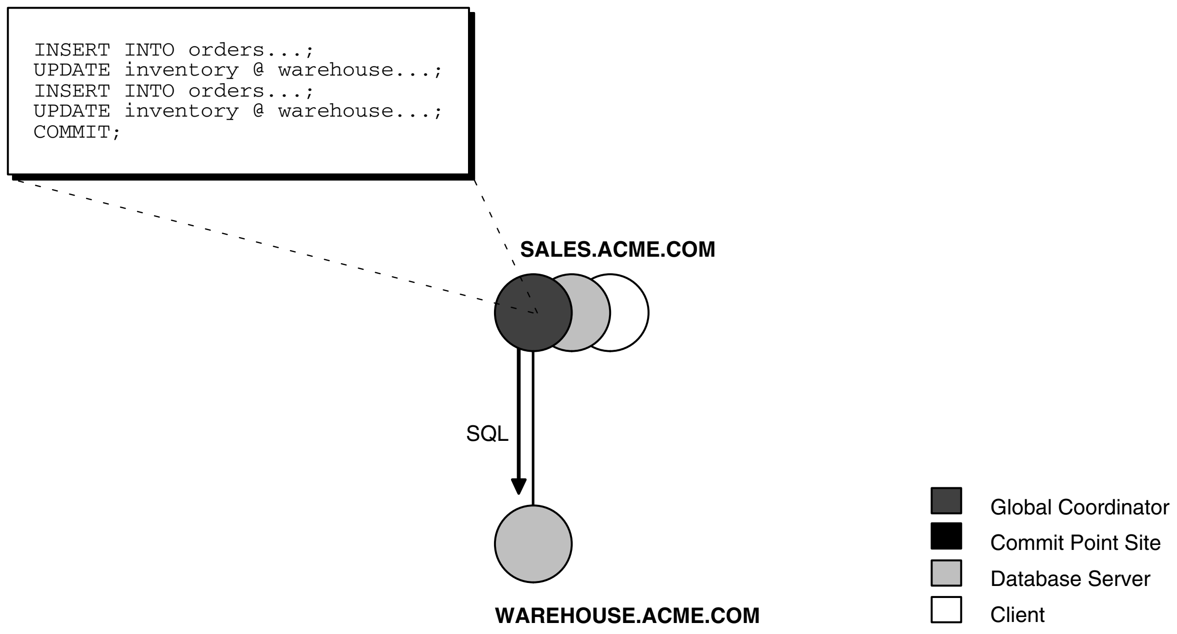
At the Sales department, a salesperson uses SQL*Plus to enter a sales order and then commit it. The application issues a number of SQL statements to enter the order into the `sales` database and update the inventory in the `warehouse` database:

```
CONNECT scott/tiger@sales.acme.com ...;
INSERT INTO orders ...;
UPDATE inventory@warehouse.acme.com ...;
INSERT INTO orders ...;
UPDATE inventory@warehouse.acme.com ...;
COMMIT;
```

These SQL statements are part of a single distributed transaction, guaranteeing that all issued SQL statements succeed or fail as a unit. Treating the statements as a unit prevents the possibility of an order being placed and then inventory not being updated to reflect the order. In effect, the transaction guarantees the consistency of data in the global database.

As each of the SQL statements in the transaction executes, the session tree is defined, as shown in Figure 32–7.

Figure 32–7 Defining the Session Tree



```
INSERT INTO orders...;
UPDATE inventory @ warehouse...;
INSERT INTO orders...;
UPDATE inventory @ warehouse...;
COMMIT;
```

Note the following aspects of the transaction:

- An order entry application running on the `sales` database initiates the transaction. Therefore, `sales.acme.com` is the global coordinator for the distributed transaction.
- The order entry application inserts a new sales record into the `sales` database and updates the inventory at the warehouse. Therefore, the nodes `sales.acme.com` and `warehouse.acme.com` are both database servers.
- Because `sales.acme.com` updates the inventory, it is a client of `warehouse.acme.com`.

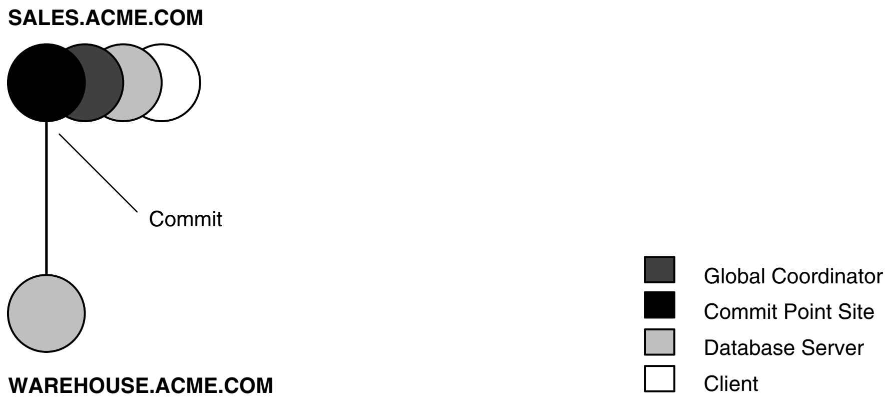
This stage completes the definition of the session tree for this distributed transaction. Each node in the tree has acquired the necessary data locks to execute the SQL statements that reference local data. These locks remain even after the SQL statements have been executed until the two-phase commit is completed.

Stage 2: Oracle Database Determines Commit Point Site

The database determines the commit point site immediately following the `COMMIT` statement. `sales.acme.com`, the global coordinator, is determined to be the commit point site, as shown in Figure 32–8.

> **See Also:** "Commit Point Strength" on page 32-6 for more information about how the commit point site is determined

Figure 32–8 Determining the Commit Point Site



Stage 3: Global Coordinator Sends Prepare Response

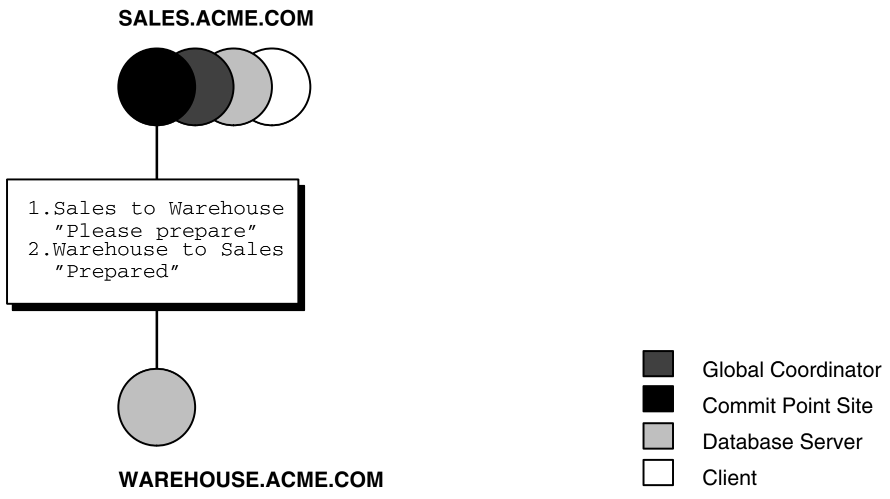
The prepare stage involves the following steps:

1. After the database determines the commit point site, the global coordinator sends the prepare message to all directly referenced nodes of the session tree, *excluding* the commit point site. In this example, `warehouse.acme.com` is the only node asked to prepare.
2. Node `warehouse.acme.com` tries to prepare. If a node can guarantee that it can commit the locally dependent part of the transaction and can record the commit information in its local redo log, then the node can successfully prepare. In this example, only `warehouse.acme.com` receives a prepare message because `sales.acme.com` is the commit point site.
3. Node `warehouse.acme.com` responds to `sales.acme.com` with a prepared message.

As each node prepares, it sends a message back to the node that asked it to prepare. Depending on the responses, one of the following can happen:

- If *any* of the nodes asked to prepare responds with an abort message to the global coordinator, then the global coordinator tells all nodes to roll back the transaction, and the operation is completed.
- If *all* nodes asked to prepare respond with a prepared or a read-only message to the global coordinator, that is, they have successfully prepared, then the global coordinator asks the commit point site to commit the transaction.

Figure 32–9 Sending and Acknowledging the Prepare Message



Stage 4: Commit Point Site Commits

The committing of the transaction by the commit point site involves the following steps:

1. Node `sales.acme.com`, receiving acknowledgment that `warehouse.acme.com` is prepared, instructs the commit point site to commit the transaction.
2. The commit point site now commits the transaction locally and records this fact in its local redo log.

Even if `warehouse.acme.com` has not yet committed, the outcome of this transaction is predetermined. In other words, the transaction *will* be committed at all nodes even if the ability of a given node to commit is delayed.

Stage 5: Commit Point Site Informs Global Coordinator of Commit

This stage involves the following steps:

1. The commit point site tells the global coordinator that the transaction has committed. Because the commit point site and global coordinator are the same node in this example, no operation is required. The commit point site knows that the transaction is committed because it recorded this fact in its online log.
2. The global coordinator confirms that the transaction has been committed on all other nodes involved in the distributed transaction.

Stage 6: Global and Local Coordinators Tell All Nodes to Commit

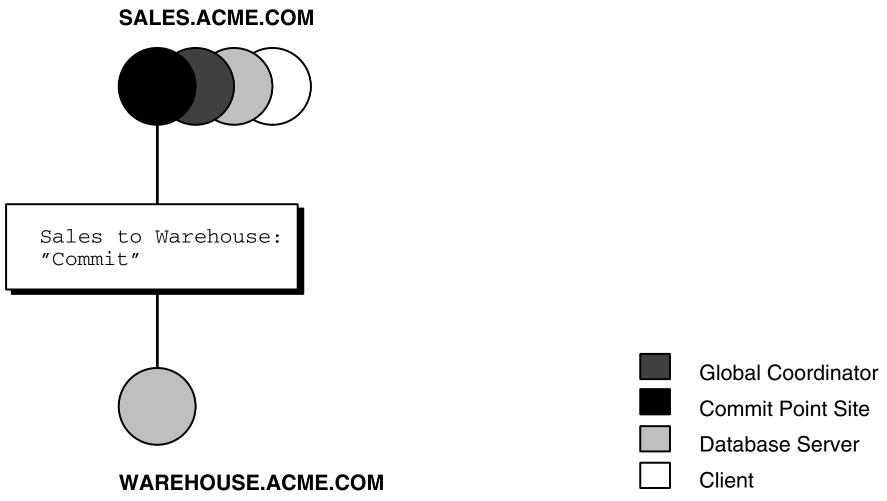
The committing of the transaction by all the nodes in the transaction involves the following steps:

1. After the global coordinator has been informed of the commit at the commit point site, it tells all other directly referenced nodes to commit.
2. In turn, any local coordinators instruct their servers to commit, and so on.

3. Each node, including the global coordinator, commits the transaction and records appropriate redo log entries locally. As each node commits, the resource locks that were being held locally for that transaction are released.

In Figure 32–10, `sales.acme.com`, which is both the commit point site and the global coordinator, has already committed the transaction locally. `sales` now instructs `warehouse.acme.com` to commit the transaction.

Figure 32–10 Instructing Nodes to Commit



Stage 7: Global Coordinator and Commit Point Site Complete the Commit

The completion of the commit of the transaction occurs in the following steps:

1. After all referenced nodes and the global coordinator have committed the transaction, the global coordinator informs the commit point site of this fact.
2. The commit point site, which has been waiting for this message, erases the status information about this distributed transaction.
3. The commit point site informs the global coordinator that it is finished. In other words, the commit point site forgets about committing the distributed transaction. This action is permissible because all nodes involved in the two-phase commit have committed the transaction successfully, so they will never have to determine its status in the future.
4. The global coordinator finalizes the transaction by forgetting about the transaction itself.

After the completion of the `COMMIT` phase, the distributed transaction is itself complete. The steps described are accomplished automatically and in a fraction of a second.

33 Managing Distributed Transactions

This chapter describes how to manage and troubleshoot distributed transactions. The following topics are included in this chapter:

Specifying the Commit Point Strength of a Node

The database with the highest commit point strength determines which node commits first in a distributed transaction. When specifying a commit point strength for each node, ensure that the most critical server will be non-blocking if a failure occurs during a prepare or commit phase. The `COMMIT_POINT_STRENGTH` initialization parameter determines the commit point strength of a node.

The default value is operating system-dependent. The range of values is any integer from 0 to 255. For example, to set the commit point strength of a database to 200, include the following line in the database initialization parameter file:

```
COMMIT_POINT_STRENGTH = 200
```

The commit point strength is only used to determine the commit point site in a distributed transaction.

When setting the commit point strength for a database, note the following considerations:

- Because the commit point site stores information about the status of the transaction, the commit point site should not be a node that is frequently unreliable or unavailable in case other nodes need information about transaction status.

- Set the commit point strength for a database relative to the amount of critical shared data in the database. For example, a database on a mainframe computer usually shares more data among users than a database on a PC. Therefore, set the commit point strength of the mainframe to a higher value than the PC.

  See Also: "Commit Point Site" on page 32-5 for a conceptual overview of commit points

Naming Transactions

You can name a transaction. This is useful for identifying a specific distributed transaction and replaces the use of the `COMMIT COMMENT` statement for this purpose.

To name a transaction, use the `SET TRANSACTION...NAME` statement. For example:

```
SET TRANSACTION ISOLATION LEVEL SERIALIZABLE
     NAME 'update inventory checkpoint 0';
```

This example shows that the user started a new transaction with isolation level equal to `SERIALIZABLE` and named it `'update inventory checkpoint 0'`.

For distributed transactions, the name is sent to participating sites when a transaction is committed. If a `COMMIT COMMENT` exists, it is ignored when a transaction name exists.

The transaction name is displayed in the `NAME` column of the `V$TRANSACTION` view, and in the `TRAN_COMMENT` field of the DBA_2PC_PENDING view when the transaction is committed.

Viewing Information About Distributed Transactions

The data dictionary of each database stores information about all open distributed transactions. You can use data dictionary tables and views to gain information about the transactions. This section contains the following topics:

- Determining the ID Number and Status of Prepared Transactions
- Tracing the Session Tree of In-Doubt Transactions

Determining the ID Number and Status of Prepared Transactions

The following view shows the database links that have been defined at the local database and stored in the data dictionary:

View	Purpose
`DBA_2PC_PENDING`	Lists all in-doubt distributed transactions. The view is empty until populated by an in-doubt transaction. After the transaction is resolved, the view is purged.

Use this view to determine the global commit number for a particular transaction ID. You can use this global commit number when manually resolving an in-doubt transaction.

The following table shows the most relevant columns (for a description of all the columns in the view, see *Oracle Database Reference*):

Table 33–1 DBA_2PC_PENDING

Column	Description
`LOCAL_TRAN_ID`	Local transaction identifier in the format *integer.integer.integer*. **Note:** When the `LOCAL_TRAN_ID` and the `GLOBAL_TRAN_ID` for a connection are the same, the node is the global coordinator of the transaction.
`GLOBAL_TRAN_ID`	Global database identifier in the format *global_db_name*e.*db_hex_id*.*local_tran_id*, where *db_hex_id* is an eight-character hexadecimal value used to uniquely identify the database. This common transaction ID is the same on every node for a distributed transaction. **Note:** When the `LOCAL_TRAN_ID` and the `GLOBAL_TRAN_ID` for a connection are the same, the node is the global coordinator of the transaction.
`STATE`	`STATE` can have the following values: ■ Collecting This category normally applies only to the global coordinator or local coordinators. The node is currently collecting information from other database servers before it can decide whether it can prepare. ■ Prepared The node has prepared and may or may not have acknowledged this to its local coordinator with a prepared message. However, no commit request has been received. The node remains prepared, holding any local resource locks necessary for the transaction to commit. ■ Committed The node (any type) has committed the transaction, but other nodes involved in the transaction may not have done the same. That is, the transaction is still pending at one or more nodes. ■ Forced Commit A pending transaction can be forced to commit at the discretion of a database administrator. This entry occurs if a transaction is manually committed at a local node. ■ Forced termination (rollback) A pending transaction can be forced to roll back at the discretion of a database administrator. This entry occurs if this transaction is manually rolled back at a local node.
`MIXED`	`YES` means that part of the transaction was committed on one node and rolled back on another node.
`TRAN_COMMENT`	Transaction comment or, if using transaction naming, the transaction name is placed here when the transaction is committed.
`HOST`	Name of the host machine.
`COMMIT#`	Global commit number for committed transactions.

Execute the following script, named `pending_txn_script`, to query pertinent information in `DBA_2PC_PENDING` (sample output included):

```
COL LOCAL_TRAN_ID FORMAT A13
COL GLOBAL_TRAN_ID FORMAT A30
COL STATE FORMAT A8
COL MIXED FORMAT A3
COL HOST FORMAT A10
COL COMMIT# FORMAT A10

SELECT LOCAL_TRAN_ID, GLOBAL_TRAN_ID, STATE, MIXED, HOST, COMMIT#
   FROM DBA_2PC_PENDING
/

SQL> @pending_txn_script

LOCAL_TRAN_ID GLOBAL_TRAN_ID                STATE    MIX HOST       COMMIT#
------------- ----------------------------- -------- --- ---------- ----------
1.15.870      HQ.ACME.COM.ef192da4.1.15.870  commit   no  dlsun183   115499
```

This output indicates that local transaction `1.15.870` has been committed on this node, but it may be pending on one or more other nodes. Because `LOCAL_TRAN_ID` and the local part of `GLOBAL_TRAN_ID` are the same, the node is the global coordinator of the transaction.

Tracing the Session Tree of In-Doubt Transactions

The following view shows which in-doubt transactions are incoming from a remote client and which are outgoing to a remote server:

View	Purpose
`DBA_2PC_NEIGHBORS`	Lists all incoming (from remote client) and outgoing (to remote server) in-doubt distributed transactions. It also indicates whether the local node is the commit point site in the transaction. The view is empty until populated by an in-doubt transaction. After the transaction is resolved, the view is purged.

When a transaction is in-doubt, you may need to determine which nodes performed which roles in the session tree. Use to this view to determine:

- All the incoming and outgoing connections for a given transaction
- Whether the node is the commit point site in a given transaction
- Whether the node is a global coordinator in a given transaction (because its local transaction ID and global transaction ID are the same)

The following table shows the most relevant columns (for an account of all the columns in the view, see *Oracle Database Reference*):

Table 33–2 DBA_2PC_NEIGHBORS

Column	Description
`LOCAL_TRAN_ID`	Local transaction identifier with the format *integer.integer.integer*. **Note:** When `LOCAL_TRAN_ID` and `GLOBAL_TRAN_ID.DBA_2PC_PENDING` for a connection are the same, the node is the global coordinator of the transaction.
`IN_OUT`	`IN` for incoming transactions; `OUT` for outgoing transactions.
`DATABASE`	For incoming transactions, the name of the client database that requested information from this local node; for outgoing transactions, the name of the database link used to access information on a remote server.

Table 33–2 (Cont.) DBA_2PC_NEIGHBORS

Column	Description
DBUSER_OWNER	For incoming transactions, the local account used to connect by the remote database link; for outgoing transactions, the owner of the database link.
INTERFACE	C is a commit message; N is either a message indicating a prepared state or a request for a read-only commit. When IN_OUT is OUT, C means that the child at the remote end of the connection is the commit point site and knows whether to commit or terminate. N means that the local node is informing the remote node that it is prepared. When IN_OUT is IN, C means that the local node or a database at the remote end of an outgoing connection is the commit point site. N means that the remote node is informing the local node that it is prepared.

Execute the following script, named `neighbors_script`, to query pertinent information in `DBA_2PC_PENDING` (sample output included):

```
COL LOCAL_TRAN_ID FORMAT A13
COL IN_OUT FORMAT A6
COL DATABASE FORMAT A25
COL DBUSER_OWNER FORMAT A15
COL INTERFACE FORMAT A3
SELECT LOCAL_TRAN_ID, IN_OUT, DATABASE, DBUSER_OWNER, INTERFACE
   FROM DBA_2PC_NEIGHBORS
/

SQL> CONNECT SYS/password@hq.acme.com
SQL> @neighbors_script

LOCAL_TRAN_ID IN_OUT DATABASE                  DBUSER_OWNER    INT
------------- ------ ------------------------- --------------- ---
1.15.870      out    SALES.ACME.COM            SYS             C
```

This output indicates that the local node sent an outgoing request to remote server `sales` to commit transaction `1.15.870`. If `sales` committed the transaction but no other node did, then you know that `sales` is the commit point site, because the commit point site always commits first.

Deciding How to Handle In-Doubt Transactions

A transaction is in-doubt when there is a failure during any aspect of the two-phase commit. Distributed transactions become in-doubt in the following ways:

- A server machine running Oracle Database software crashes
- A network connection between two or more Oracle Databases involved in distributed processing is disconnected
- An unhandled software error occurs

See Also: "In-Doubt Transactions" on page 32-11 for a conceptual overview of in-doubt transactions

You can manually force the commit or rollback of a local, in-doubt distributed transaction. Because this operation can generate consistency problems, perform it only when specific conditions exist.

This section contains the following topics:

- Discovering Problems with a Two-Phase Commit
- Determining Whether to Perform a Manual Override
- Analyzing the Transaction Data

Discovering Problems with a Two-Phase Commit

The user application that commits a distributed transaction is informed of a problem by one of the following error messages:

```
ORA-02050: transaction ID rolled back,
           some remote dbs may be in-doubt
ORA-02053: transaction ID committed,
           some remote dbs may be in-doubt
ORA-02054: transaction ID in-doubt
```

A robust application should save information about a transaction if it receives any of the preceding errors. This information can be used later if manual distributed transaction recovery is desired.

No action is required by the administrator of any node that has one or more in-doubt distributed transactions due to a network or system failure. The automatic recovery features of the database transparently complete any in-doubt transaction so that the same outcome occurs on all nodes of a session tree (that is, all commit or all roll back) after the network or system failure is resolved.

In extended outages, however, you can force the commit or rollback of a transaction to release any locked data. Applications must account for such possibilities.

Determining Whether to Perform a Manual Override

Override a specific in-doubt transaction manually *only* when one of the following conditions exists:

- The in-doubt transaction locks data that is required by other transactions. This situation occurs when the `ORA-01591` error message interferes with user transactions.
- An in-doubt transaction prevents the extents of a undo segment from being used by other transactions. The first portion of the local transaction ID of an in-doubt distributed transaction corresponds to the ID of the undo segment, as listed by the data dictionary view `DBA_2PC_PENDING`.
- The failure preventing the two-phase commit phases to complete cannot be corrected in an acceptable time period. Examples of such cases include a telecommunication network that has been damaged or a damaged database that requires a long recovery time.

Normally, you should make a decision to locally force an in-doubt distributed transaction in consultation with administrators at other locations. A wrong decision can lead to database inconsistencies that can be difficult to trace and that you must manually correct.

If none of these conditions apply, *always* allow the automatic recovery features of the database to complete the transaction. If any of these conditions are met, however, consider a local override of the in-doubt transaction.

Analyzing the Transaction Data

If you decide to force the transaction to complete, analyze available information with the following goals in mind.

Find a Node that Committed or Rolled Back

Use the DBA_2PC_PENDING view to find a node that has either committed or rolled back the transaction. If you can find a node that has already resolved the transaction, then you can follow the action taken at that node.

Look for Transaction Comments

See if any information is given in the TRAN_COMMENT column of DBA_2PC_PENDING for the distributed transaction. Comments are included in the COMMENT clause of the COMMIT statement, or if transaction naming is used, the transaction name is placed in the TRAN_COMMENT field when the transaction is committed.

For example, the comment of an in-doubt distributed transaction can indicate the origin of the transaction and what type of transaction it is:

```
COMMIT COMMENT 'Finance/Accts_pay/Trans_type 10B';
```

The SET TRANSACTION...NAME statement could also have been used (and is preferable) to provide this information in a transaction name.

See Also: "Naming Transactions" on page 33-2

Look for Transaction Advice

See if any information is given in the ADVICE column of DBA_2PC_PENDING for the distributed transaction. An application can prescribe advice about whether to force the commit or force the rollback of separate parts of a distributed transaction with the ADVISE clause of the ALTER SESSION statement.

The advice sent during the prepare phase to each node is the advice in effect at the time the most recent DML statement executed at that database in the current transaction.

For example, consider a distributed transaction that moves an employee record from the emp table at one node to the emp table at another node. The transaction can protect the record--even when administrators independently force the in-doubt transaction at each node--by including the following sequence of SQL statements:

```
ALTER SESSION ADVISE COMMIT;
INSERT INTO emp@hq ... ;    /*advice to commit at HQ */
ALTER SESSION ADVISE ROLLBACK;
DELETE FROM emp@sales ... ; /*advice to roll back at SALES*/

ALTER SESSION ADVISE NOTHING;
```

If you manually force the in-doubt transaction following the given advice, the worst that can happen is that each node has a copy of the employee record; the record cannot disappear.

Manually Overriding In-Doubt Transactions

Use the `COMMIT` or `ROLLBACK` statement with the `FORCE` option and a text string that indicates either the local or global transaction ID of the in-doubt transaction to commit.

Note: In all examples, the transaction is committed or rolled back on the local node, and the local pending transaction table records a value of forced commit or forced termination for the `STATE` column the row for this transaction.

This section contains the following topics:

- Manually Committing an In-Doubt Transaction
- Manually Rolling Back an In-Doubt Transaction

Manually Committing an In-Doubt Transaction

Before attempting to commit the transaction, ensure that you have the proper privileges. Note the following requirements:

User Committing the Transaction	Privilege Required
You	`FORCE TRANSACTION`
Another user	`FORCE ANY TRANSACTION`

Committing Using Only the Transaction ID

The following SQL statement commits an in-doubt transaction:

```
COMMIT FORCE 'transaction_id';
```

The variable *transaction_id* is the identifier of the transaction as specified in either the `LOCAL_TRAN_ID` or `GLOBAL_TRAN_ID` columns of the `DBA_2PC_PENDING` data dictionary view.

For example, assume that you query `DBA_2PC_PENDING` and determine that `LOCAL_TRAN_ID` for a distributed transaction is `1:45.13`.

You then issue the following SQL statement to force the commit of this in-doubt transaction:

```
COMMIT FORCE '1.45.13';
```

Committing Using an SCN

Optionally, you can specify the SCN for the transaction when forcing a transaction to commit. This feature lets you commit an in-doubt transaction with the SCN assigned when it was committed at other nodes.

Consequently, you maintain the synchronized commit time of the distributed transaction even if there is a failure. Specify an SCN only when you can determine the SCN of the same transaction already committed at another node.

For example, assume you want to manually commit a transaction with the following global transaction ID:

```
SALES.ACME.COM.55d1c563.1.93.29
```

First, query the DBA_2PC_PENDING view of a remote database also involved with the transaction in question. Note the SCN used for the commit of the transaction at that node. Specify the SCN when committing the transaction at the local node. For example, if the SCN is 829381993, issue:

```
COMMIT FORCE 'SALES.ACME.COM.55d1c563.1.93.29', 829381993;
```

See Also: *Oracle Database SQL Language Reference* for more information about using the COMMIT statement

Manually Rolling Back an In-Doubt Transaction

Before attempting to roll back the in-doubt distributed transaction, ensure that you have the proper privileges. Note the following requirements:

User Committing the Transaction	Privilege Required
You	FORCE TRANSACTION
Another user	FORCE ANY TRANSACTION

The following SQL statement rolls back an in-doubt transaction:

```
ROLLBACK FORCE 'transaction_id';
```

The variable *transaction_id* is the identifier of the transaction as specified in either the LOCAL_TRAN_ID or GLOBAL_TRAN_ID columns of the DBA_2PC_PENDING data dictionary view.

For example, to roll back the in-doubt transaction with the local transaction ID of 2.9.4, use the following statement:

```
ROLLBACK FORCE '2.9.4';
```

Note: You cannot roll back an in-doubt transaction to a savepoint.

See Also: *Oracle Database SQL Language Reference* for more information about using the ROLLBACK statement

Purging Pending Rows from the Data Dictionary

Before RECO recovers an in-doubt transaction, the transaction appears in DBA_2PC_PENDING.STATE as COLLECTING, COMMITTED, or PREPARED. If you force an in-doubt transaction using COMMIT FORCE or ROLLBACK FORCE, then the states FORCED COMMIT or FORCED ROLLBACK may appear.

Automatic recovery normally deletes entries in these states. The only exception is when recovery discovers a forced transaction that is in a state inconsistent with other sites in the transaction. In this case, the entry can be left in the table and the MIXED column in DBA_2PC_PENDING has a value of YES. These entries can be cleaned up with the DBMS_TRANSACTION.PURGE_MIXED procedure.

If automatic recovery is not possible because a remote database has been permanently lost, then recovery cannot identify the re-created database because it receives a new database ID when it is re-created. In this case, you must use the PURGE_LOST_DB_ENTRY procedure in the DBMS_TRANSACTION package to clean up the entries. The entries do not hold up database resources, so there is no urgency in cleaning them up.

See Also: *Oracle Database PL/SQL Packages and Types Reference* for more information about the `DBMS_TRANSACTION` package

Executing the PURGE_LOST_DB_ENTRY Procedure

To manually remove an entry from the data dictionary, use the following syntax (where *trans_id* is the identifier for the transaction):

```
DBMS_TRANSACTION.PURGE_LOST_DB_ENTRY('trans_id');
```

For example, to purge pending distributed transaction `1.44.99`, enter the following statement in SQL*Plus:

```
EXECUTE DBMS_TRANSACTION.PURGE_LOST_DB_ENTRY('1.44.99');
```

Execute this procedure only if significant reconfiguration has occurred so that automatic recovery cannot resolve the transaction. Examples include:

- Total loss of the remote database
- Reconfiguration in software resulting in loss of two-phase commit capability
- Loss of information from an external transaction coordinator such as a TPMonitor

Determining When to Use DBMS_TRANSACTION

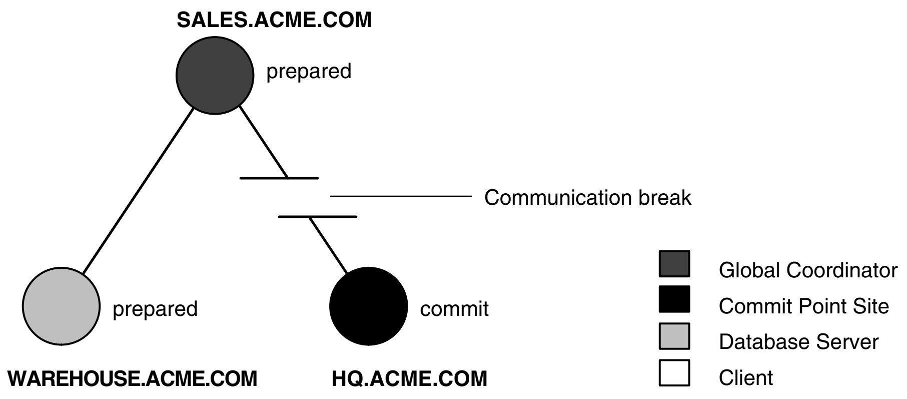
The following tables indicates what the various states indicate about the distributed transaction what the administrator's action should be:

STATE Column	**State of Global Transaction**	**State of Local Transaction**	**Normal Action**	**Alternative Action**
Collecting	Rolled back	Rolled back	None	`PURGE_LOST_DB_ENTRY` (only if autorecovery cannot resolve transaction)
Committed	Committed	Committed	None	`PURGE_LOST_DB_ENTRY` (only if autorecovery cannot resolve transaction)
Prepared	Unknown	Prepared	None	Force commit or rollback
Forced commit	Unknown	Committed	None	`PURGE_LOST_DB_ENTRY` (only if autorecovery cannot resolve transaction)
Forced rollback	Unknown	Rolled back	None	`PURGE_LOST_DB_ENTRY` (only if autorecovery cannot resolve transaction)
Forced commit	Mixed	Committed	Manually remove inconsistencies then use `PURGE_MIXED`	-
Forced rollback	Mixed	Rolled back	Manually remove inconsistencies then use `PURGE_MIXED`	-

Manually Committing an In-Doubt Transaction: Example

Figure 33–1, illustrates a failure during the commit of a distributed transaction. In this failure case, the prepare phase completes. During the commit phase, however, the commit confirmation of the commit point site never reaches the global coordinator, even though the commit point site committed the transaction. Inventory data is locked and cannot be accessed because the in-doubt transaction is critical to other transactions. Further, the locks must be held until the in-doubt transaction either commits or rolls back.

Figure 33–1 Example of an In-Doubt Distributed Transaction



You can manually force the local portion of the in-doubt transaction by following the steps detailed in the following sections:

Step 1: Record User Feedback

Step 2: Query DBA_2PC_PENDING

Step 3: Query DBA_2PC_NEIGHBORS on Local Node

Step 4: Querying Data Dictionary Views on All Nodes

Step 5: Commit the In-Doubt Transaction

Step 6: Check for Mixed Outcome Using DBA_2PC_PENDING

Step 1: Record User Feedback

The users of the local database system that conflict with the locks of the in-doubt transaction receive the following error message:

```
ORA-01591: lock held by in-doubt distributed transaction 1.21.17
```

In this case, `1.21.17` is the local transaction ID of the in-doubt distributed transaction. You should request and record this ID number from users that report problems to identify which in-doubt transactions should be forced.

Step 2: Query DBA_2PC_PENDING

After connecting with SQL*Plus to `warehouse`, query the local `DBA_2PC_PENDING` data dictionary view to gain information about the in-doubt transaction:

```
CONNECT SYS/password@warehouse.acme.com
SELECT * FROM DBA_2PC_PENDING WHERE LOCAL_TRAN_ID = '1.21.17';
```

The database returns the following information:

```
Column Name            Value
---------------------- --------------------------------------
LOCAL_TRAN_ID          1.21.17
GLOBAL_TRAN_ID         SALES.ACME.COM.55d1c563.1.93.29
STATE                  prepared
MIXED                  no
ADVICE
TRAN_COMMENT           Sales/New Order/Trans_type 10B
FAIL_TIME              31-MAY-91
FORCE_TIME
RETRY_TIME             31-MAY-91
OS_USER                SWILLIAMS
OS_TERMINAL            TWA139:
HOST                   system1
DB_USER                SWILLIAMS
COMMIT#
```

Determining the Global Transaction ID

The global transaction ID is the common transaction ID that is the same on every node for a distributed transaction. It is of the form:

global_database_name.hhhhhhhh.local_transaction_id

where:

- *global_database_name* is the database name of the global coordinator.
- *hhhhhhhh* is the internal database identifier of the global coordinator (in hexadecimal).
- *local_transaction_id* is the corresponding local transaction ID assigned on the global coordinator.

Note that the last portion of the global transaction ID and the local transaction ID match at the global coordinator. In the example, you can tell that `warehouse` is *not* the global coordinator because these numbers do not match:

```
LOCAL_TRAN_ID          1.21.17
GLOBAL_TRAN_ID         ... 1.93.29
```

Determining the State of the Transaction

The transaction on this node is in a prepared state:

```
STATE          prepared
```

Therefore, `warehouse` waits for its coordinator to send either a commit or a rollback request.

Looking for Comments or Advice

The transaction comment or advice can include information about this transaction. If so, use this comment to your advantage. In this example, the origin and transaction type is in the transaction comment:

```
TRAN_COMMENT           Sales/New Order/Trans_type 10B
```

It could also be provided as a transaction name with a `SET TRANSACTION...NAME` statement.

This information can reveal something that helps you decide whether to commit or rollback the local portion of the transaction. If useful comments do not accompany an in-doubt transaction, you must complete some extra administrative work to trace the session tree and find a node that has resolved the transaction.

Step 3: Query DBA_2PC_NEIGHBORS on Local Node

The purpose of this step is to climb the session tree so that you find coordinators, eventually reaching the global coordinator. Along the way, you may find a coordinator that has resolved the transaction. If not, you can eventually work your way to the commit point site, which will always have resolved the in-doubt transaction. To trace the session tree, query the `DBA_2PC_NEIGHBORS` view on each node.

In this case, you query this view on the `warehouse` database:

```
CONNECT SYS/password@warehouse.acme.com
SELECT * FROM DBA_2PC_NEIGHBORS
  WHERE LOCAL_TRAN_ID = '1.21.17'
  ORDER BY SESS#, IN_OUT;

Column Name            Value
---------------------- --------------------------------------
LOCAL_TRAN_ID          1.21.17
IN_OUT                 in
DATABASE               SALES.ACME.COM
DBUSER_OWNER           SWILLIAMS
INTERFACE              N
DBID                   000003F4
SESS#                  1
BRANCH                 0100
```

Obtaining Database Role and Database Link Information

The `DBA_2PC_NEIGHBORS` view provides information about connections associated with an in-doubt transaction. Information for each connection is different, based on whether the connection is **inbound** (`IN_OUT = in`) or **outbound** (`IN_OUT = out`):

IN_OUT	Meaning	DATABASE	DBUSER_OWNER
in	Your node is a server of another node.	Lists the name of the client database that connected to your node.	Lists the local account for the database link connection that corresponds to the in-doubt transaction.
out	Your node is a client of other servers.	Lists the name of the database link that connects to the remote node.	Lists the owner of the database link for the in-doubt transaction.

In this example, the `IN_OUT` column reveals that the `warehouse` database is a server for the `sales` client, as specified in the DATABASE column:

```
IN_OUT                 in
DATABASE               SALES.ACME.COM
```

The connection to `warehouse` was established through a database link from the `swilliams` account, as shown by the `DBUSER_OWNER` column:

```
DBUSER_OWNER           SWILLIAMS
```

Determining the Commit Point Site

Additionally, the `INTERFACE` column tells whether the local node or a subordinate node is the commit point site:

```
INTERFACE              N
```

Neither `warehouse` nor any of its descendants is the commit point site, as shown by the `INTERFACE` column.

Step 4: Querying Data Dictionary Views on All Nodes

At this point, you can contact the administrator at the located nodes and ask each person to repeat Steps 2 and 3 using the global transaction ID.

Note: If you can directly connect to these nodes with another network, you can repeat Steps 2 and 3 yourself.

For example, the following results are returned when Steps 2 and 3 are performed at `sales` and `hq`.

Checking the Status of Pending Transactions at sales

At this stage, the `sales` administrator queries the `DBA_2PC_PENDING` data dictionary view:

```
SQL> CONNECT SYS/password@sales.acme.com
SQL> SELECT * FROM DBA_2PC_PENDING
   > WHERE GLOBAL_TRAN_ID = 'SALES.ACME.COM.55d1c563.1.93.29';

Column Name            Value
---------------------- --------------------------------------
LOCAL_TRAN_ID          1.93.29
GLOBAL_TRAN_ID         SALES.ACME.COM.55d1c563.1.93.29
STATE                  prepared
MIXED                  no
ADVICE
TRAN_COMMENT           Sales/New Order/Trans_type 10B
FAIL_TIME              31-MAY-91
FORCE_TIME
RETRY_TIME             31-MAY-91
OS_USER                SWILLIAMS
OS_TERMINAL            TWA139:
HOST                   system1
DB_USER                SWILLIAMS
COMMIT#
```

Determining the Coordinators and Commit Point Site at sales

Next, the `sales` administrator queries `DBA_2PC_NEIGHBORS` to determine the global and local coordinators as well as the commit point site:

```
SELECT * FROM DBA_2PC_NEIGHBORS
   WHERE GLOBAL_TRAN_ID = 'SALES.ACME.COM.55d1c563.1.93.29'
   ORDER BY SESS#, IN_OUT;
```

This query returns three rows:

- The connection to `warehouse`

- The connection to hq
- The connection established by the user

Reformatted information corresponding to the rows for the warehouse connection appears below:

```
Column Name            Value
---------------------- --------------------------------------
LOCAL_TRAN_ID          1.93.29
IN_OUT                 OUT
DATABASE               WAREHOUSE.ACME.COM
DBUSER_OWNER           SWILLIAMS
INTERFACE              N
DBID                   55d1c563
SESS#                  1
BRANCH                 1
```

Reformatted information corresponding to the rows for the hq connection appears below:

```
Column Name            Value
---------------------- --------------------------------------
LOCAL_TRAN_ID          1.93.29
IN_OUT                 OUT
DATABASE               HQ.ACME.COM
DBUSER_OWNER           ALLEN
INTERFACE              C
DBID                   00000390
SESS#                  1
BRANCH                 1
```

The information from the previous queries reveal the following:

- sales is the global coordinator because the local transaction ID and global transaction ID match.
- Two outbound connections are established from this node, but no inbound connections. sales is not the server of another node.
- hq or one of its servers is the commit point site.

Checking the Status of Pending Transactions at HQ

At this stage, the hq administrator queries the DBA_2PC_PENDING data dictionary view:

```
SELECT * FROM DBA_2PC_PENDING@hq.acme.com
   WHERE GLOBAL_TRAN_ID = 'SALES.ACME.COM.55d1c563.1.93.29';

Column Name            Value
---------------------- --------------------------------------
LOCAL_TRAN_ID          1.45.13
GLOBAL_TRAN_ID         SALES.ACME.COM.55d1c563.1.93.29
STATE                  COMMIT
MIXED                  NO
ACTION
TRAN_COMMENT           Sales/New Order/Trans_type 10B
FAIL_TIME              31-MAY-91
FORCE_TIME
RETRY_TIME             31-MAY-91
OS_USER                SWILLIAMS
OS_TERMINAL            TWA139:
```

```
HOST                    SYSTEM1
DB_USER                 SWILLIAMS
COMMIT#                 129314
```

At this point, you have found a node that resolved the transaction. As the view reveals, it has been committed and assigned a commit ID number:

```
STATE                   COMMIT
COMMIT#                 129314
```

Therefore, you can force the in-doubt transaction to commit at your local database. It is a good idea to contact any other administrators you know that could also benefit from your investigation.

Step 5: Commit the In-Doubt Transaction

You contact the administrator of the `sales` database, who manually commits the in-doubt transaction using the global ID:

```
SQL> CONNECT SYS/password@sales.acme.com
SQL> COMMIT FORCE 'SALES.ACME.COM.55d1c563.1.93.29';
```

As administrator of the `warehouse` database, you manually commit the in-doubt transaction using the global ID:

```
SQL> CONNECT SYS/password@warehouse.acme.com
SQL> COMMIT FORCE 'SALES.ACME.COM.55d1c563.1.93.29';
```

Step 6: Check for Mixed Outcome Using DBA_2PC_PENDING

After you manually force a transaction to commit or roll back, the corresponding row in the pending transaction table remains. The state of the transaction is changed depending on how you forced the transaction.

Every Oracle Database has a **pending transaction table**. This is a special table that stores information about distributed transactions as they proceed through the two-phase commit phases. You can query the pending transaction table of a database through the `DBA_2PC_PENDING` data dictionary view (see Table 33–1).

Also of particular interest in the pending transaction table is the mixed outcome flag as indicated in `DBA_2PC_PENDING.MIXED`. You can make the wrong choice if a pending transaction is forced to commit or roll back. For example, the local administrator rolls back the transaction, but the other nodes commit it. Incorrect decisions are detected automatically, and the damage flag for the corresponding pending transaction record is set (`MIXED=yes`).

The RECO (Recoverer) background process uses the information in the pending transaction table to finalize the status of in-doubt transactions. You can also use the information in the pending transaction table to manually override the automatic recovery procedures for pending distributed transactions.

All transactions automatically resolved by RECO are removed from the pending transaction table. Additionally, all information about in-doubt transactions correctly resolved by an administrator (as checked when RECO reestablishes communication) are automatically removed from the pending transaction table. However, all rows resolved by an administrator that result in a mixed outcome across nodes remain in the pending transaction table of all involved nodes until they are manually deleted using `DBMS_TRANSACTIONS.PURGE_MIXED`.

Data Access Failures Due to Locks

When you issue a SQL statement, the database attempts to lock the resources needed to successfully execute the statement. If the requested data is currently held by statements of other uncommitted transactions, however, and remains locked for a long time, a timeout occurs.

Consider the following scenarios involving data access failure:

- Transaction Timeouts
- Locks from In-Doubt Transactions

Transaction Timeouts

A DML statement that requires locks on a remote database can be blocked if another transaction own locks on the requested data. If these locks continue to block the requesting SQL statement, then the following sequence of events occurs:

1. A timeout occurs.
2. The database rolls back the statement.
3. The database returns this error message to the user:

   ```
   ORA-02049: time-out: distributed transaction waiting for lock
   ```

Because the transaction did not modify data, no actions are necessary as a result of the timeout. Applications should proceed as if a deadlock has been encountered. The user who executed the statement can try to reexecute the statement later. If the lock persists, then the user should contact an administrator to report the problem.

Locks from In-Doubt Transactions

A query or DML statement that requires locks on a local database can be blocked indefinitely due to the locked resources of an in-doubt distributed transaction. In this case, the database issues the following error message:

```
ORA-01591: lock held by in-doubt distributed transaction identifier
```

In this case, the database rolls back the SQL statement immediately. The user who executed the statement can try to reexecute the statement later. If the lock persists, the user should contact an administrator to report the problem, *including* the ID of the in-doubt distributed transaction.

The chances of these situations occurring are rare considering the low probability of failures during the critical portions of the two-phase commit. Even if such a failure occurs, and assuming quick recovery from a network or system failure, problems are automatically resolved without manual intervention. Thus, problems usually resolve before they can be detected by users or database administrators.

Simulating Distributed Transaction Failure

You can force the failure of a distributed transaction for the following reasons:

- To observe RECO automatically resolving the local portion of the transaction
- To practice manually resolving in-doubt distributed transactions and observing the results

This section describes the features available and the steps necessary to perform such operations.

Forcing a Distributed Transaction to Fail

You can include comments in the `COMMENT` parameter of the `COMMIT` statement. To intentionally induce a failure during the two-phase commit phases of a distributed transaction, include the following comment in the `COMMENT` parameter:

```
COMMIT COMMENT 'ORA-2PC-CRASH-TEST-n';
```

where *n* is one of the following integers:

n	Effect
1	Crash commit point after collect
2	Crash non-commit-point site after collect
3	Crash before prepare (non-commit-point site)
4	Crash after prepare (non-commit-point site)
5	Crash commit point site before commit
6	Crash commit point site after commit
7	Crash non-commit-point site before commit
8	Crash non-commit-point site after commit
9	Crash commit point site before forget
10	Crash non-commit-point site before forget

For example, the following statement returns the following messages if the local commit point strength is greater than the remote commit point strength and both nodes are updated:

```
COMMIT COMMENT 'ORA-2PC-CRASH-TEST-7';

ORA-02054: transaction 1.93.29 in-doubt
ORA-02059: ORA_CRASH_TERST_7 in commit comment
```

At this point, the in-doubt distributed transaction appears in the `DBA_2PC_PENDING` view. If enabled, RECO automatically resolves the transaction.

Disabling and Enabling RECO

The RECO background process of an Oracle Database instance automatically resolves failures involving distributed transactions. At exponentially growing time intervals, the RECO background process of a node attempts to recover the local portion of an in-doubt distributed transaction.

RECO can use an existing connection or establish a new connection to other nodes involved in the failed transaction. When a connection is established, RECO automatically resolves all in-doubt transactions. Rows corresponding to any resolved in-doubt transactions are automatically removed from the pending transaction table of each database.

You can enable and disable RECO using the `ALTER SYSTEM` statement with the `ENABLE/DISABLE DISTRIBUTED RECOVERY` options. For example, you can temporarily disable RECO to force the failure of a two-phase commit and manually resolve the in-doubt transaction.

The following statement disables RECO:

```
ALTER SYSTEM DISABLE DISTRIBUTED RECOVERY;
```

Alternatively, the following statement enables RECO so that in-doubt transactions are automatically resolved:

```
ALTER SYSTEM ENABLE DISTRIBUTED RECOVERY;
```

Note: Single-process instances (for example, a PC running MS-DOS) have no separate background processes, and therefore no RECO process. Therefore, when a single-process instance that participates in a distributed system is started, you must manually enable distributed recovery using the preceding statement.

Managing Read Consistency

An important restriction exists in the Oracle Database implementation of distributed read consistency. The problem arises because each system has its own SCN, which you can view as the database internal timestamp. The Oracle Database server uses the SCN to decide which version of data is returned from a query.

The SCNs in a distributed transaction are synchronized at the end of each remote SQL statement and at the start and end of each transaction. Between two nodes that have heavy traffic and especially distributed updates, the synchronization is frequent. Nevertheless, no practical way exists to keep SCNs in a distributed system absolutely synchronized: a window always exists in which one node may have an SCN that is somewhat in the past with respect to the SCN of another node.

Because of the SCN gap, you can execute a query that uses a slightly old snapshot, so that the most recent changes to the remote database are not seen. In accordance with read consistency, a query can therefore retrieve consistent, but out-of-date data. Note that all data retrieved by the query will be from the old SCN, so that if a locally executed update transaction updates two tables at a remote node, then data selected from both tables in the next remote access contain data prior to the update.

One consequence of the SCN gap is that two consecutive `SELECT` statements can retrieve different data even though no DML has been executed between the two statements. For example, you can issue an update statement and then commit the update on the remote database. When you issue a `SELECT` statement on a view based on this remote table, the view does not show the update to the row. The next time that you issue the `SELECT` statement, the update is present.

You can use the following techniques to ensure that the SCNs of the two machines are synchronized just before a query:

- Because SCNs are synchronized at the end of a remote query, precede each remote query with a dummy remote query to the same site, for example, `SELECT * FROM DUAL@REMOTE`.
- Because SCNs are synchronized at the start of every remote transaction, commit or roll back the current transaction before issuing the remote query.

Part VI

Appendices

This part contains Appendices for the Oracle Database Administrator's Guide. It contains the following sections:

- Appendix A, "Moving from DBMS_JOB to DBMS_SCHEDULER"

A
Moving from DBMS_JOB to DBMS_SCHEDULER

This appendix illustrates some examples of how you can take jobs created with the DBMS_JOB package and rewrite them using the DBMS_SCHEDULER package.

Creating a Job

An example of creating a job using DBMS_JOB is the following:

```
VARIABLE jobno NUMBER;
BEGIN
DBMS_JOB.SUBMIT(:jobno, 'INSERT INTO employees VALUES (7935, ''SALLY'',
   ''DOGAN'', ''sally.dogan@xyzcorp.com'', NULL, SYSDATE, ''AD_PRES'', NULL,
    NULL, NULL, NULL);', SYSDATE, 'SYSDATE+1');
COMMIT;
END;
/
```

An equivalent statement using DBMS_SCHEDULER is the following:

```
BEGIN
DBMS_SCHEDULER.CREATE_JOB(
   job_name          =>  'job1',
   job_type          =>  'PLSQL_BLOCK',
   job_action        =>  'INSERT INTO employees VALUES (7935, ''SALLY'',
     ''DOGAN'', ''sally.dogan@xyzcorp.com'', NULL, SYSDATE,''AD_PRES'', NULL,
      NULL, NULL, NULL);');
   start_date        =>  SYSDATE,
   repeat_interval   =>  'FREQ = DAILY; INTERVAL = 1');
END;
/
```

Altering a Job

An example of altering a job using DBMS_JOB is the following:

```
BEGIN
DBMS_JOB.WHAT(31, 'INSERT INTO employees VALUES (7935, ''TOM'', ''DOGAN'',
   ''tom.dogan@xyzcorp.com'', NULL, SYSDATE,''AD_PRES'', NULL,
   NULL, NULL, NULL);');
COMMIT;
END;
/
```

This changes the action for JOB1 to insert a different value. An equivalent statement using DBMS_SCHEDULER is the following:

```
BEGIN
DBMS_SCHEDULER.SET_ATTRIBUTE(
   name          => 'JOB1',
   attribute     => 'job_action',
   value         => 'INSERT INTO employees VALUES (7935, ''TOM'', ''DOGAN'',
      ''tom.dogan@xyzcorp.com'', NULL, SYSDATE, ''AD_PRES'', NULL,
      NULL, NULL, NULL);');
END;
/
```

Removing a Job from the Job Queue

The following example removes a job using DBMS_JOB, where 14144 is the number of the job being run:

```
BEGIN
DBMS_JOB.REMOVE(14144);
COMMIT;
END;
/
```

Using DBMS_SCHEDULER, you would issue the following statement instead:

```
BEGIN
   DBMS_SCHEDULER.DROP_JOB('myjob1');
END;
/
```

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* for more information about the DBMS_SCHEDULER package
- Chapter 27, "Scheduling Jobs with Oracle Scheduler"

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