# Oracle8*i*

Administrator's Guide

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**Administrator's Guide, Release 2 (8.1.6)**

**Part No. A76956-01**

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# Preface

This guide is for people who administer the operation of an Oracle database system. These people, referred to as "database administrators" (DBAs), are assumed to be responsible for ensuring the smooth operation of an Oracle database system and for monitoring its use. The responsibilities of database administrators are described in Chapter 1.

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**Note:** The Oracle8i Administrator's Guide contains information that describes the features and functionality of the Oracle8 and the Oracle8 Enterprise Edition products. Oracle8 and Oracle8 Enterprise Edition have the same basic features. However, several advanced features are available only with the Enterprise Edition, and some of these are optional. For example, to perform automated tablespace point-in-time recovery (using Recovery Manager), you must have the Enterprise Edition.

For information about the differences between Oracle8 and the Oracle8 Enterprise Edition and the features and options that are available to you, please refer to *Getting to Know Oracle8i.*

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## Audience

Readers of this guide are assumed to be familiar with relational database concepts. They are also assumed to be familiar with the operating system environment under which they are running Oracle.

### Readers Interested in Installation and Migration Information

Administrators frequently participate in installing the Oracle Server software and migrating existing Oracle databases to newer formats (for example, Version 7 databases to Oracle8 format). This guide is not an installation or migration manual.

If your primary interest is installation, see your operating system-specific Oracle documentation.

If your primary interest is database or application migration, see the *Oracle8i Migration* manual.

### Readers Interested in Application Design Information

In addition to administrators, experienced users of Oracle and advanced database application designers might also find information in this guide useful.

However, database application developers should also see the *Oracle8i Application Developer's Guide - Fundamentals* and the documentation for the tool or language product they are using to develop Oracle database applications.

## How to Use This Guide

Every reader of this guide should read Chapter 1 of *Oracle8i Concepts*. This overview of the concepts and terminology related to Oracle provides a foundation for the more detailed information in this guide. The rest of *Oracle8i Concepts* explains the Oracle architecture and features, and how they operate in more detail.

## Structure

This guide contains the following parts and chapters.

### Part I: Basic Database Administration

| | |
|---|---|
| Chapter 1, "The Oracle Database Administrator" | This chapter serves as a general introduction to typical tasks performed by database administrators, such as installing software and planning a database. |
| Chapter 2, "Creating an Oracle Database" | This chapter describes the most important considerations when creating a database. Consult this chapter when in the database planning stage. |
| Chapter 3, "Starting Up and Shutting Down" | Consult this chapter when you wish to start up a database, alter its availability, or shut it down. Parameter files related to starting up and shutting down are also described here. |

### Part II: Oracle Server Configuration

| | |
|---|---|
| Chapter 4, "Managing Oracle Processes" | This chapter helps you identify different Oracle processes, such as dedicated server processes and multi-threaded server processes. Consult this chapter when configuring, modifying, tracking and managing processes. |
| Chapter 5, "Managing Control Files" | This chapter describes all aspects of managing control files (such as naming, creating, troubleshooting, and dropping control files). |
| Chapter 6, "Managing the Online Redo Log" | This chapter describes all aspects of managing the online redo log: planning, creating, renaming, dropping, or clearing online redo log files. |
| Chapter 7, "Managing Archived Redo Logs" | Consult this chapter for information about archive modes, tuning archiving, and viewing. |
| Chapter 8, "Managing Job Queues" | Consult this chapter before working with job queues. All aspects of submitting, removing, altering, and fixing job queues are described. |

## Part III: Database Storage

| | |
|---|---|
| Chapter 9, "Managing Tablespaces" | This chapter provides guidelines to follow as you manage tablespaces, and describes how to create, manage, alter, drop and move data between tablespaces. |
| Chapter 10, "Managing Datafiles" | This chapter provides guidelines to follow as you manage datafiles, and describes how to create, change, alter, rename and view information about datafiles. |
| Chapter 11, "Managing Rollback Segments" | Consult this chapter for guidelines to follow when working with rollback segments. |

## Part IV: Schema Objects

| | |
|---|---|
| Chapter 12, "Guidelines for Managing Schema Objects" | Consult this chapter for descriptions of common tasks, such as setting storage parameters, deallocating space and managing space. |
| Chapter 13, "Managing Tables" | Consult this chapter for general table management guidelines, as well as information about creating, altering, maintaining and dropping tables. |
| Chapter 14, "Managing Indexes" | Consult this chapter for general guidelines about indexes, including creating, altering, monitoring and dropping indexes. |
| Chapter 15, "Managing Partitioned Tables and Indexes" | This chapter describes what a partitioned table (and index) is and how to create and manage it. |
| Chapter 16, "Managing Clusters" | Consult this chapter for general guidelines to follow when creating, altering and dropping clusters. |

| | |
|---|---|
| Chapter 17, "Managing Hash Clusters" | Consult this chapter for general guidelines to follow when altering or dropping hash clusters. |
| Chapter 18, "Managing Views, Sequences and Synonyms" | This chapter describes all aspects of managing views, sequences and synonyms. |
| Chapter 19, "General Management of Schema Objects" | This chapter covers more specific aspects of schema management than those identified in Chapter 12. Consult this chapter for information about table analysis, truncation of tables and clusters, database triggers, integrity constraints, object dependencies. You will also find a number of specific examples. |
| Chapter 20, "Addressing Data Block Corruption" | This chapter describes how to use the procedures in the DBMS_REPAIR package to detect and correct data block corruption. |

### Part V: Database Security

| | |
|---|---|
| Chapter 21, "Establishing Security Policies" | This chapter describes all aspects of database security, including system, data and user security policies, as well as specific tasks associated with password management. |
| Chapter 22, "Managing Users and Resources" | This chapter describes session and user licensing, user authentication, and provides specific examples of tasks associated with managing users and resources. |
| Chapter 23, "Managing User Privileges and Roles" | This chapter contains information about all aspects of managing user privileges and roles. Consult this chapter to find out how to grant and revoke privileges and roles. |
| Chapter 24, "Auditing Database Use" | This chapter describes how to create, manage and view audit information. |

### Part VI: Database Resource Management

| | |
|---|---|
| Chapter 25, "The Database Resource Manager" | This chapter describes how to use the Database Resource Manager to allocate resources. |

# Conventions

This section explains the conventions used in this manual including the following:

- Text
- Syntax diagrams and notation
- Code examples

## Text

This section explains the conventions used within the text.

### UPPERCASE Characters

Uppercase text is used to call attention to command keywords, object names, parameters, filenames, and so on.

For example, "If you create a private rollback segment, the name must be included in the ROLLBACK_SEGMENTS parameter of the parameter file."

### *Italicized* Characters

Italicized words within text are book titles or emphasized words.

## Syntax Diagrams and Notation

The syntax diagrams and notation in this manual show the syntax for SQL commands, functions, hints, and other elements. This section tells you how to read syntax diagrams and examples and write SQL statements based on them.

### Keywords

*Keywords* are words that have special meanings in the SQL language. In the syntax diagrams in this manual, keywords appear in uppercase. You must use keywords in your SQL statements exactly as they appear in the syntax diagram, except that they can be either uppercase or lowercase. For example, you must use the CREATE keyword to begin your CREATE TABLE statements just as it appears in the CREATE TABLE syntax diagram.

### Parameters

*Parameters* act as place holders in syntax diagrams. They appear in lowercase. Parameters are usually names of database objects, Oracle datatype names, or expressions. When you see a parameter in a syntax diagram, substitute an object or expression of the appropriate type in your SQL statement. For example, to write a CREATE TABLE statement, use the name of the table you want to create, such as EMP, in place of the *table* parameter in the syntax diagram. (Note that parameter names appear in italics in the text.)

### Code Examples

SQL and SQL*Plus commands and statements are separated from the text of paragraphs in a monospaced font as follows:

```
INSERT INTO emp (empno, ename) VALUES (1000, 'JFEE');
ALTER TABLESPACE users ADD DATAFILE 'users2.ora' SIZE 50K;
```

Example statements can include punctuation, such as commas or quotation marks. All punctuation in example statements is required. All example statements terminate with a semicolon (;). Depending on the application, a semicolon or other terminator may or may not be required to end a statement.

Uppercase words in example statements indicate the keywords within Oracle SQL. When you issue statements, however, keywords are not case sensitive.

Lowercase words in example statements indicate words supplied only for the context of the example. For example, lowercase words may indicate the name of a table, column, or file.

## What's New in Release 2 (8.1.6)

The following are new features introduced in this release:

- DB_BLOCK_CHECKING and DB_BLOCK_CHECKSUM are always TRUE in the system tablespaces.
- You can now control the amount of trace information sent to LOG_ARCHIVE_TRACE.
- You can now exchange a hash partitioned table with subpartitions of a composite partitioned table.
- You can issue an ALTER DATABASE SUSPEND or RESUME statement to halt I/O to datafiles and the control files, allowing the database to be backed up without I/O interference.

- The ALTER SYSTEM SHUTDOWN IMMEDIATE statement allows you to shut down a specific MTS dispatcher process.
- You can create global or schema-independent users, and specify global roles.
- Multi-tier authentication and authorization allows users to be connected through a middle tier.

Additionally, this book has been reorganized, and many chapters have been rewritten.

# Part I

## Basic Database Administration

Part I provides an overview of the responsibilities of a database administrator, and describes the creation of a database and how to start up and shut down an instance of the database. It contains the following chapters:

- Chapter 1, "The Oracle Database Administrator"
- Chapter 2, "Creating an Oracle Database"
- Chapter 3, "Starting Up and Shutting Down"

# 1

# The Oracle Database Administrator

This chapter describes the responsibilities of the person who administers the Oracle server, the database administrator.

The following topics are included:

- Types of Oracle Users
- Database Administrator Security and Privileges
- Database Administrator Authentication
- Password File Administration
- Database Administrator Utilities
- Priorities of a Database Administrator
- Identifying Your Oracle Database Software Release

# Types of Oracle Users

At your site, the types of users and their responsibilities may vary. For example, at a large site the duties of a database administrator might be divided among several people.

This section includes the following topics:



## Database Administrators

Because an Oracle database system can be quite large and have many users, someone or some group of people must manage this system. The *database administrator* (DBA) is this manager. Every database requires at least one person to perform administrative duties.

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

- Installing and upgrading the Oracle 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 your Oracle license agreement
- 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 Corporation for technical support

## Security Officers

In some cases, a database might also have one or more security officers. A *security officer* is primarily concerned with enrolling users, controlling and monitoring user access to the database, and maintaining system security. You might not be responsible for these duties if your site has a separate security officer.

## Application Developers

An *application developer* designs and implements database applications An application developer's 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 the above information to a database administrator
- Tuning the application during development
- Establishing an application's security measures during development

## Application Administrators

An Oracle site might also have one or more application administrators. An *application administrator* is responsible for the administration needs of a particular application.

## Database Users

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

- Entering, modifying, and deleting data, where permitted

- Generating reports of data

### Network Administrators

At some sites there may be one or more network administrators. Network administrators may be responsible for administering Oracle networking products, such as Net8.

> **See Also:** For information on network administration in a distributed environment, see *Oracle8i Distributed Database Systems.*

## Database Administrator Security and Privileges

To accomplish administrative tasks in Oracle, you need extra privileges both 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 includes the following topics:

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

### 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 that executes Oracle, you might need an operating system account or ID to gain access to the operating system. If so, your operating system account might require more operating system privileges or access rights than many database users require (for example, to perform Oracle software installation). Although you do not need the Oracle files to be stored in your account, you should have access to them.

> **See Also:** The method of distinguishing a database administrator's account is operating system specific. See your operating system-specific Oracle documentation for information.

### Database Administrator Usernames

Two user accounts are automatically created with the database and granted the DBA role. These two user accounts are:

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

These two usernames are described in the following sections.

> **Note:** To prevent inappropriate access to the data dictionary tables, you must change the passwords for the SYS and SYSTEM usernames immediately after creating an Oracle database.

You will probably want to create at least one additional administrator username to use when performing daily administrative tasks.

### SYS

When any database is created, the user SYS, identified by the password CHANGE_ON_INSTALL, is automatically created and granted the DBA role.

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

Most database users should never be able to connect using the SYS account. You can connect to the database using this account but should do so only when instructed by Oracle personnel or documentation.

### SYSTEM

When a database is created, the user SYSTEM, identified by the password MANAGER, is also automatically created and granted all system privileges for the database.

The SYSTEM username creates additional tables and views that display administrative information, and internal tables and views used by Oracle tools. Never create in the SYSTEM schema tables of interest to individual users.

### The DBA Role

A predefined role, named "DBA", is automatically created with every Oracle database. This role contains all database system privileges. Therefore, it is very powerful and should be granted only to fully functional database administrators.

## Database Administrator Authentication

Database administrators must often perform special operations such as shutting down or starting up a database. Because these operations should not be performed by normal database users, the database administrator usernames need a more secure authentication scheme.

This section includes the following topics:

- Selecting an Authentication Method
- Using Operating System Authentication
- OSOPER and OSDBA
- Using an Authentication Password File

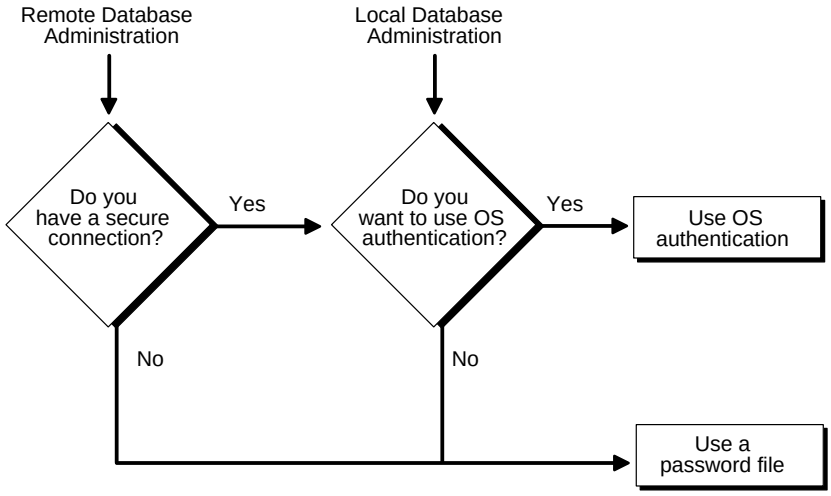
### Selecting an Authentication Method

The following methods for authenticating database administrators replace the CONNECT INTERNAL syntax provided with earlier versions of Oracle (CONNECT INTERNAL continues to be supported for backward compatibility only):

- Operating system authentication
- Password files

Depending on whether you wish to administer your database locally on the same machine where the database resides or to administer many different databases from a single remote client, you can choose between operating system authentication or password files to authenticate database administrators. Figure 1–1 illustrates the choices you have for database administrator authentication schemes.

***Figure 1–1 Database Administrator Authentication Methods***




On most operating systems, OS authentication for database administrators involves placing the OS username of the database administrator in a special group (on UNIX systems, this is the DBA group) or giving that OS username a special process right.

The database uses password files to keep track of database usernames that have been granted administrator privileges.

> **See Also:** More information on user authentication can be found in *Oracle8i Concepts.*

## Using Operating System Authentication

If you choose, you can have your operating system authenticate users performing database administration operations.

1. Set up the user to be authenticated by the operating system.
2. Make sure that the initialization parameter, REMOTE_LOGIN_ PASSWORDFILE, is set to NONE, which is the default value for this parameter.
3. Authenticated users should now be able to connect to a local database, or to connect to a remote database over a secure connection, by typing one of the following SQL*Plus commands:

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

If you successfully connect as INTERNAL using an earlier release of Oracle, you should be able to continue to connect successfully using the new syntax shown in Step 3.

---

**Note:** To connect as SYSOPER or SYSDBA using OS authentication you do not need the SYSOPER or SYSDBA system privileges. Instead, the server verifies that you have been granted the appropriate OSDBA or OSOPER roles at the operating system level.

CONNECT is an SQL*Plus command. For information on its usage and syntax, see *SQL*Plus User's Guide and Reference.*

---

## OSOPER and OSDBA

Two special operating system roles control database administrator logins when using operating system authentication: OSOPER and OSDBA.

| | |
|---|---|
| OSOPER | Permits the user to perform STARTUP, SHUTDOWN, ALTER DATABASE OPEN / MOUNT, ALTER DATABASE BACKUP, ARCHIVE LOG, and RECOVER, and includes the RESTRICTED SESSION privilege. |
| OSDBA | Contains all system privileges with ADMIN OPTION, and the OSOPER role; permits CREATE DATABASE and time-based recovery. |

OSOPER and OSDBA can have different names and functionality, depending on your operating system.

The OSOPER and OSDBA roles can only be granted to a user through the operating system. They cannot be granted through a GRANT statement, nor can they be revoked or dropped. When a user logs on with administrator privileges and REMOTE_LOGIN_PASSWORDFILE is set to NONE, Oracle communicates with the operating system and attempts to enable first OSDBA and then, if unsuccessful, OSOPER. If both attempts fail, the connection fails. How you grant these privileges through the operating system is operating system specific.

If you are performing remote database administration, you should consult your Net8 documentation to determine if you are using a secure connection. Most popular connection protocols, such as TCP / IP and DECnet, are not secure, regardless of which version of Net8 you are using.

**See Also:** For information about OS authentication of database administrators, see your operating system-specific Oracle documentation.

## Using an Authentication Password File

If you have determined that you need to use a password file to authenticate users performing database administration, you must complete the steps outlined below. Each of these steps is explained in more detail in the following sections of this chapter.

1. Create the password file using the ORAPWD utility.

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

2. Set the REMOTE_LOGIN_PASSWORDFILE initialization parameter to EXCLUSIVE.

3. Add users to the password file by using SQL to grant the appropriate privileges to each user who needs to perform database administration, as shown in the following examples.

   ```
   GRANT SYSDBA TO scott;
   GRANT SYSOPER TO scott;
   ```

   The privilege SYSDBA permits the user to perform the same operations as OSDBA. Likewise, the privilege SYSOPER permits the user to perform the same operations as OSOPER.

4. Privileged users should now be able to connect to the database by using a command similar to the one shown below.

   ```
   CONNECT scott/tiger@acct.hq.com AS SYSDBA
   ```

# Password File Administration

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

This section includes the following topics:

- Using ORAPWD
- Setting REMOTE_LOGIN_ PASSWORDFILE

- Adding Users to a Password File
- Connecting with Administrator Privileges
- Maintaining a Password File

> **See Also:** See your operating system-specific Oracle documentation for information on using the installer utility to install the password file.

## Using ORAPWD

When you invoke the password file creation utility without supplying any parameters, you receive a message indicating the proper use of the command as shown in the following sample output:

```
orapwd
Usage: orapwd file=<fname> password=<password> entries=<users>
where
file - name of password file (mand),
password - password for SYS and INTERNAL (mand),
entries - maximum number of distinct DBAs and OPERs (opt),
There are no spaces around the equal-to (=) character.
```

For example, the following command creates a password file named ACCT.PWD that allows up to 30 privileged users with different passwords. The file is initially created with the password SECRET for users connecting as SYSOPER or SYSDBA:

```
ORAPWD FILE=acct.pwd PASSWORD=secret ENTRIES=30
```

Following are descriptions of the parameters in the ORAPWD utility.

**FILE**

This parameter sets the name of the password file being created. You must specify the full pathname for the file. The contents of this file are encrypted, and the file is not user-readable. This parameter is mandatory.

The types of file names allowed for the password file are operating system specific. Some platforms require the password file to be a specific format and located in a specific directory. Other platforms allow the use of environment variables to specify the name and location of the password file. See your operating system-specific Oracle documentation for the names and locations allowed on your platform.

If you are running multiple instances of Oracle using the Oracle Parallel Server, the environment variable for each instance should point to the same password file.

**WARNING: It is critically important to the security of your system that you protect your password file and 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 SYSOPER and SYSDBA. If you issue the ALTER USER statement to change the password after connecting to the database, both the password stored in the data dictionary and the password stored in the password file are updated. The INTERNAL user is supported for backwards compatibility only. This parameter is mandatory.

#### ENTRIES

This parameter specifies the number of entries that you would like the password file to accept. This corresponds to the number of distinct users allowed to connect to the database as SYSDBA or SYSOPER. The actual number of entries that can be entered may be somewhat higher, as the ORAPWD utility will continue to assign password entries until an operating system block is filled. For example, if your operating system block size is 512 bytes, it will hold 4 password entries and the number of password entries allocated will always be a multiple of 4.

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

**WARNING:** When you exceed this limit, you must create a new password file. To prevent this from happening, select a number larger than you think you will ever need.

## 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 described below.

**Note:** To start up an instance of a database, you must specify a database name and a parameter file to initialize the instance settings. You may specify a fully-qualified remote database name using Net8. However, the initialization parameter file and any associated files, such as a configuration file, must exist on the client machine. That is, the parameter file must be on the machine from which you are starting the instance.

**NONE**
Setting this parameter to NONE causes Oracle to behave as if the password file does not exist. That is, no privileged connections are allowed over non-secure connections. NONE is the default value for this parameter.

**EXCLUSIVE**
An EXCLUSIVE password file can be used with only one database. Only an EXCLUSIVE file can contain the names of users other than SYSOPER and SYSDBA. Using an EXCLUSIVE password file allows you to grant SYSDBA and SYSOPER system privileges to individual users and have them connect as themselves.

**SHARED**
A SHARED password file can be used by multiple databases. However, the only users recognized by a SHARED password file are SYSDBA and SYSOPER; you cannot add users to a SHARED password file. All users needing SYSDBA or SYSOPER system privileges must connect using the same name, SYS, and password. This option is useful if you have a single DBA administering multiple databases.

**Suggestion:** To achieve the greatest level of security, you should set the REMOTE_LOGIN_PASSWORDFILE file initialization parameter to EXCLUSIVE immediately after creating the password file.

## 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, you receive an error message if you attempt to grant these privileges.

A user's name only remains in the password file while that user has at least one of these two privileges. When you revoke the last of these privileges from a user, that user is removed from the password file.

#### To Create a Password File and Add New Users to It

1. Follow the instructions for creating a password file.
2. Set the REMOTE_LOGIN_PASSWORDFILE initialization parameter to EXCLUSIVE.
3. Connect with SYSDBA privileges as shown in the following example:

   ```
   CONNECT SYS/change_on_install 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 SYSOPER or SYSDBA privileges to yourself and other users as appropriate.
6. These users are now added to the password file and can connect to the database as SYSOPER or SYSDBA with a username and password (instead of using SYS). The use of a password file does not prevent OS authenticated users from connecting if they meet the criteria for OS authentication.

### Granting and Revoking SYSOPER and SYSDBA 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 scott;
```

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

```
REVOKE SYSDBA FROM scott;
```

Because SYSDBA and SYSOPER are the most powerful database privileges, the ADMIN OPTION is not used. Only users currently connected as SYSDBA (or INTERNAL) can grant SYSDBA or SYSOPER system privileges to another user. This is also true of REVOKE. These privileges cannot be granted to roles, since roles are only available after database startup. Do not confuse the SYSDBA and SYSOPER database privileges with operating system roles, which are a completely independent feature.

More information on system privileges is contained in Chapter 23, "Managing User Privileges and Roles".

### Listing Password File Members

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

**USERNAME**
The name of the user that is recognized by the password file.

**SYSDBA**
If the value of this column is TRUE, the user can log on with SYSDBA system privileges.

**SYSOPER**
If the value of this column is TRUE, the user can log on with SYSOPER system privileges.

## Connecting with Administrator Privileges

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

### Connecting with Administrator Privileges: Example

For example, assume user SCOTT has issued the following statements:

```
CONNECT scott/tiger
CREATE TABLE scott_test(name VARCHAR2(20));
```

Later, when SCOTT issues these statements:

```
CONNECT scott/tiger AS SYSDBA
SELECT * FROM scott_test;
```

He receives an error that SCOTT_TEST does not exist. That is because SCOTT now references the SYS schema by default, whereas the table was created in the SCOTT schema.

### Non-Secure Remote Connections

To connect to Oracle as a privileged user over a non-secure connection, you must meet the following conditions:

- The server to which you are connecting must have a password file.
- You must be granted the SYSOPER or SYSDBA system privilege.
- You must connect using a username and password.

### Local and Secure Remote Connections

To connect to Oracle as a privileged user over a local or a secure remote connection, you must meet either of the following sets of conditions:

- You can connect using a password file, provided that you meet the criteria outlined for non-secure connections in the previous bulleted list.
- If the server is not using a password file, or you have not been granted SYSOPER or SYSDBA privileges and are therefore not in the password file, your operating system name must be authenticated for a privileged connection by the operating system. This form of authentication is operating system specific.

More information on password file administration is contained in "Password File Administration" on page 1-9.

> **See Also:** Consult your operating system-specific Oracle documentation for details on operating system authentication.

## Maintaining a Password File

This section describes how to expand the number of password file users if the password file becomes full and how to remove the password file, as well as how to avoid changing the state of 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 re-grant the privileges to the users.

#### To Replace a Password File

1. Note which users have SYSDBA or SYSOPER privileges by querying the V$PWFILE_USERS view.

2. Shut down the database.
3. Delete the existing password file.
4. Follow the instructions for creating a new password file using the ORAPWD utility in "Using ORAPWD" on page 1-10. Be sure to set the ENTRIES parameter to a sufficiently large number.
5. Follow the instructions in "Adding Users to a Password File" on page 1-12.

### Removing a Password File

If you determine that you no longer need to use a password file to authenticate users, you can delete the password file and reset the REMOTE_LOGIN_PASSWORDFILE initialization parameter to NONE. After removing this file, only users who can be authenticated by the operating system can perform database administration operations.

---

**WARNING: Do not remove or modify the password file if you have a database or instance mounted using REMOTE_LOGIN_PASSWORDFILE=EXCLUSIVE (or SHARED). If you do, you will be unable to reconnect remotely using the password file. Even if you replace it, you cannot use the new password file, because the timestamps and checksums will be wrong.**

---

### Changing the Password File State

The password file state is stored in the password file. When you first create a password file, its default state is SHARED. You can change the state of the password file by setting the parameter REMOTE_LOGIN_PASSWORDFILE. When you start up an instance, Oracle retrieves the value of this parameter from the initialization parameter file stored on your client machine. When you mount the database, Oracle compares the value of this parameter to the value stored in the password file. If these values do not match, the value stored in the file is overwritten.

**WARNING: You should use caution to ensure that an EXCLUSIVE password file is not accidentally changed to SHARED. If you plan to allow instance start up from multiple clients, each of those clients must have an initialization parameter file, and the value of the parameter REMOTE_LOGIN_PASSWORDFILE must be the same in each of these files. Otherwise, the state of the password file could change depending upon where the instance was started.**

# Database Administrator Utilities

Several utilities are available to help you maintain and control the Oracle server.

The following topics are included in this section:

- SQL*Loader
- Export and Import

**See Also:** Information about Oracle supplied utilities is contained in *Oracle8i Utilities*

## SQL*Loader

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

## Export and Import

The Export and Import utilities allow you to move existing data in Oracle format to and from Oracle databases. For example, export files can archive database data, or move data among different Oracle databases that run on the same or different operating systems.

# Priorities of a Database Administrator

In general, you must perform a series of steps to get the database system up and running, and then maintain it. The steps are:

Step 1: Install the Oracle Software

The following sections include details about each step.

---

**Note:** If migrating to a new release, back up your existing production database before installation. For more information on preserving your existing production database, see *Oracle8i Migration*.

---

## Step 1: Install the Oracle Software

As the database administrator, you must install the Oracle 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 and the database tools and applications are executed on remote machines; in this case, you must also install the Oracle Net8 drivers necessary to connect the remote machines to the computer that executes Oracle.

For more information on what software to install, see "Identifying Your Oracle Database Software Release" on page 1-21.

> **See Also:** For specific requirements and instructions for installation, see your operating system-specific Oracle documentation and your installation guides for your front-end tools and Net8 drivers.

## Step 2: Evaluate the Database Server Hardware

After installation, evaluate how Oracle and its applications can best use the available computer resources. This evaluation should reveal the following information:

- How many disk drives are available to Oracle and its databases

- How many, if any, dedicated tape drives are available to Oracle and its databases
- How much memory is available to the instances of Oracle you will run (see your system's configuration documentation)

## Step 3: Plan the Database

As the database administrator, you must plan:

- The database's logical storage structure
- 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, where the datafiles will be physically stored (on which disk drives), and what type of information will be stored in each tablespace. When planning the database's overall logical storage structure, take into account the effects that this structure will have when the database is actually created and running. Such considerations include how the database's logical storage structure will affect the following items:

- The performance of the computer executing Oracle
- 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's objects and the storage characteristics for each of these objects. By planning relationships between objects and the physical storage of each object before creating it, you can directly impact 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 can dramatically affect application performance.

During the above planning phases, also plan a backup strategy for the database. After developing this strategy, you might find that you want to alter the database's planned logical storage structure or database design 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, refer to accepted industry-standard books that explain these studies.

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

## Step 4: Create and Open the Database

Once you have finalized the database design, you can create the database and open it for normal use. You can create a database at installation time, using Oracle's Database Configuration Assistant, or you can supply your own scripts for creating a database. Either way, refer to Chapter 2, "Creating an Oracle Database", for information on creating a database and Chapter 3, "Starting Up and Shutting Down" for guidance in starting up the database.

## Step 5: Implement the Database Design

Once you have created and started the database, you can implement the database's planned logical structure by creating all necessary rollback segments and tablespaces. Once this is built, you can create the objects for your database. Part III, "Database Storage" and Part IV, "Schema Objects" contain information which can help you create logical storage structures and objects for your database.

## Step 6: Back Up the Database

After you have created the database structure, carry out the planned backup strategy for your database by creating any additional redo log files, taking the first full database backup (online or offline), and scheduling future database backups at regular intervals.

> **See Also:** See the *Oracle8i Backup and Recovery Guide* or *Oracle8i Recovery Manager User's Guide and Reference* for instructions on customizing your backup operations and performing recovery procedures.

## Step 7: Enroll System Users

Once you have backed up the database structure, you can begin to enroll the users of the database in accordance with your Oracle license agreement, create roles for these users, and grant appropriate roles to them.

The following chapters will help you in this endeavor:

- Chapter 21, "Establishing Security Policies"
- Chapter 22, "Managing Users and Resources"
- Chapter 23, "Managing User Privileges and Roles"

### Step 8: Tune Database Performance

Optimizing the database system's performance is one of your ongoing responsibilities. Additionally, Oracle provides a database resource management feature which allows you control how resources are allocated to various user groups. The database resource manager is described in Chapter 25, "The Database Resource Manager".

> **See Also:** *Oracle8i Designing and Tuning for Performance* contains information about tuning your database and applications.

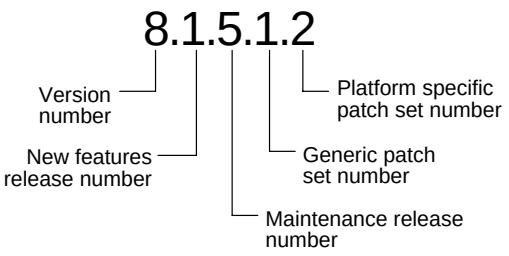
## Identifying Your Oracle Database Software Release

Because Oracle products continue to evolve or maintenance is required to fix problems and enhance functionality, new releases of the database server are the result. It is normal that multiple releases are present at any point in time. To fully identify a release, as many as five numbers may be required. The significance of these numbers is discussed below.

### Release Number Format

An Oracle database server distribution tape might be labeled "release 8.1.5.1.1". The following will help you understand the release level nomenclature used by Oracle.

***Figure 1–2 Example of an Oracle Release Number***




### Version Number

This is the most general identifier. It represents a major new edition (or version) of the software and contains significant new functionality. Example: version 8 (may also be identified as release 8.0).

### New Features Release Number

This number represents a new features release level. Example: release 8.1.

### Maintenance Release Number

This number represents a maintenance release level. A few new features may also be included. Examples: release 8.0.4, release 8.1.6.

### Generic Patch Set Number

This number identifies a generic patch set. The patch set is applicable across all operating system and hardware platforms. Example: patch set release 8.1.5.2

### Platform Specific Patch Set Number

This number represents a patch set that is applicable only to specific operating system and hardware platforms. Example: patch set release 8.0.4.1.1.

## Checking Your Current Release Number

To identify which release of the Oracle database server is currently installed, and to see the release levels of other Oracle components you are using, query the data dictionary view PRODUCT_COMPONENT_VERSION. A sample query is shown below. Note that other product release levels may increment independently of the database server.

```
SELECT * FROM product_component_version;

PRODUCT                        VERSION                   STATUS
-----------------------------  ------------------------- --------------------
CORE                           8.1.5.0.0                 Production
NLSRTL                         3.4.0.0.0                 Production
Oracle8i Enterprise Edition    8.1.5.0.0                 Production
PL/SQL                         8.1.5.0.0                 Production
TNS for 32-bit Windows:        8.1.5.0.0                 Production
5 rows selected.
```

The information displayed by this query is important for reporting problems with your software.

Optionally, you may query the V$VERSION view to see component level information.

# 2

# Creating an Oracle Database

This chapter discusses the process of creating an Oracle database, and includes the following topics:

- Considerations Before Creating a Database
- The Oracle Database Configuration Assistant (DBCA)
- Manually Creating an Oracle Database
- Installation Parameters
- Considerations After Creating a Database
- Initial Tuning Guidelines

> **See Also:** This chapter discussed the creation of a single instance database. While much of this material is still relevant, for information specific to an Oracle Parallel Server environment, see the *Oracle8i Parallel Server Setup and Configuration Guide.*

# Considerations Before Creating a Database

Database creation prepares several operating system files so they can 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. Creating a database can also 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
- Creation Prerequisites
- Deciding How to Create an Oracle Database

## Planning for Database Creation

Consider the following actions as you plan for database creation:

- Plan your database tables and indexes, and estimate how much space they will require. Other chapters in this book contain information about creating various database schema objects and can help you make these estimates, as can *Oracle8i Concepts*.
- Become familiar with the various installation parameters which will make up your initialization parameter file. Information on some parameters is found in "Installation Parameters" on page 2-16 and elsewhere in this book, but a complete reference for initialization parameters is found in *Oracle8i Reference*.
- Plan how to protect your new database from failures, including the configuration of its online and archived redo log (and how much space it will require), and a backup strategy. Online and archived redo logs are discussed in Chapter 6, "Managing the Online Redo Log" and Chapter 7, "Managing Archived Redo Logs". Other information necessary for planning a backup strategy is contained in *Oracle8i Backup and Recovery Guide*.
- Select the database character set. You must specify the database character set when you create the database. All character data, including data in the data dictionary, is stored in the database character set. If users access the database using a different character set, the database character set should be the same as, or a superset of, all character sets they use. National language support is the subject of the *Oracle8i National Language Support Guide*.
- Select your database block size. This is specified as an initialization parameter and cannot be changed without recreating the database.

- Select your global database name. This name is specified in the CREATE DATABASE statement, and is also specified by an initialization parameter.

Additionally, become familiar with the principles and options of starting up and shutting down an instance and mounting and opening a database. These are the topics of Chapter 3. Other methods may be discussed in your Oracle operating system-specific documentation.

## Creation Prerequisites

To create a new database, the following prerequisites must be met:

- The desired Oracle software is installed. This includes setting up various environment variables unique to your operating system and establishing the directory structure for software and database files.
- You 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 startup and shutdown an instance before the database is created or opened. This authentication is discussed in "Database Administrator Authentication" on page 1-6.
- Sufficient memory is available to start the Oracle instance.
- There is sufficient disk storage space for the planned database on the computer that executes Oracle.

All of these are discussed in the Oracle installation guide specific to your operating system. Additionally, the Oracle Universal Installer will guide you through your installation and provide help in setting up environment variables, directory structure, and authorizations.

## Deciding How to Create an Oracle Database

Creating a database includes the following operations:

- Creating information structures, including the data dictionary, that Oracle requires to access and use the database
- Creating and initializing the control files and redo log files for the database
- Creating new datafiles or erasing data that existed in previous datafiles

You use the CREATE DATABASE statement to perform these operations, but other actions are necessary before you have an operational database. A few of these actions are creating user and temporary tablespaces, building views of the data

dictionary tables, and installing Oracle built-in packages. This is why the database creation process involves executing a prepared script. But, you do not necessarily have to prepare this script yourself.

You have the following options for creating your new Oracle database:

- Use the Oracle Database Configuration Assistant (DBCA)

  DBCA is launched by the Oracle Universal Installer and can automatically create a starter database for you. You have the option of using DBCA or not, and you also have the option to create a custom database. Additionally, you can launch DBCA as a stand-alone tool anytime you want to build a new database. DBCA provides the simplest means of creating a database. See "The Oracle Database Configuration Assistant (DBCA)" on page 2-4.

- Create the database manually from a script

  You might choose to create your database manually if you already have existing scripts, or have different requirements than can be met by using DBCA. Oracle provides a sample database creation script and a sample initialization parameter file with the database software files it distributes, both of which can be edited to suit your needs. See "Manually Creating an Oracle Database" on page 2-9.

- Migrate or upgrade an existing database

  If you are using a previous release of Oracle, database creation is required only if you want an entirely new database. Otherwise, you can migrate your existing Oracle database managed by a previous version of Oracle and use it with the new version of the Oracle software. Database migration is not discussed in this book. The *Oracle8i Migration* manual contains information about migrating an existing database.

## The Oracle Database Configuration Assistant (DBCA)

DBCA is a graphical user interface (GUI) tool that interacts with the Oracle Universal Installer, or can be used stand-alone, to simplify the creation of a database. It is described in the following sections:

- Advantages of Using DBCA
- DBCA Modes for Database Creation

## Advantages of Using DBCA

Here are some of the advantages of using DBCA.

- It uses Optimal Flexible Architecture (OFA), whereby database files and administrative files, including initialization files, follow standard naming and placement practices.
- It's fast. A ready made database can be copied into place rather than going through a lengthy creation process. It can be customized more later, if desired.
- Decisions have already been made for you. You do not need to spend time deciding how to set parameters.
- It customizes your database for you. Even if you do not choose to copy the starter database, you can still direct DBCA to generate a script that will create an OLTP, Warehousing, or Multipurpose environment for your database. You need answer only a few questions presented to you by DBCA. It will automatically include MTS if you have over a specified number of users.

Descriptions of the types of databases created by DBCA (OLTP, Warehousing, and Multipurpose) are presented in "Identifying Your Database Environment" on page 2-6.

You can create, delete, or modify databases using DBCA. The modify option is to allow you to enable options that are not already enabled. Only the create database option is discussed in this section.

## DBCA Modes for Database Creation

When you run DBCA from the Oracle Universal Installer at installation, the installation type that you select for the Oracle Universal Installer affects the type of database (OLTP, Warehousing, or Multipurpose) that you can create. Here are the installation types that the Oracle Universal Installer presents you with.

| Installation Types | User Input Required for Database Creation | |
|---|---|---|
| | Minimal | Extensive |
| ■ Typical | X | |
| ■ Minimal | X | |
| ■ Custom | X | X |

"Selecting the Database Creation Method" on page 2-6, outlines the type of databases that can be created based upon your choice of installation type.

## Identifying Your Database Environment

Oracle Universal Installer enables you to create an Oracle8*i* database that operates in one of the following environments. Identify the environment appropriate for your Oracle8*i* database:

| Environment | Description |
|---|---|
| Online Transaction Processing (OLTP) | Many concurrent users performing numerous transactions requiring rapid access to data. Availability, speed, concurrence, and recoverability are key issues.<br>Transactions consist of reading (SELECT statements), writing (INSERT and UPDATE statements), and deleting (DELETE statements) data in database tables. |
| Warehousing<br>(or DSS) | Users perform numerous, complex queries that process large volumes of data. Response time, accuracy, and availability are key issues.<br>These queries (typically read-only) range from a simple fetch of a few records to numerous complex queries that sort thousands of records from many different tables.<br>Warehousing environments are also known as Decision Support System [DSS]) environments |
| Multipurpose | Both types of applications can access this database. |

## Selecting the Database Creation Method

The types of Oracle databases (OLTP, Warehousing, and Multipurpose) created with the Typical, Minimal, and Custom installation types and the amount of user input required are described below. Review these selections and identify the database that best matches your database requirements and database creation expertise:

| If You Perform These Steps... | Then... |
|---|---|
| **1.** Select the *Typical installation type*. | Oracle Database Configuration Assistant automatically starts at the end of installation and creates a preconfigured, ready-to-use Multipurpose starter database with:<br>■ Default initialization parameters<br>■ Automatic installation and configuration of Oracle options and *inter*Media components[1]<br>■ Advanced replication capabilities<br>■ Database configuration of multi-threaded server mode[2]<br>■ Archiving mode of NOARCHIVELOG<br>No user input is required. |
| **1.** Select the *Minimal installation type*.<br>**2.** Select Yes when prompted to create a starter database.<br>**Note:** If you select No, all server components except a database are installed. You can create your database later by manually running Oracle Database Configuration Assistant or with a SQL script. See the *Oracle8i Administrator's Guide for Windows NT* for instructions.<br>**Note:** A Multipurpose database is also installable through the Oracle Internet Directory installation type. That database is only for storing Oracle Internet Directory information. | Oracle Database Configuration Assistant automatically starts at the end of installation and creates the same Oracle8*i* database that you receive with *Typical*, with the following exceptions:<br>■ No installation and configuration of Oracle options and *inter*Media components is available<br>■ Database configuration of dedicated server mode |

| If You Perform These Steps... | Then... |
|---|---|
| 1. Select the *Custom installation type*.<br>2. Select Oracle Server and additional products in the *Available Products* window.<br>3. Select Yes when prompted to create a starter database.<br>4. Oracle Database Configuration Assistant prompts you to select either of two *database creation methods*:<br>■ *Custom*<br>■ *Typical* | **If You Select the Custom database creation method...**<br>Oracle Database Configuration Assistant guides you in the creation of a database fully customized to match the environment (OLTP, Warehousing, or Multipurpose) and database configuration mode (dedicated server or multi-threaded server) you select. Options and interMedia components (if installed) and advanced replication (if selected) are also automatically configured. Select this option only if you are experienced with advanced database creation procedures, such as customizing:<br>■ Data, control, and redo log file settings<br>■ Tablespace and extent sizes<br>■ Database memory parameters<br>■ Archiving modes, formats, and destinations<br>■ Trace file destinations<br>■ Character set values<br>**If You Select the Typical database creation method...**<br>You have two choices. Oracle Database Configuration Assistant's role in database creation depends on your selection:<br>**If you select...**<br>■ *Copy existing files from CD*<br>Oracle Database Configuration Assistant creates the same Oracle8*i* database as described under *Typical* on the previous page. Options and interMedia components (if installed) are also automatically configured. No user input is required.[3]<br>■ *Create new database files*<br>Oracle Database Configuration Assistant prompts you to answer several questions, including selecting a database environment (OLTP, Warehousing, or Multipurpose) and specifying the number of concurrent connections. Oracle Database Configuration Assistant then dynamically creates a database. Options and interMedia components (if installed) and advanced replication (if selected) are also automatically configured.[3, 4] |

[1] Oracle Database Configuration Assistant only configures options that were installed through Oracle Universal Installer.

[2] See Chapter 5 of *Oracle8i Administrator's Guide for Windows NT* for descriptions of dedicated server mode and multi-threaded server mode (also known as shared server mode).

[3] If you selected Oracle JServer for installation, the database is created in multi-threaded server mode for IIOP clients.

[4] If you select OLTP as your database environment and enter 20 or more for the number of concurrent database connections, your database is created in multi-threaded server mode. Otherwise, the server mode is dedicated.

# Manually Creating an Oracle Database

Manually creating a database can best be illustrated by examining a sample database creation script. But you should also be aware of the steps to follow in creating your database, and what to do if things go wrong or you change your mind.

This section discusses:

- Steps for Creating an Oracle Database
- Examining a Database Creation Script
- Troubleshooting Database Creation
- Dropping a Database

## Steps for Creating an Oracle Database

These steps, which describe how to create an Oracle database, should be followed in the order presented. You will previously have created an environment for creating your Oracle database, including operating-system-dependent environmental variables, as part of the Oracle software installation process.

### To Create a New Database and Make It Available for System Use

1. Decide on your instance identifier (DB_NAME and SID).

   The Oracle instance identifier should match the name of the database (the value of DB_NAME). This identifier is used to avoid confusion with other Oracle instances that you may create later and run concurrently on your system.

   See your operating system-specific Oracle documentation for more information.

2. Create the initialization parameter file.

   The instance (System Global Area and background processes) for any Oracle database is started using an initialization parameter file. To create a parameter file for the database you are about to make, use your operating system to make a copy of the initialization parameter file that Oracle provides on the distribution media. Give this copy a new filename. You can then edit and customize this new file for the new database. See "Installation Parameters" on page 2-16 for suggestions on which parameters you may want to edit. Also see "Using Initialization Parameter Files" on page 3-15.

Each database on your system should have at least one customized initialization parameter file that corresponds only to that database. Do not use the same file for several databases.

---

**Note:** In distributed processing environments, Enterprise Manager is often executed from a client machine of the network. If a client machine is being used to execute Enterprise Manager and create a new database, you need to copy the new initialization parameter file (currently located on the computer executing Oracle) to your client workstation. This procedure is operating system dependent. For more information about copying files among the computers of your network, see your operating system-specific Oracle documentation.

Enterprise Manager is not discussed in this book. It is described briefly in "Using Oracle Enterprise Manager" on page 3-4

---

3. Start SQL*Plus and connect to your Oracle instance as SYSDBA.

   This example assumes that you have proper authorization.

   ```
   $ SQLPLUS /nolog
   CONNECT username/password AS sysdba
   ```

4. Start an instance.

   You can start an instance without mounting a database; typically, you do so only during database creation. Use the STARTUP statement with the NOMOUNT option. If no PFILE is specified, the initialization parameter file is read from an operating system specific default location.

   ```
   STARTUP NOMOUNT;
   ```

   The STARTUP statement is discussed in Chapter 3, "Starting Up and Shutting Down".

   At this point, there is no database. Only an SGA and background processes are started in preparation for the creation of a new database.

5. Create the database.

   To create the new database, use the SQL CREATE DATABASE statement, optionally setting parameters within the statement to name the database,

establish maximum numbers of files, name the files and set their sizes, and so on.

To make the database functional, you will need to create additional files and tablespaces. This is usually done by running a database creation script. See "Examining a Database Creation Script" on page 2-11.

6. Run the scripts necessary to build views, synonyms, etc.

   The primary scripts that you must run are:

   - CATALOG.SQL—creates the views of data dictionary tables and the dynamic performance views
   - CATPROC.SQL—establishes the usage of PL/SQL functionality and creates many of the PL/SQL Oracle supplied packages

   See your Oracle installation guide for your operating system for the location of these 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 *Oracle8i Reference*.

7. Back up the database.

   You should make 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 the *Oracle8i Backup and Recovery Guide*.

> **See Also:** These steps provide general information about database creation on all operating systems. See your operating system-specific Oracle documentation for information about creating databases on your platform.

## Examining a Database Creation Script

This section examines and explains a database creation script, similar to sample scripts distributed with your operating system.

### The Database Creation Script

Here is a sample database creation script which creates database RBDB1. See the next section, "Interpreting the Script", for a narrative interpreting the script.

```
-- Create database
```

```
CREATE DATABASE rbdb1
    CONTROLFILE REUSE
    LOGFILE '/u01/oracle/rbdb1/redo01.log' SIZE 1M REUSE,
            '/u01/oracle/rbdb1/redo02.log' SIZE 1M REUSE,
            '/u01/oracle/rbdb1/redo03.log' SIZE 1M REUSE,
            '/u01/oracle/rbdb1/redo04.log' SIZE 1M REUSE
    DATAFILE '/u01/oracle/rbdb1/system01.dbf' SIZE 10M REUSE
      AUTOEXTEND ON
      NEXT 10M MAXSIZE 200M
    CHARACTER SET WE8ISO8859P1;

-- Create another (temporary) system tablespace
CREATE ROLLBACK SEGMENT rb_temp STORAGE (INITIAL 100 k NEXT 250 k);

-- Alter temporary system tablespace online before proceding
ALTER ROLLBACK SEGMENT rb_temp ONLINE;

-- Create additional tablespaces ...
-- RBS: For rollback segments
-- USERs: Create user sets this as the default tablespace
-- TEMP: Create user sets this as the temporary tablespace
CREATE TABLESPACE rbs
    DATAFILE '/u01/oracle/rbdb1/rbs01.dbf' SIZE 5M REUSE AUTOEXTEND ON
      NEXT 5M MAXSIZE 150M;
CREATE TABLESPACE users
    DATAFILE '/u01/oracle/rbdb1/users01.dbf' SIZE 3M REUSE AUTOEXTEND ON
      NEXT 5M MAXSIZE 150M;
CREATE TABLESPACE temp
    DATAFILE '/u01/oracle/rbdb1/temp01.dbf' SIZE 2M REUSE AUTOEXTEND ON
      NEXT 5M MAXSIZE 150M;

-- Create rollback segments.
CREATE ROLLBACK SEGMENT rb1 STORAGE(INITIAL 50K NEXT 250K)
  tablespace rbs;
CREATE ROLLBACK SEGMENT rb2 STORAGE(INITIAL 50K NEXT 250K)
  tablespace rbs;
CREATE ROLLBACK SEGMENT rb3 STORAGE(INITIAL 50K NEXT 250K)
  tablespace rbs;
CREATE ROLLBACK SEGMENT rb4 STORAGE(INITIAL 50K NEXT 250K)
  tablespace rbs;

-- Bring new rollback segments online and drop the temporary system one
ALTER ROLLBACK SEGMENT rb1 ONLINE;
ALTER ROLLBACK SEGMENT rb2 ONLINE;
ALTER ROLLBACK SEGMENT rb3 ONLINE;
```

```
ALTER ROLLBACK SEGMENT rb4 ONLINE;

ALTER ROLLBACK SEGMENT rb_temp OFFLINE;
DROP ROLLBACK SEGMENT rb_temp ;
```

## Interpreting the Script

The above database creation script is interpreted here.

### The CREATE DATABASE Statement

```
CREATE DATABASE rbdb1
    CONTROLFILE REUSE
    LOGFILE '/u01/oracle/rbdb1/redo01.log' SIZE 1M REUSE,
            '/u01/oracle/rbdb1/redo02.log' SIZE 1M REUSE,
            '/u01/oracle/rbdb1/redo03.log' SIZE 1M REUSE,
            '/u01/oracle/rbdb1/redo04.log' SIZE 1M REUSE
    DATAFILE '/u01/oracle/rbdb1/system01.dbf' SIZE 10M REUSE
      AUTOEXTEND ON
      NEXT 10M MAXSIZE 200M
    CHARACTER SET WE8ISO8859P1;
```

When you execute a CREATE DATABASE statement, Oracle performs the following operations:

- Creates the datafiles for the database.
- Creates the control files for the database. See Chapter 5, "Managing Control Files".
- Creates the redo log files for the database. See Chapter 6, "Managing the Online Redo Log".
- Creates the SYSTEM tablespace and the SYSTEM rollback segment.
- Creates the data dictionary.
- Creates the users SYS and SYSTEM. See "Database Administrator Usernames" on page 1-4.
- Specifies the character set that stores data in the database
- Mounts and opens the database for use

The values of the MAXLOGFILES, MAXLOGMEMBERS, MAXDATAFILES, MAXLOGHISTORY, and MAXINSTANCES options in this example assume the default values, which are operating system-dependent. The database is mounted in the default modes NOARCHIVELOG and EXCLUSIVE and then opened.

The items and information in the example statement above result in creating a database with the following characteristics:

- The new database is named RBDB1.
- The SYSTEM tablespace of the new database is comprised of one 10 MB datafile: `/u01/oracle/rbdb1/system01.dbf`.
- The new database has four redo log files of 1 MB
- The new database does not overwrite any existing control files specified in the parameter file.
- The `WE8ISO8859P1` character set is used.

---

**Note:** You can set several limits during database creation. Some of these limits are also subject to superseding limits of the operating system and can affect each other. For example, if you set MAXDATAFILES, Oracle allocates enough space in the control file to store MAXDATAFILES filenames, even if the database has only one datafile initially; 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 *Oracle8i SQL Reference* and your operating system-specific Oracle documentation.

---

**See Also:** For information about the CREATE DATABASE statement, character sets, and database creation see the *Oracle8i SQL Reference*.

#### Creating Another System Rollback Segment

```
CREATE ROLLBACK SEGMENT rb_temp STORAGE (INITIAL 100 k NEXT 250 k);
ALTER ROLLBACK SEGMENT rb_temp ONLINE;
```

These statements create a temporary system rollback segment to use while other database tablespaces are being created. For a discussion of rollback segments, see Chapter 11, "Managing Rollback Segments".

#### Creating a Tablespace for Rollback Segments

```
CREATE TABLESPACE rbs
    DATAFILE '/u01/oracle/rbdb1/rbs01.dbf' SIZE 5M REUSE AUTOEXTEND ON
      NEXT 5M MAXSIZE 150M;
```

This statement creates the tablespace to hold rollback segments. See Chapter 9, "Managing Tablespaces" and Chapter 11, "Managing Rollback Segments".

#### Creating a Users Tablespace

```
CREATE TABLESPACE users
    DATAFILE '/u01/oracle/rbdb1/users01.dbf' SIZE 3M REUSE AUTOEXTEND ON
      NEXT 5M MAXSIZE 150M;
```

This statement creates a tablespace that can be assigned as a default tablespace in user profiles. See Chapter 9, "Managing Tablespaces" and "Assigning a Default Tablespace" on page 22-16.

#### Creating a Temporary Tablespace

```
CREATE TABLESPACE temp
    DATAFILE '/u01/oracle/rbdb1/temp01.dbf' SIZE 2M REUSE AUTOEXTEND ON
      NEXT 5M MAXSIZE 150M;
```

A temporary tablespace has a special usage for sort operations. A user can be assigned this temporary tablespace in a user profile. See Chapter 9, "Managing Tablespaces" and "Assigning a Default Tablespace" on page 22-16.

#### Creating Rollback Segments

```
CREATE ROLLBACK SEGMENT rb1 STORAGE(INITIAL 50K NEXT 250K)
  tablespace rbs;
CREATE ROLLBACK SEGMENT rb2 STORAGE(INITIAL 50K NEXT 250K)
  tablespace rbs;
CREATE ROLLBACK SEGMENT rb3 STORAGE(INITIAL 50K NEXT 250K)
  tablespace rbs;
CREATE ROLLBACK SEGMENT rb4 STORAGE(INITIAL 50K NEXT 250K)
  tablespace rbs;

-- Bring new rollback segments online and drop the temporary system one
ALTER ROLLBACK SEGMENT rb1 ONLINE;
ALTER ROLLBACK SEGMENT rb2 ONLINE;
ALTER ROLLBACK SEGMENT rb3 ONLINE;
ALTER ROLLBACK SEGMENT rb4 ONLINE;

ALTER ROLLBACK SEGMENT rb_temp OFFLINE;
```

```
DROP ROLLBACK SEGMENT rb_temp ;
```

This series of statements creates the rollback segments to be used for user transactions. When initially created, they are OFFLINE. They must explicitly be brought online. Also, the temporary system rollback segment now is taken offline and then dropped.

For more information, see Chapter 11, "Managing Rollback Segments".

### Troubleshooting Database Creation

If for any reason database creation fails, shut down the instance and delete any files created by the CREATE DATABASE statement before you attempt to create it once again.

After correcting the error that caused the failure of the database creation, try running the script again.

### Dropping a Database

To drop a database, remove its datafiles, redo log files, and all other associated files (control files, parameter files, archived log files).

To view the names of the database's datafiles and redo log files, query the data dictionary views V$DATAFILE and V$LOGFILE.

> **See Also:** For more information about these views, see the *Oracle8i Reference*.

## Installation Parameters

As stated in the steps for creating a database, you will want to edit the Oracle supplied initialization parameter file. Oracles intent is to provide appropriate values in this starter initialization parameter file; it is suggested that you alter a minimum of parameters. As you become more familiar with your database and environment, you can dynamically tune many of these parameters with the ALTER SYSTEM statement. Any of these altered parameters that you wish to make permanent, should be updated in the initialization parameter file.

The following topic are discussed in this section:

- A Sample Initialization File
- Editing the Initialization Parameter File

**See Also:** For more information about initialization parameters and descriptions of all of the parameters, see the *Oracle8i Reference*.

## A Sample Initialization File

Listed here is a sample of an Oracle supplied initialization parameter file that has been edited as the parameter file that can be used with the RBDB1 database. You will note that, within the script, Oracle has provided guidance for the settings of the initialization parameters.

```
###########################################################################################
# Example INIT.ORA file
#
# This file is provided by Oracle Corporation to help you customize
# your RDBMS installation for your site.  Important system parameters
# are discussed, and example settings given.
#
# Some parameter settings are generic to any size installation.
# For parameters that require different values in different size
# installations, three scenarios have been provided: SMALL, MEDIUM
# and LARGE.  Any parameter that needs to be tuned according to
# installation size will have three settings, each one commented
# according to installation size.
#
# Use the following table to approximate the SGA size needed for the
# three scenarious provided in this file:
#
#                      -------Installation/Database Size------
#                       SMALL           MEDIUM          LARGE
#  Block         2K     4500K            6800K          17000K
#  Size          4K     5500K            8800K          21000K
#
# To set up a database that multiple instances will be using, place
# all instance-specific parameters in one file, and then have all
# of these files point to a master file using the IFILE command.
# This way, when you change a public
# parameter, it will automatically change on all instances.  This is
# necessary, since all instances must run with the same value for many
# parameters. For example, if you choose to use private rollback segments,
# these must be specified in different files, but since all gc_*
# parameters must be the same on all instances, they should be in one file.
#
# INSTRUCTIONS: Edit this file and the other INIT files it calls for
# your site, either by using the values provided here or by providing
# your own.  Then place an IFILE= line into each instance-specific
```

```
# INIT file that points at this file.
#
# NOTE: Parameter values suggested in this file are based on conservative
# estimates for computer memory availability. You should adjust values upward
# for modern machines.
#
###############################################################################

db_name = RBDB1

db_files = 1024                                                    # INITIAL
# db_files = 80                                                    # SMALL
# db_files = 400                                                   # MEDIUM
# db_files = 1500                                                  # LARGE

control_files = ("/u01/oracle/rbdb1/control01.ctl",
                 "/u01/oracle/rbdb1/control02.ctl")

db_file_multiblock_read_count = 8                                  # INITIAL
# db_file_multiblock_read_count = 8                                # SMALL
# db_file_multiblock_read_count = 16                               # MEDIUM
# db_file_multiblock_read_count = 32                               # LARGE

db_block_buffers = 8192                                            # INITIAL
# db_block_buffers = 100                                           # SMALL
# db_block_buffers = 550                                           # MEDIUM
# db_block_buffers = 3200                                          # LARGE

shared_pool_size = 15728640                                        # INITIAL
# shared_pool_size = 3500000                                       # SMALL
# shared_pool_size = 5000000                                       # MEDIUM
# shared_pool_size = 9000000                                       # LARGE

log_checkpoint_interval = 10000
log_checkpoint_timeout = 1800

processes = 59                                                     # INITIAL
# processes = 50                                                   # SMALL
# processes = 100                                                  # MEDIUM
# processes = 200                                                  # LARGE

parallel_max_servers = 5                                           # SMALL
# parallel_max_servers = 4 x (number of CPUs)                      # MEDIUM
# parallel_max_servers = 4 x (number of CPUs)                      # LARGE
```

```
log_buffer = 32768                                                    # INITIAL
# log_buffer = 32768                                                  # SMALL
# log_buffer = 32768                                                  # MEDIUM
# log_buffer = 163840                                                 # LARGE

#audit_trail = true  # if you want auditing
#timed_statistics = true  # if you want timed statistics
max_dump_file_size = 10240  # limit trace file size to 5M each

# Uncommenting the line below will cause automatic archiving if archiving has
# been enabled using ALTER DATABASE ARCHIVELOG.
# log_archive_start = true
# log_archive_dest_1 = "location=/u01/oracle/rbdb1/archive"
# log_archive_format = "%%RBDB1%%T%TS%S.ARC"

# If using private rollback segments, place lines of the following
# form in each of your instance-specific init.ora files:
rollback_segments = (rb1, rb2, rb3, rb4)

# If using public rollback segments, define how many
# rollback segments each instance will pick up, using the formula
#   # of rollback segments = transactions / transactions_per_rollback_segment
# In this example each instance will grab 40/5 = 8
# transactions = 40
# transactions_per_rollback_segment = 5

# Global Naming -- enforce that a dblink has same name as the db it connects to
global_names = true

# Edit and uncomment the following line to provide the suffix that will be
# appended to the db_name parameter (separated with a dot) and stored as the
# global database name when a database is created.  If your site uses
# Internet Domain names for e-mail, then the part of your e-mail address after
# the '@' is a good candidate for this parameter value.
db_domain = us.acme.com
#global database name is db_name.db_domain
compatible = 8.1.0
```

## Editing the Initialization Parameter File

To create a new database, these are some of the initialization parameters that you will want to edit. Depending upon your configuration and options, and how you want to tune your database, there can be other initialization parameters for you to

edit or add. Many of these other initialization parameters are discussed throughout this book.

You should also add the appropriate license initialization parameter(s).

These parameters are described in the following sections:

- DB_NAME and DB_DOMAIN
- CONTROL_FILES
- DB_BLOCK_SIZE
- DB_BLOCK_BUFFERS
- PROCESSES
- ROLLBACK_SEGMENTS
- License Parameters

### DB_NAME and DB_DOMAIN

A database's *global database name* (name and location within a network structure) is created by setting both the DB_NAME and DB_DOMAIN parameters before database creation. After creation, the database's name cannot be easily changed, as you must also recreate the control file. The DB_NAME parameter determines the local name component of the database's name, while the DB_DOMAIN parameter indicates the domain (logical location) within a network structure. The combination of the settings for these two parameters should 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
```

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 (of the parameter file) and the database name in the control file are not the same, the database does not start.

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, pay special attention to this initialization parameter before database creation.

**See Also:** For more information about distributed databases, see *Oracle8i Distributed Database Systems*.

### CONTROL_FILES

Include the CONTROL_FILES parameter in your new parameter file and set its value to a list of control filenames to use for the new database. If you want Oracle to create new operating system files when creating your database's control files, make sure that the filenames listed in the CONTROL_FILES parameter do not match any filenames that currently exist on your system. If you want Oracle to reuse or overwrite existing files when creating your database's control files, make sure that the filenames listed in the CONTROL_FILES parameter match the filenames that currently exist.

**WARNING: Use extreme caution when setting this option. If you inadvertently specify a file that you did not intend and execute the CREATE DATABASE statement, the previous contents of that file will be overwritten.**

If no filenames are listed for the CONTROL_FILES parameter, Oracle uses a default filename.

Oracle Corporation strongly recommends you use at least two control files stored on separate physical disk drives for each database. Therefore, when specifying the CONTROL_FILES parameter of the new parameter file, follow these guidelines:

- List at least two filenames for the CONTROL_FILES parameter.
- Place each control file on a separate physical disk drives by fully specifying filenames that refer to different disk drives for each filename.

**Note:** The file specification for control files is operating system-dependent. Regardless of your operating system, *always* fully specify filenames for your control files.

When you execute the CREATE DATABASE statement (in Step 7), the control files listed in the CONTROL_FILES parameter of the parameter file will be created.

> **See Also:** The default filename for the CONTROL_FILES parameter is operating system-dependent. See your operating system-specific Oracle documentation for details.

### DB_BLOCK_SIZE

The default data block size for every Oracle server is operating system-specific. The Oracle data block size is typically either 2K or 4K. Generally, the default data block size is adequate. In some cases, however, a larger data block size provides greater efficiency in disk and memory I/O (access and storage of data). Such cases include:

- Oracle 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 uses a small operating system block size. For example, if the operating system block size is 1K and the data block size matches this, Oracle 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.

Each database's block size is set during database creation by the initialization parameter DB_BLOCK_SIZE. The block size *cannot* be changed after database creation except by re-creating the database. If a database's block size is different from the operating system block size, make the database block size a multiple of the operating system's block size.

For example, if your operating system's block size is 2K (2048 bytes), the following setting for the DB_BLOCK_SIZE initialization parameter would be valid:

```
DB_BLOCK_SIZE=4096
```

DB_BLOCK_SIZE also determines the size of the database buffers in the buffer cache of the System Global Area (SGA).

> **See Also:** For details about your default block size, see your operating system-specific Oracle documentation.

### DB_BLOCK_BUFFERS

This parameter determines the number of buffers in the buffer cache in the System Global Area (SGA). The number of buffers affects the performance of the cache. Larger cache sizes reduce the number of disk writes of modified data. However, a large cache may take up too much memory and induce memory paging or swapping.

Estimate the number of data blocks that your application accesses most frequently, including tables, indexes, and rollback segments. This estimate is a rough approximation of the minimum number of buffers the cache should have. Typically, 1000 to 2000 is a practical minimum for the number of buffers.

> **See Also:** For more information about tuning the buffer cache, see *Oracle8i Designing and Tuning for Performance*.

### PROCESSES

This parameter determines the maximum number of operating system processes that can be connected to Oracle concurrently. The value of this parameter must include 5 for the background processes and 1 for each user process. For example, if you plan to have 50 concurrent users, set this parameter to at least 55.

### ROLLBACK_SEGMENTS

This parameter is a list of the rollback segments an Oracle instance acquires at database startup. List your rollback segments as the value of this parameter.

> **Note:** After installation, you must create at least one rollback segment in the SYSTEM tablespace in addition to the SYSTEM rollback segment before you can create any schema objects.

## License Parameters

Oracle helps you ensure that your site complies with its Oracle license agreement. If your site is licensed by concurrent usage, you can track and limit the number of sessions concurrently connected to an instance. If your site is licensed by named users, you can limit the number of named users created in a database. To use this facility, you need to know which type of licensing agreement your site has and what the maximum number of sessions or named users is. Your site might use either type of licensing (session licensing or named user licensing), but not both.

For more information about managing licensing, see "Session and User Licensing" on page 22-2.

**LICENSE_MAX_SESSIONS and LICENSE_SESSIONS_WARNING** You can set a limit on the number of concurrent sessions that can connect to a database on the specified computer. To set the maximum number of concurrent sessions for an instance, set the parameter LICENSE_MAX_SESSIONS in the parameter file that starts the instance, as shown in the following example:

```
LICENSE_MAX_SESSIONS = 80
```

In addition to setting a maximum number of sessions, you can set a warning limit on the number of concurrent sessions. Once this limit is reached, additional users can continue to connect (up to the maximum limit), but Oracle sends a warning for each connecting user. To set the warning limit for an instance, set the parameter LICENSE_SESSIONS_WARNING. Set the warning limit to a value lower than LICENSE_MAX_SESSIONS.

For instances running with the Parallel Server, each instance can have its own concurrent usage limit and warning limit. However, the sum of the instances' limits must not exceed the site's session license.

> **See Also:** For more information about setting licensing limits when using the Parallel Server, see the *Oracle8i Parallel Server Administration, Deployment, and Performance* and *Oracle8i Parallel Server Setup and Configuration Guide.*

**LICENSE_MAX_USERS** 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 parameter in the database's parameter file, as shown in the following example:

```
LICENSE_MAX_USERS = 200
```

For instances running with the Parallel Server, all instances connected to the same database should have the same named user limit.

## 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. If more than one database exists in your database system, specify the parameter file to use with any subsequent database startup.

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. See your operating system-specific Oracle documentation for the additional products. Usually, command files are provided to create and load these tables into the database's data dictionary.

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

A newly created database has only two users, SYS and SYSTEM. The passwords for these two usernames should be changed soon after the database is created. For more information about the users SYS and SYSTEM see "Database Administrator Usernames" on page 1-4.

For information about changing a user's password see "Altering Users" on page 22-18.

# Initial Tuning Guidelines

You can make a few significant tuning alterations to Oracle immediately following installation. By following these instructions, you can reduce the need to tune Oracle when it is running. This section gives recommendations for the following installation issues:

- Allocating Rollback Segments
- Choosing the Number of DB_BLOCK_LRU_LATCHES
- Distributing I/O

> **See Also:** For more information on tuning any of these initialization parameters, see *Oracle8i Designing and Tuning for Performance*.

## Allocating Rollback Segments

Proper allocation of rollback segments makes for optimal database performance. The size and number of rollback segments required for optimal performance depends on your application. *Oracle8i Designing and Tuning for Performance* contains some general guidelines for choosing how many rollback segments to allocate based on the number of concurrent transactions on your Oracle server. These guidelines are appropriate for most application mixes.

To create rollback segments, use the CREATE ROLLBACK SEGMENT statement. The size of your rollback segment can also affect performance. Rollback segment size is determined by the storage parameters in the CREATE ROLLBACK SEGMENT statement. Your rollback segments must be large enough to hold the rollback entries for your transactions.

## Choosing the Number of DB_BLOCK_LRU_LATCHES

Contention for the LRU (least recently used) latch can impede performance on symmetric multiprocessor (SMP) machines with a large number of CPUs. The LRU latch controls the replacement of buffers in the buffer cache. For SMP systems, Oracle automatically sets the number of LRU latches to be one half the number of CPUs on the system. For non-SMP systems, one LRU latch is sufficient.

You can specify the number of LRU latches on your system with the initialization parameter DB_BLOCK_LRU_LATCHES. This parameter sets the maximum value for the desired number of LRU latches. Each LRU latch will control a set of buffers and Oracle balances allocation of replacement buffers among the sets.

## Distributing I/O

Proper distribution of I/O can improve database performance dramatically. I/O can be distributed during installation of Oracle. Distributing I/O during installation can reduce the need to distribute I/O later when Oracle is running.

There are several ways to distribute I/O when you install Oracle:

- Redo log file placement
- Datafile placement
- Separation of tables and indexes
- Density of data (rows per data block)

# 3

# Starting Up and Shutting Down

This chapter describes the procedures for starting and stopping an Oracle database, and includes the following topics:

- Starting Up a Database
- Altering Database Availability
- Shutting Down a Database
- Suspending and Resuming a Database
- Using Initialization Parameter Files

# Starting Up a Database

When you start up a database, you create an instance of that database, and you choose the state in which the database starts. Normally, you would start up an instance by *mounting* and *opening* the database, thus making it available for any valid user to connect to it and perform typical data access operations. However, there are other options and these are also discussed in this section.

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



## Preparing to Start an Instance

You need to perform some preliminary steps before attempting to start an instance of your database .

1. Start SQL*Plus without connecting to the database by entering:

   ```
   SQLPLUS
   ```

2. Connect to Oracle as SYSDBA:

   ```
   CONNECT username/password AS sysdba
   ```

   Note that you cannot be connected via a multi-threaded server.

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

> **See Also:** CONNECT, STARTUP, and SHUTDOWN are SQL*Plus commands. They are described, and their syntax is presented, in *SQL*Plus User's Guide and Reference.*

## Options for Starting Up a Database

There are options as to the method you use for starting up (and administering) an instance of your database. While three methods are mentioned, using SQL*Plus is the only method that is within the scope of this book.

### Using SQL*Plus

To start up a database use SQL*Plus to connect to Oracle with administrator privileges (as shown previously) and then issue the STARTUP command. When you enter a STARTUP command, you can specify the database name and the full path of the initialization parameter file:

```
STARTUP database_name PFILE=myinit.ora
```

If you do not specify *database_name*, Oracle uses the value specified by the DB_NAME initialization parameter in the specified PFILE. The manner in which you specify the path for the initialization parameter file is operating system specific. If you do not specify the PFILE option, Oracle uses the default parameter file location, as specified in the Oracle installation guide for your operating system.

You can start an instance and database in a variety of ways:

- 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 recreation 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 restricted mode that allows access for database administrators only.

> **Note:** You cannot start a database instance if you are connected to the database via a multi-threaded server process.

In addition, you can force the instance to start, or start the instance and have complete media recovery begin immediately. If your operating system supports the Oracle Parallel Server (OPS), you may start an instance and mount the database in either exclusive or shared mode.

### 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 wish to bring up SQL*Plus. RMAN is not discussed in this book, but is the topic of *Oracle8i Recovery Manager User's Guide and Reference.*

### Using Oracle Enterprise Manager

You can choose to use the Oracle Enterprise Manager for administering your database, including starting up and shutting down. The Oracle Enterprise Manager is a separate Oracle product, that combines a graphical console, agents, common services, and tools to provide an integrated and comprehensive systems management platform for managing Oracle products.It allows you to perform the functions discussed in this book using a GUI interface, rather than command lines.

See the following books to become familiar with the Oracle Enterprise Manager:

- *Oracle Enterprise Manager Concepts Guide*
- *Oracle Enterprise Manager Administrator's Guide*

## Starting an Instance: Scenarios

The following scenarios describe and illustrate the many ways in which you can start up an instance. For more information about the restrictions that apply when combining options of the STARTUP command, see the *SQL*Plus User's Guide and Reference.*

> **Note:** You may 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 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, Oracle returns a warning message and does not open the database.

### 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 option:

```
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:

- Renaming datafiles, as described in Chapter 10, "Managing Datafiles".
- Adding, dropping, or renaming redo log files, as described in Chapter 6, "Managing the Online Redo Log".
- Enabling and disabling redo log archiving options, as described in Chapter 7, "Managing Archived Redo Logs".
- Performing full database recovery. Database recovery is the topic of *Oracle8i Backup and Recovery Guide* and *Oracle8i Recovery Manager User's Guide and Reference.*

Start an instance and mount the database, but leave it closed by using the STARTUP command with the MOUNT option:

```
STARTUP MOUNT;
```

### 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 typical data access operations.

Start an instance and then mount and open the database by using the STARTUP command by itself (this example uses the database name as specified by the DB_NAME initialization parameter in the standard PFILE):

```
STARTUP;
```

### Restricting Access to a Database at Startup

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

- Perform structure maintenance, such as rebuilding indexes
- Perform an export or import of database data
- Perform a data load (with SQL*Loader)
- Temporarily prevent typical users from using data

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.

Start an instance (and, optionally, mount and open the database) in restricted mode by using the STARTUP command with the RESTRICT option:

```
STARTUP RESTRICT;
```

Later, use the ALTER SYSTEM statement to disable the RESTRICTED SESSION feature. If you open the database in nonrestricted mode and later find 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 3-9.

> **See Also:** For more information on the ALTER SYSTEM statement, see the *Oracle8i SQL Reference*.

### 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 option:

```
STARTUP FORCE;
```

If an instance is running, STARTUP FORCE shuts it down with mode ABORT before restarting it. To understand the side effects of aborting the current instance, see "Shutting Down with the ABORT Option" on page 3-13.

### 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 option:

```
STARTUP OPEN RECOVER;
```

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

### Starting in Exclusive or Parallel Mode

If your Oracle server allows multiple instances to access a single database concurrently (Oracle Parallel Server option), choose whether to mount the database exclusively or in parallel. For example, to open in parallel mode you can issue:

```
STARTUP OPEN sales PFILE=initsale.ora PARALLEL;
```

Multiple instances can now access the database.

If you specify EXCLUSIVE (the default), then the database can only be mounted and opened by the current instance. The following statement starts an instance, mounts and opens the database named `sales` in exclusive mode, and restricts access to administrative personnel.

```
STARTUP OPEN sales PFILE=initsale.ora EXCLUSIVE RESTRICT;
```

> **See Also:** For more information about starting up in exclusive or parallel mode, see the *Oracle8i Parallel Server Administration, Deployment, and Performance* manual.

### Automatic Database Startup at Operating System Start

Many sites use procedures to enable automatic startup of one or more Oracle 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 procedure topics, see your operating system-specific Oracle documentation.

### Starting Remote Instances

If your local Oracle server is part of a distributed database, you might need 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 a database's availability:

- 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.

When mounting the database, indicate whether to mount the database exclusively to this instance or concurrently to other instances.

To mount a database to a previously started instance, use the SQL statement ALTER DATABASE with the MOUNT option. Use the following statement when you want to mount a database in exclusive mode:

```
ALTER DATABASE MOUNT;
```

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), see "Starting an Instance and Mounting a Database" on page 3-5.

## 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 option:

```
ALTER DATABASE OPEN;
```

After executing this statement, any valid Oracle 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 "state" modifications that don't generate redo. For example, you can take datafiles offline or bring them online since these operations do not effect data content.

Ideally, you open a database read-only when you alternate a standby database between read-only and recovery mode; note that these are mutually exclusive modes.

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;
```

---

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

---

**See Also:** For more information about the ALTER DATABASE statement, see the *Oracle8i SQL Reference.*

For more conceptual details about opening a database in read-only mode, see *Oracle8i Concepts.*

## Restricting Access to an Open Database

To place an instance in restricted mode, use the SQL statement ALTER SYSTEM with the ENABLE RESTRICTED SESSION clause. After placing an instance in restricted mode, you might want to kill all current user sessions before performing any administrative tasks. To lift an instance from restricted mode, use ALTER SYSTEM with the DISABLE RESTRICTED SESSION option.

For reasons why you might want to place an instance in restricted mode, see "Restricting Access to a Database at Startup" on page 3-5.

# Shutting Down a Database

The following sections describe shutdown procedures:

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

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
```

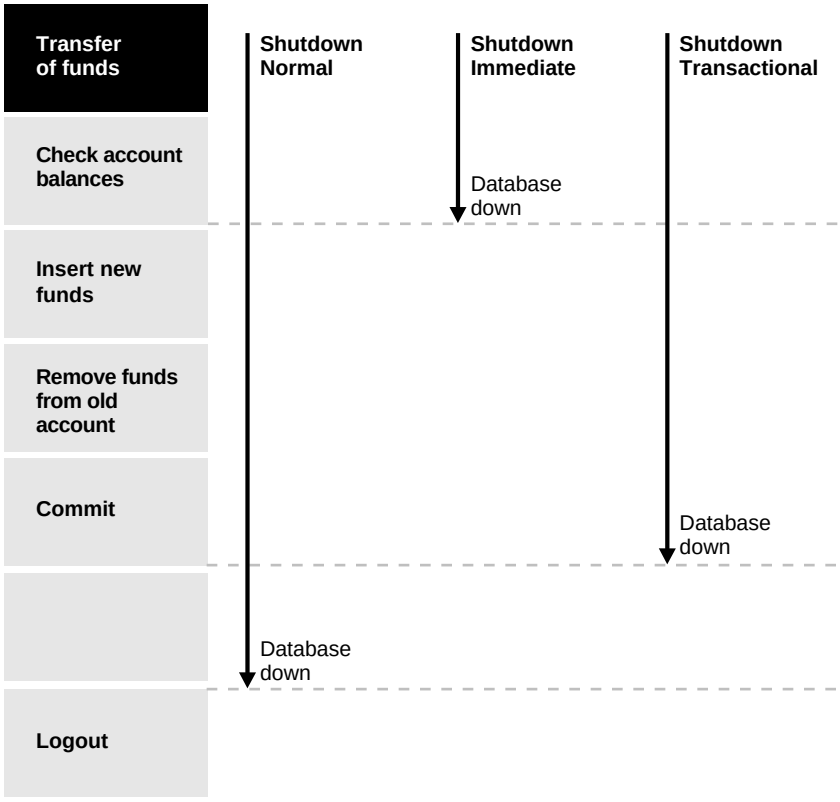
---

**Attention:** You cannot shut down a database if you are connected to the database via a multi-threaded server process.

---

To shut down a database and instance, first connect as SYSOPER or SYSDBA. Figure 3–1 shows the sequence of events when the different SHUTDOWN commands are entered during a transfer of funds from one bank account to another.

***Figure 3–1 Sequence of Events During Different Types of SHUTDOWN.***




## Shutting Down with the NORMAL Option

Normal database shutdown proceeds with the following conditions:

- No new connections are allowed after the statement is issued.
- Before the database is shut down, Oracle waits for all currently connected users to disconnect from the database.
- The next startup of the database will not require any instance recovery procedures.

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

```
SHUTDOWN NORMAL;
```

## Shutting Down with the IMMEDIATE Option

Use immediate database shutdown only in the following situations:

- A power shutdown is going to occur soon.
- The database or one of its applications is functioning irregularly.

Immediate database shutdown proceeds with the following conditions:

- Any uncommitted transactions are rolled back. (If long uncommitted transactions exist, this method of shutdown might not complete quickly, despite its name.)
- Oracle does not wait for users currently connected to the database to disconnect; Oracle implicitly rolls back active transactions and disconnects all connected users.
- The next startup of the database will not require any instance recovery procedures.

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

```
SHUTDOWN IMMEDIATE;
```

---

**Note:** The SHUTDOWN IMMEDIATE statement disconnects all existing idle connections and shuts down the database. If, however, you have submitted processes (for example, inserts, selects or updates) that are awaiting results, the SHUTDOWN TRANSACTIONAL statement allows the process to complete before disconnecting.

---

## Shutting Down with the TRANSACTIONAL Option

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

```
SHUTDOWN TRANSACTIONAL;
```

After submitting this statement, no client can start a new transaction on this instance. If clients attempt to start a new transaction, they are disconnected. 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 Option

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

- The database or one of its applications is functioning irregularly *and* neither 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.

Aborting an instance shuts down a database and yields the following results:

- Current client SQL statements being processed by Oracle are immediately terminated.
- Uncommitted transactions are not rolled back.
- Oracle does not wait for users currently connected to the database to disconnect; Oracle implicitly disconnects all connected users.
- The next startup of the database *will* require instance recovery procedures.

If *both* the normal and immediate shutdown options do not work, abort the current database instance immediately by issuing the SHUTDOWN command with the ABORT option:

```
SHUTDOWN ABORT;
```

## Suspending and Resuming a Database

The ALTER SYSTEM SUSPEND statement suspends a database by halting all I/O to datafiles (file header and file data) and control files, thus allowing a database to be backed up without I/O interference. When the database becomes suspended all

preexisting I/O operations will complete and any new database accesses will be in a queued state.

The suspend command suspends the database, and is not specific to an instance. Therefore, in an OPS environment, if the suspend command is entered on one system, then internal locking mechanisms will propagate the halt request across instances, thereby quiescing all active instances in a given cluster. However, do not start a new instance while you suspend another instance, since the new instance will not be suspended.

Use the ALTER SYSTEM RESUME statement to resume normal database operations. Note that you can specify the SUSPEND and RESUME 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 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. For details about backing up a database using the database suspend/resume feature, see *Oracle8i Backup and Recovery Guide.*

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

---

**WARNING: 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
```

# Using Initialization Parameter Files

The following sections include information about how to use initialization parameter files:

- The Sample Initialization Parameter File
- The Number of Initialization Parameter Files
- The Location of the Initialization Parameter File in Distributed Environments

To start an instance, Oracle must read an *initialization parameter file*, which is a text file containing a list of instance configuration parameters. Often, although not always, this file is named INIT.ORA or INIT*sid*.ORA, where *sid* is operating system specific.

---

**Note:** If you are using Oracle Enterprise Manager, see the *Oracle Enterprise Manager Administrator's Guide* for information about using stored configurations as an alternative to the initialization parameter file.

---

You can edit parameter values in a parameter file with a basic text editor; however, editing methods are operating system specific. Oracle treats string literals defined for National Language Support (NLS) parameters in the file as if they are in the database character set.

**See Also:** For more information about initialization parameter files specific to your installation, see your operating system-specific Oracle documentation.

A description for every initialization parameter is contained in the *Oracle8i Reference*.

## The Sample Initialization Parameter File

A sample parameter file (INIT.ORA or INIT*sid*.ORA) is included in the Oracle distribution set. This sample file's parameters are adequate for initial installations of an

Oracle database. After your system is operating and you have some experience with Oracle, you will probably want to change some parameter values.

> **See Also:** For more information about optimizing a database's performance using the initialization parameter file, see *Oracle8i Designing and Tuning for Performance*.

## The Number of Initialization Parameter Files

Each Oracle database has at least one initialization parameter file that corresponds only to that database. This way, database-specific parameters such as DB_NAME and CONTROL_FILES in a given file always pertain to a particular database. It is also possible to have several different initialization parameter files for a single database. For example, you can have several different parameter files for a single database so you can optimize the database's performance in different situations.

## The Location of the Initialization Parameter File in Distributed Environments

The client you use to access the database must be able to read a database's initialization parameter file to start a database's instance. Therefore, always store a database's parameter file on the computer executing the client.

In non-distributed processing installations, the same computer executes Oracle and the client. This computer already has the parameter file stored on one of its disk drives. In distributed processing installations, however, local client workstations can administer a database stored on a remote machine. In this type of configuration, the local client machines must each store a copy of the parameter file for the corresponding databases.

> **See Also:** For more information about using administering Oracle in a distributed environment, see *Oracle8i Distributed Database Systems*.

# Part II

# Oracle Server Configuration

Part II describes Oracle server processes and control files which comprise the structure of the Oracle database server and support its operation. It includes the following chapters

- Chapter 4, "Managing Oracle Processes"
- Chapter 5, "Managing Control Files"
- Chapter 6, "Managing the Online Redo Log"
- Chapter 7, "Managing Archived Redo Logs"
- Chapter 8, "Managing Job Queues"

# 4

# Managing Oracle Processes

This chapter describes how to manage the processes of an Oracle instance, and includes the following topics:

- Server Processes
- Configuring Oracle for the Multi-Threaded Server
- Tracking Oracle Background Processes
- Managing Processes for the Parallel Query Option
- Managing Processes for External Procedures
- Terminating Sessions

# Server Processes

Oracle creates server processes to handle the requests of user processes connected to an instance. A server process can be either a *dedicated server process*, where one server process services only one user process, or it can be a shared server process, where a server process can service multiple user processes. *Shared server processes* are part of Oracle's *multi-threaded server(MTS)* architecture.

> **See Also:** For conceptual information about server processes, see *Oracle8i Concepts.*

## Dedicated Server Processes

Figure 4–1 illustrates how dedicated server processes works.

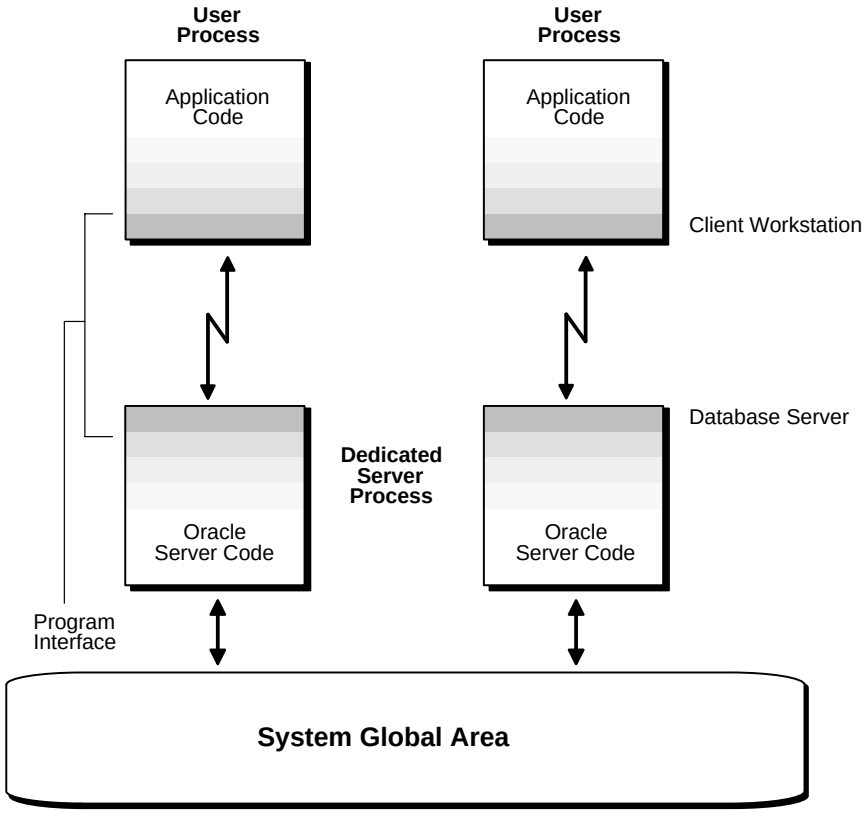
In general, it is better to be connected through a dispatcher to use a shared server process; it can be more efficient because it keeps the number of processes required for the running instance low. In the following situations, however, users and administrators should explicitly connect to an instance 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 Enterprise Manager to start up, shut down, or perform media recovery on a database
- To use Recovery Manager to back up, restore or recover a database

To request a dedicated server connection when the server is configured for MTS, users must connect using a NET8 *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:** For a complete description of the Net8 net service name, see the *Net8 Administrator's Guide* and your operating system-specific Oracle documentation.

***Figure 4–1 Oracle Dedicated Server Processes***

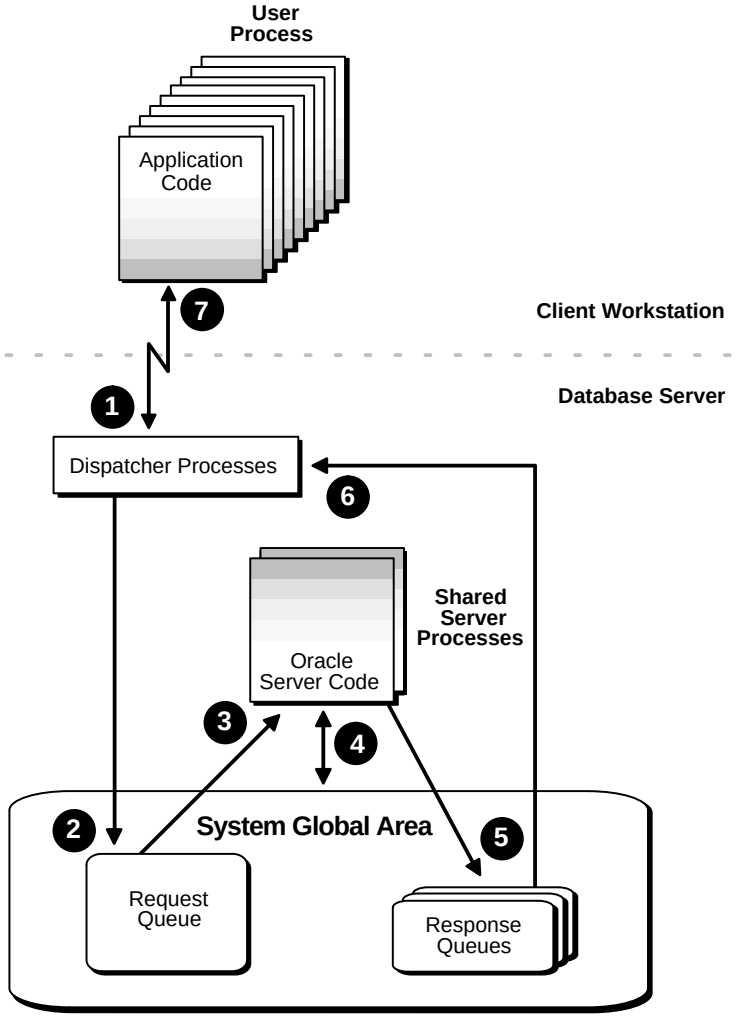



## Multi-Threaded Server Processes

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

The *multi-threaded server* architecture eliminates the need for a dedicated server process for each connection (see Figure 4–2).

***Figure 4–2 Oracle Multi-Threaded Server Processes***




In a multi-threaded server (MTS) configuration, client user processes connect to a dispatcher. A dispatcher can support multiple client connections concurrently. Each client connection is bound to a virtual circuit. A virtual circuit 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 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 MTS architecture over the dedicated server model is the reduction of system resources, enabling the support of an increased number of users.

The multi-threaded server architecture requires Net8. User processes targeting the multi-threaded server must connect through Net8, even if they are on the same machine as the Oracle instance.

There are several things that must be done to configure your system for MTS. These are discussed in the following section.

> **See Also:** To learn more about MTS, including additional features such as connection pooling, see the *Net8 Administrator's Guide*.

# Configuring Oracle for the Multi-Threaded Server

MTS is activated by the setting of database initialization parameters, and requires that a Net8 listener process be active. This section discusses the setting of initialization parameters and how to alter them. For specifics relating to Net8, see the *Net8 Administrator's Guide*.

## Initialization Parameters for MTS

The initialization parameters controlling MTS are:

| Parameter | Description |
|---|---|
| **Required** | |
| MTS_DISPATCHERS | Configures dispatcher processes in the multi-threaded server architecture. |
| **Optional. If you do not specify the following parameters, Oracle selects appropriate defaults.** | |
| MTS_MAX_DISPATCHERS | Specifies the maximum number of dispatcher processes allowed to be running simultaneously. |
| MTS_SERVERS | Specifies the number of server processes that you want to create when an instance is started up. |
| MTS_MAX_SERVERS | Specifies the maximum number of shared server processes allowed to be running simultaneously. |

| Parameter | Description |
|---|---|
| MTS_CIRCUITS | Specifies the total number of virtual circuits that are available for inbound and outbound network sessions. |
| MTS_SESSIONS | Specifies the total number of MTS user sessions to allow. Setting this parameter enables you to reserve user sessions for dedicated servers. |
| **Other initialization parameters affected by MTS that may require adjustment.** | |
| LARGE_POOL_SIZE | Specifies the size in bytes of the large pool allocation heap. MTS may force the default value to be set too high causing performance problems or the database won't start. See the *Oracle8i Reference* for further details. |
| SESSIONS | Specifies the maximum number of sessions that can be created in the system. May need to be adjusted for MTS. See the *Oracle8i Reference* for further details. |

**See Also:** For detailed descriptions of settings and defaults for these parameters see the *Net8 Administrator's Guide* and *Oracle8i Reference.*

## MTS_DISPATCHERS: Setting the Initial Number of Dispatchers

The number of dispatcher processes started at instance startup is controlled by the MTS_DISPATCHERS initialization parameter. At least one dispatcher process is created for every communication protocol specified in the parameter. You can specify multiple MTS_DISPATCHERS parameters in the initialization file, but they must be adjacent to each other. Internally, Oracle will assign an INDEX value to each MTS_MISPATCHERS parameter, so that you can later specifically refer to that MTS_DISPATCHERS parameter in an ALTER SYSTEM statement.

The appropriate number of dispatcher processes for each instance depends upon the performance you want from your database, the host operating system's limit on the number of connections per process (which is operating system dependent), and the number of connections required per network protocol. The instance must be able to provide as many connections as there are concurrent users on the database system. After instance startup, you can start more dispatcher processes if needed. This is discussed in "Adding and Removing Dispatcher Processes" on page 4-8.

A ratio of 1 dispatcher for every 1000 connections works well for typical systems, but round up to the next integer. For example, if you anticipate 1500 connections at peak time, then you may want to configure 2 dispatchers. Being too aggressive in

your estimates is not beneficial, because configuring too many dispatchers can degrade performance. Use this ratio as your guide, but tune according to your particular circumstances.

The following are some examples of setting the MTS_DISPATCHERS initialization parameter.

***Example 4–1***

To force the IP address used for the dispatchers, enter the following:

```
MTS_DISPATCHERS="(ADDRESS=(PROTOCOL=TCP)\
     (HOST=144.25.16.201))(DISPATCHERS=2)"
```

This will start two dispatchers that will listen in on the IP address, which must be a valid IP address for the host that the instance is on, which must be a card that is accessible to the dispatchers.

***Example 4–2***

To force the exact location of dispatchers, add the PORT as follows:

```
MTS_DISPATCHERS="(ADDRESS=(PROTOCOL=TCP)(HOST=144.25.16.201)(PORT=5000))"
MTS_DISPATCHERS="(ADDRESS=(PROTOCOL=TCP)(HOST=144.25.16.201)(PORT=5001))"
```

## MTS_SERVERS: Setting the Initial Number of Shared Servers

The MTS_SERVERS parameter specifies the number of server processes that you want to create when an instance is started up. Oracle dynamically adjusts the number of shared server processes based on the length of the request queue. The number of shared server processes that can be created ranges between the values of the initialization parameters MTS_SERVERS and MTS_MAX_SERVERS.

Typical systems seem to stabilize at a ratio of one shared server for every ten connections. For OLTP applications, the connections-to-servers ratio could be higher, because the rate of requests could be low, or the ratio of server usage to request could be low. 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.

Set MTS_MAX_SERVERS to a reasonable value based on your application. Oracle provides good defaults for MTS_SERVERS and MTS_MAX_SERVERS for a typical configuration, but the optimal values for these settings can be different depending upon your application.

> **Note:** On Windows NT, take care when setting MTS_MAX_SERVERS to a high value: each server is a thread in a common process.

MTS_MAX_SERVERS is a static initialization parameter, so you cannot change it without shutting down your database. However, MTS_SERVERS is a dynamic initialization parameter and can be changed using an ALTER SYSTEM statement.

## Modifying Dispatcher and Server Processes

You can modify the settings for MTS_DISPATCHERS and MTS_SERVERS dynamically when an instance is running. If you have the ALTER SYSTEM privilege, you can use the ALTER SYSTEM statement to make such changes.

> **See Also:** For information about the ALTER SYSTEM statement, see the *Oracle8i SQL Reference.*

### Changing the Minimum Number of Shared Server Processes

After starting an instance, you can change the minimum number of shared server processes by using the SQL statement ALTER SYSTEM. Oracle will eventually terminate servers that are idle when there are more shared servers than the minimum limit you specify.

If you set MTS_SERVERS to 0, Oracle will terminate all current servers when they become idle and will not start any new servers until you increase MTS_SERVERS. Thus, setting MTS_SERVERS to 0 may be used to effectively disable the multi-threaded server.

The following statement dynamically sets the number of shared server processes to two:

```
ALTER SYSTEM SET MTS_SERVERS = 2
```

### Adding and Removing Dispatcher Processes

You can control the number of dispatcher processes in the instance. If the V$QUEUE, V$DISPATCHER and V$DISPATCHER_RATE views indicate that the load on the dispatcher processes is consistently high, starting additional dispatcher processes to route user requests may improve performance. In contrast, if the load on dispatchers is consistently low, reducing the number of dispatchers may improve performance.

To change the number of dispatcher processes, use the SQL statement ALTER SYSTEM.

You can start new dispatcher processes for an existing MTS_DISPATCHERS value, or you may add new MTS_DISPATCHERS values. You can add dispatchers up to the limit specified by MTS_MAX_DISPATCHERS.

If you reduce the number of dispatchers for a particular MTS dispatcher value, the dispatchers are not immediately removed. Rather, as users disconnect, Oracle is eventually able to terminate dispatchers down to the limit you specify in MTS_DISPATCHERS.

The following statement dynamically changes the number of dispatcher processes for the TCP/IP protocol to 5, and adds dispatcher processes for the SPX protocol. There was no MTS_DISPATCHES initialization parameter for the SPX protocol (the only MTS dispatchers parameter was the one for the TCP protocol), so this statement effectively adds one.

```
ALTER SYSTEM
SET MTS_DISPATCHERS =
'(PROTOCOL=TCP)(DISPATCHERS=5) (INDEX=0)',
'(PROTOCOL=SPX)(DISPATCHERS=2) (INDEX=1)';
```

If there are currently fewer than 5 dispatcher processes for TCP, Oracle creates new ones. If there are currently more than 5, Oracle terminates some of them after the connected users disconnect.

---

**Note:** The INDEX keyword can be used to identify which MTS_DISPATCHERS parameter to modify. The INDEX value can range from 0 to n, where n is one less than the defined number of MTS_DISPATCHER parameters. If your ALTER SYSTEM statement specifies an INDEX value equal to n+1, a new MTS_DISPATCHERS parameter is added. To identify the index number assigned to an MTS_DISPATCHERS parameter, query the CONF_INDX value in the V$DISPATCHER view.

---

### Shutting Down Specific Dispatcher Processes

It is possible to shut down specific dispatcher processes. To identify the name of the specific dispatcher process to be shut down, use the V$DISPATCHER dynamic performance view.

```
SELECT name, network FROM v$dispatcher;
```

```
NAME  NETWORK
----  -------------------------------------------------------------------
D000  (ADDRESS=(PROTOCOL=tcp)(HOST=rbaylis-hpc.us.oracle.com)(PORT=3499))
D001  (ADDRESS=(PROTOCOL=tcp)(HOST=rbaylis-hpc.us.oracle.com)(PORT=3531))
D002  (ADDRESS=(PROTOCOL=tcp)(HOST=rbaylis-hpc.us.oracle.com)(PORT=3532))
```

Each dispatcher is uniquely identified by a name of the form Dnnn.

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 Oracle 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 database links terminated before shutting down.

## Monitoring MTS

The following are useful views for obtaining information about your MTS 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_RATE | Provides rate statistics for the dispatcher processes. |
| V$QUEUE | Contains information on the multi-thread message queues. |
| V$SHARED_SERVER | Contains information on the shared server processes. |
| V$CIRCUIT | Contains information about virtual circuits, which are user connections to the database through dispatchers and servers. |
| V$MTS | Contains information for tuning MTS. |
| V$SGA | Contains size information about various system global area (SGA) groups. May be useful when tuning MTS. |
| V$SGASTAT | Detailed statistical information about the SGA, useful for tuning. |

| View | Description |
|---|---|
| V$SHARED_POOL_RESERVED | Lists statistics to help tune the reserved pool and space within the shared pool. |

**See Also:** All of these views are described in detail in the *Oracle8i Reference.*

For specific information about monitoring and tuning the multi-threaded server, see *Oracle8i Designing and Tuning for Performance*.

# Tracking Oracle Background Processes

An Oracle instance can have many background processes. This section presents general methods of monitoring and tracking these processes, and includes the following topics:

- What are the Oracle Background Processes
- Monitoring the Processes of an Oracle Instance
- Trace Files, the Alert Log, and Background Processes

**See Also:** For a more detailed description of the background processes, see *Oracle8i Concepts.*

## What are the Oracle Background Processes

Briefly, these are the Oracle background processes.

- Database writer (DBWn)

  The Database Writer writes modified blocks from the database buffer cache to the datafiles. Although one database writer process (DBW0) is sufficient for most systems, you can configure additional processes (DBW1 through DBW9) to improve write performance for a system that modifies data heavily. The initialization parameter DB_WRITER_PROCESSES specifies the number of DBWn processes.

- 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), and LGWR

writes the redo log entries sequentially into an online redo log file. If the database has a multiplexed redo log, LGWR writes the redo log entries to a group of online redo log files. See Chapter 6, "Managing the Online 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 DBWn; this event is called a checkpoint. The checkpoint process is responsible for signalling DBWn 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 crash recovery when a failed instance starts up again. In a multiple instance system (one that uses Oracle Parallel Server), 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 crash 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.

  SMON also coalesces free extents within the database's dictionary-managed tablespaces to make free space contiguous and easier to allocate (see "Coalescing Free Space in Dictionary-Managed Tablespaces" on page 9-12).

- 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 dispatcher (see below) and server processes and restarts them if they have failed. For information about PMON, see *Oracle8i Concepts.*

- Archiver (ARCn)

  One or more archiver processes copy the online redo log files to archival storage when they are full or a log switch occurs. Archiver processes are the subject of Chapter 7, "Managing Archived Redo Logs".

- Recoverer (RECO)

  The recoverer process is used to resolve distributed transactions that are pending due to 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 *Oracle8i Distributed Database Systems.*

- Dispatcher (Dnnn)

  Dispatchers are optional background processes, present only when the multi-threaded server (MTS) configuration is used. MTS was discussed previously in "Configuring Oracle for the Multi-Threaded Server" on page 4-5.

- Lock (LCK0)

  In an Oracle Parallel Server, a lock process provides inter-instance locking. For information about this background process, see *Oracle8i Parallel Server Setup and Configuration Guide*, *Oracle8i Parallel Server Administration, Deployment, and Performance*, and *Oracle8i Parallel Server Concepts.*

- Job Queue (SNPn)

  In a distributed database configuration, up to 36 job queue processes can automatically refresh table snapshots. They wake up periodically and refresh any snapshots that are scheduled to be refreshed. For information about creating and refreshing snapshots, see *Oracle8i Replication*, *Oracle8i Replication Management API Reference*, and *Getting Started with Replication Manager.*

  Another function of these processes is to propagate queued messages to queues on other databases. See *Oracle8i Application Developer's Guide - Advanced Queuing*) for information on propagating queued messages.

  These processes also execute job requests created by the DBMS_JOBS package. This is the subject of Chapter 8, "Managing Job Queues".

  Unlike most Oracle background processes, if an SNP process fails, it does not cause instance failure.

- Queue Monitor (QMNn)

  The queue monitor process is an optional background process for Oracle Advanced Queuing. You can configure up to 10 queue monitor processes. Like the SNPn processes, if these processes fail, they do not cause instance failure. The AQ_TM_PROCESSES initialization parameter specifies the creation of queue monitor processes at instance startup. For information about Advanced Queuing, see *Oracle8i Application Developer's Guide - Advanced Queuing.*

## Monitoring the Processes of an Oracle Instance

This section lists some of the views which you can use to monitor an Oracle instance. These views are more general in their scope. There are other views, more specific to a process, which are discussed in the section of this book where the process is described. Also presented are views and scripts for monitoring the status of locks.

> **See Also:** All of these views are described in detail in the *Oracle8i Reference.*
>
> *Oracle8i Designing and Tuning for Performance* provides information for resolving performance problems and conflicts which may be revealed through the monitoring of these views.

### Process and Session Views

These views provide process and session specific information.

| 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 | This view 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, and more operations are added for every Oracle release. |
| 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 per SQL string. Also provides statistics about SQL statements that are in memory, parsed, and ready for execution. |
| V$LATCH | Contains statistics for non-parent latches and summary statistics for parent latches. |

### Monitoring Locks

The UTLLOCKT.SQL script displays a simple character lock wait-for graph in tree-structured fashion. Using an ad hoc query tool, such as SQL*Plus, the script prints the sessions in the system that are waiting for locks and the corresponding blocking locks. The location of this script file is operating system dependent; see your operating system-specific Oracle documentation. A second script, CATBLOCK.SQL, creates the lock views that UTLLOCKT.SQL needs, so you must run it before running UTLLOCKT.SQL.

The following view can be used for monitoring locks.

| View | Description |
|---|---|
| V$LOCK | Lists the locks currently held by the Oracle server and outstanding requests for a lock or latch. |

## Trace Files, the Alert Log, and Background Processes

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, while other information is for Oracle Worldwide Support. Trace file information is also used to tune applications and instances.

The *alert log* is a special trace file. The alert log of a database is a chronological log of messages and errors, which includes the following:

- All internal errors (ORA-600), block corruption errors (ORA-1578), and deadlock errors (ORA-60) that occur
- Administrative operations, such as CREATE / ALTER / DROP DATABASE / TABLESPACE / ROLLBACK SEGMENT SQL statements and STARTUP, SHUTDOWN, and ARCHIVE LOG
- Several messages and errors relating to the functions of shared server and dispatcher processes
- Errors occurring during the automatic refresh of a snapshot
- The values of all initialization parameters at the time the database and instance start

Oracle uses the alert log to keep a log of these special operations as an alternative to displaying such information on an operator's console (although many systems

display information on the console). If an operation is successful, a "completed" message is written in the alert log, along with a timestamp.

### Using the Trace Files

You can periodically check the alert log and other trace files of an instance to see if the background processes have encountered errors. For example, when the Log Writer process (LGWR) cannot write to a member of a group, an error message indicating the nature of the problem is written to the LGWR trace file and the database's alert log. If you see such error messages, a media or I/O problem has occurred, and should be corrected immediately.

Oracle also writes values of initialization parameters to the alert log, in addition to other important statistics. For example, when you shut down an instance normally or immediately (but do not abort), Oracle writes the highest number of sessions concurrently connected to the instance, since the instance started, to the alert log. You can use this number to see if you need to upgrade your Oracle session license.

### Specifying the Location of Trace Files

All trace files for background processes and the alert log are written to the destination specified by the initialization parameter BACKGROUND_DUMP_DEST. All trace files for server processes are written to the destination specified by the initialization parameter USER_DUMP_DEST. The names of trace files are operating system specific, but usually include the name of the process writing the file (such as LGWR and RECO).

### 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. This limit is set as a 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 Oracle continues to append to the file. You can safely delete the alert log while the instance is running, although you might want to make an archived copy of it first.

### Controlling When Oracle Writes to Trace Files

Background processes always write to a trace file when appropriate. In the case of the LGWR background process, it is possible, through an initialization parameter, to control the amount and type of trace information that is produced. This is described in"Controlling Trace Output Generated by the Archivelog Process" on page 7-25. Other background processes do not have this flexibility.

Trace files are written on behalf of server processes (in addition to being written to during internal errors) only if the initialization parameter SQL_TRACE is set to TRUE. Regardless of the current value of SQL_TRACE, each session can enable or disable trace logging on behalf of the associated server process by using the SQL statement ALTER SESSION with the SET SQL_TRACE parameter.

```
ALTER SESSION SET SQL_TRACE TRUE;
```

For the multi-threaded server, each session using a dispatcher is routed to a shared server process, and trace information is written to the server's 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's trace files. Because the SQL trace facility for server processes can cause significant system overhead, enable this feature only when collecting statistics.

> **See Also:** For information about the names of trace files, see your operating system-specific Oracle documentation.
>
> For information about initialization parameters that control the writing to trace files, see the *Oracle8i Reference.*

# Managing Processes for the Parallel Query Option

This section describes how, with the parallel query option, Oracle can perform parallel processing. In this configuration Oracle can divide the work of processing certain types of SQL statements among multiple query server processes. The following topics are included:

- Managing the Query Servers
- Variations in the Number of Query Server Processes

> **See Also:** For more information about the parallel query option, see *Oracle8i Designing and Tuning for Performance* and *Oracle8i Concepts.*

## Managing the Query Servers

When you start your instance, the Oracle database server creates a pool of query server processes available for any query coordinator. Specify the number of query server processes that Oracle creates at instance startup via the initialization parameter PARALLEL_MIN_SERVERS.

Query server processes remain associated with a statement throughout its execution phase. When the statement is completely processed, its query server processes become available to process other statements. The query coordinator process returns any resulting data to the user process issuing the statement.

### Variations in the Number of Query Server Processes

If the volume of SQL statements processed concurrently by your instance changes drastically, the Oracle database server automatically changes the number of query server processes in the pool to accommodate this volume.

If this volume increases, then Oracle automatically creates additional query server processes to handle incoming statements. The maximum number of query server processes for your instance is specified by the initialization parameter PARALLEL_MAX_SERVERS.

If this volume subsequently decreases, Oracle terminates a query server process if it has been idle for the period of time specified by the initialization parameter PARALLEL_SERVER_IDLE_TIME. Oracle does not reduce the size of the pool below the value of PARALLEL_MIN_SERVERS, no matter how long the query server processes have been idle.

If all query servers in the pool are occupied and the maximum number of query servers has been started, a query coordinator processes the statement sequentially.

> **See Also:** For more information about monitoring an instance's pool of query servers and determining the appropriate values of the initialization parameters, see *Oracle8i Designing and Tuning for Performance*.

## Managing Processes for External Procedures

You may have shared libraries of C functions that you wish to call from an Oracle database. This section describes how to set up an environment for calling those external procedures.

---

**Note:** Although not required, it is recommended that you perform these tasks during installation.

---

The database administrator grants execute privileges for appropriate libraries to application developers, who in turn create external procedures and grant execute privilege on the specific external procedures to other users.

## Setting up an Environment for Calling External Routines

Follow these steps to set up an environment for calling external routines.

1. Edit the `tnsnames.ora` file by adding an entry that enables you to connect to the listener process (and subsequently, the EXTPROC process).
2. Edit the `listener.ora` file by adding an entry for the "external procedure listener."
3. Start a separate listener process to exclusively handle external procedures.
4. The EXTPROC process spawned by the listener inherits the operating system privileges of the listener, so Oracle strongly recommends that you restrict the privileges for the separate listener process. The process should not have permission to read or write to database files, or the Oracle server address space.

   Also, the owner of this separate listener process should not be ORACLE (which is the default owner of the server executable and database files).
5. If not already installed, place the EXTPROC executable in `$ORACLE_HOME/bin`.

Be aware that 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). These symbols are not resolved and can cause your external procedure to fail.

## Sample Entry in `tnsnames.ora`

The following is a sample entry for the external procedure listener in `tnsnames.ora`.

```
extproc_connection_data = (DESCRIPTION =
                             (ADDRESS = (PROTOCOL=IPC)
                                        (KEY=extproc_key)
                              )
                            (CONNECT_DATA = (SID = extproc_agent)
                          )
```

In this example, and all callouts for external procedures, the entry name EXTPROC_CONNECTION_DATA cannot be changed; it must be entered exactly as it appears

here. The key you specify, in this case EXTPROC_KEY, must match the KEY you specify in the `listener.ora` file. Additionally, the SID name you specify, in this case EXTPROC_AGENT, must match the SID_NAME entry in the `listener.ora` file.

### Sample Entry in `listener.ora`

The following is a sample entry for the external procedure in `listener.ora`.

```
EXTERNAL_PROCEDURE_LISTENER =

(ADDRESS_LIST =
    (ADDRESS = (PROTOCOL=ipc)
               (KEY=extproc_key)
     )
)
...
SID_LIST_EXTERNAL_PROCEDURE_LISTENER =

(SID_LIST =
     (SID_DESC = (SID_NAME=extproc_agent)
                 (ORACLE_HOME=/oracle)
                 (PROGRAM=extproc)
      )
)
```

In this example, the PROGRAM must be EXTPROC, and cannot be changed; it must be entered exactly as it appears in this example. The SID_NAME must match the SID name in the `tnsnames.ora` file. The ORACLE_HOME must be set to the directory where your Oracle software is installed. The EXTPROC executable must reside in `$ORACLE_HOME/bin`.

> **See Also:** For more information about external procedures, see the *PL/SQL User's Guide and Reference.*
>
> For more information about the `tnsnames.ora` and `listener.ora` files, see the *Net8 Administrator's Guide.*

## Terminating Sessions

In some situations, you might want 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 includes the following topics:

- Identifying Which Session to Terminate
- Terminating an Active Session
- Terminating an Inactive Session

When a session is terminated, the session's transaction is rolled back and resources (such as locks and memory areas) held by the session are immediately released and available to other sessions.

Terminate a current session using the SQL statement ALTER SYSTEM KILL SESSION.

The following statement terminates the session whose SID 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's index number and serial number. To identify the index (SID) and serial number of a session, query the V$SESSION dynamic performance view.

The following query identifies all sessions for the user JWARD:

```
SELECT sid, serial#
  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. A session is INACTIVE if it is not making a SQL call to Oracle.

> **See Also:** For a description of the status values for a session, see *Oracle8i Reference.*

## Terminating an Active Session

If a user session is making a SQL call to Oracle (ACTIVE status) when it is terminated, 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 returns the following message:

```
ORA-01012: not logged on
```

If an active session cannot be interrupted (it is performing network I/O or rolling back a transaction), the 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 (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, STATUS 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, 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.
```

# 5

# Managing Control Files

This chapter explains how to create and maintain the control files for your database and includes the following topics:

# What is a Control File?

Every Oracle database has a *control file*. A control files records the physical structure of the database and contains:

- The database name
- Names and locations of associated databases and online redo log files
- The timestamp of the database creation
- The current log sequence number
- Checkpoint information

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 must be created during database creation. On some operating systems, Oracle creates multiple copies. You should create two or more copies of the control file during database creation. You might also need to 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 includes the following topics:

- Name Control Files
- Multiplex Control Files on Different Disks
- Place Control Files Appropriately
- Manage the Size of Control Files

## Name Control Files

Assign control file names via the CONTROL_FILES initialization parameter in the database's initialization parameter file. CONTROL_FILES specifies one or more names of control files separated by commas. The instance startup procedure recognizes and opens all the listed files. The instance writes to and maintains all listed control files during database operation.

> **See Also:** For a description of the CONTROL_FILES initialization parameter, see *Oracle8i Reference*.

## Multiplex Control Files on Different Disks

Every Oracle database should have at least two control files, each stored on a different 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 an intact copy of the control file and the instance can be restarted; no media recovery is required.

The following describes the behavior of multiplexed control files:

- Two or more filenames are listed for the initialization parameter CONTROL_FILES in the database's initialization parameter file. Oracle writes to both files
- The first file listed in the CONTROL_FILES parameter is the only file read by the Oracle Server during database operation.
- If any of the control files become unavailable during database operation, the instance becomes inoperable and should be aborted.

The only disadvantage of having multiple control files is that all operations that update the control files (such as adding a datafile or checkpointing the database) can take slightly longer. However, this difference is usually insignificant (especially for operating systems that can perform multiple, concurrent writes) and does not justify using only a single control file.

---

**Attention:** Oracle strongly recommends that your database has a minimum of two control files on different disks.

---

## Place Control Files Appropriately

Each copy of a control file should be stored on a different disk drive. Furthermore, a control file copy should be stored on every disk drive that stores members of online redo log groups, if the online redo log is multiplexed. By storing control files in these locations, you minimize the risk that all control files and all groups of the online redo log will be lost in a single disk failure.

## Manage the Size of Control Files

The main determinants of a control file's size 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:** The maximum control file size is operating system specific. See your operating system-specific Oracle documentation for more information.

For the syntax of the CREATE DATABASE statement, see the *Oracle8i SQL Reference*.

# Creating Control Files

This section describes ways to create control files, and includes the following topics:

- Creating Initial Control Files
- Creating Additional Control File Copies, and Renaming and Relocating Control Files
- New Control Files
- Creating New Control Files

## Creating Initial Control Files

You create the initial control files of an Oracle database by specifying one or more control filenames in the CONTROL_FILES initialization parameter in the initialization parameter file used during database creation. The filenames specified in CONTROL_FILES should be fully specified. Filename specification is operating system-specific.

If files with the specified names currently exist at the time of database creation, you must specify the CONTROLFILE REUSE parameter in the CREATE DATABASE statement, or else an error occurs. Also, if the size of the old control file differs from that of the new one, you cannot use the REUSE option. The size of the control file changes between some releases of Oracle, 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.

If you do not specify files for CONTROL_FILES before database creation, Oracle creates a control file and uses a default filename. The default name is also operating system-specific.

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:** For more information about specifying control files, see your operating system-specific Oracle documentation.

## Creating Additional Control File Copies, and Renaming and Relocating Control Files

You add a new control file by copying an existing file to a new location and adding the file's 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's name in the control file list.

In both cases, to guarantee that control files do not change during the procedure, shut down the instance before copying the control file.

### To Multiplex or Move Additional Copies of the Current Control Files

1. Shut down the database.
2. Copy an existing control file to a different location, using operating system commands.
3. Edit the CONTROL_FILES parameter in the database's initialization parameter file to add the new control file's name, or to change the existing control filename.
4. Restart the database.

## New Control Files

You can create a new control file for a database using the CREATE CONTROLFILE statement. This is necessary 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 one of the permanent database settings originally specified in the CREATE DATABASE statement, *including the database's name*, MAXLOGFILES, MAXLOGMEMBERS, MAXLOGHISTORY, MAXDATAFILES, and MAXINSTANCES.

  For example, you might need to change a database's name if it conflicts with another database's name in a distributed environment. Or, as another example, you might need to change one of the previously mentioned parameters if the original setting is too low.

The following statement creates a new control file for the PROD database (formerly a database that used a different database name):

```
CREATE CONTROLFILE
   SET DATABASE prod
   LOGFILE GROUP 1 ('logfile1A', 'logfile1B') SIZE 50K,
    GROUP 2 ('logfile2A', 'logfile2B') SIZE 50K
   NORESETLOGS
   DATAFILE 'datafile1' SIZE 3M, 'datafile2' SIZE 5M
 MAXLOGFILES 50
 MAXLOGMEMBERS 3
 MAXDATAFILES 200
 MAXINSTANCES 6
 ARCHIVELOG;
```

**WARNING: The CREATE CONTROLFILE statement can potentially damage specified datafiles and online redo log files; omitting a filename can cause loss of the data in that file, or loss of access to the entire database. Employ caution when using this statement and be sure to follow the steps in the next section.**

**See Also:** FFor information on changing the global database name and the DB_DOMAIN initialization parameter, see *Oracle8i Distributed Database Systems.*

## Creating New Control Files

This section provides step-by-step instructions for creating new control files.

### To Create New Control Files

1. Make a list of all datafiles and online redo log files of the database.

   If you followed the recommendations for database backups, you should already have a list of datafiles and online redo log files that reflect the current structure of the database.

   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 online 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 with normal priority, if possible. Use the IMMEDIATE or ABORT options only as a last resort.

3. Back up all datafiles and online redo log files of the database.

4. Start up an new instance, but do not mount or open the database.

5. Create a new control file for the database using the CREATE CONTROLFILE statement.

   When creating the new control file, select the RESETLOGS option if you have lost any online redo log groups in addition to the control files. In this case, you will need to recover from the loss of the redo logs (Step 8). You must also specify the RESETLOGS option if you have renamed the database. Otherwise, select the NORESETLOGS option.

6. Store a backup of the new control file on an offline storage device.

7. Edit the initialization parameter file of the database.

   Edit the initialization parameter file of the database to indicate all of the control files created in Step 5 and Step 6 (not including the backup control file) in the CONTROL_FILES parameter. If you are renaming the database, edit the DB_NAME parameter 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 option (Step 5), you can recover the database with complete, closed database recovery.

   If the new control file was created using the RESETLOGS option, 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.

9. Open the database.

   Open the database using one of the following methods:

   - If you did not perform recovery, open the database normally.
   - If you performed complete, closed database recovery in Step 8, start up the database.

- If you specified RESETLOGS when creating the control file, use the ALTER DATABASE statement, indicating RESETLOGS.

The database is now open and available for use.

**See Also:** See the *Oracle8i Backup and Recovery Guide* for more information about:

- Listing database files
- Backing up all datafiles and online redo log files of the database
- Recovering online or archived redo log files
- Closed database recovery

# Troubleshooting After Creating Control Files

After issuing the CREATE CONTROLFILE statement, you may encounter some common errors. This section describes the most common control file usage errors, and includes the following topics:



## 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 Oracle has detected inconsistencies between the data dictionary and the control file, such as a datafile that the data dictionary includes but the control file does not list.

If a datafile exists in the data dictionary but not in the new control file, Oracle 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.

In the following two cases only, the actual datafile corresponding to MISSING*nnnn* can be made accessible by renaming MISSING*nnnn* to point to it.

**Case 1**: The new control file was created using the CREATE CONTROLFILE statement with the NORESETLOGS option, thus allowing the database to be opened without using the RESETLOGS option. This would be possible only if all online redo logs are available.

**Case 2**: It was necessary to use the RESETLOGS option of the CREATE CONTROLFILE statement, thus forcing the database to be opened using the RESETLOGS option, but the actual datafile corresponding to MISSING*nnnn* was read-only or offline normal.

If, on the other hand, it was necessary to open the database using the RESETLOGS option, and MISSING*nnnn* corresponds to a datafile that was not read-only or offline normal, then the rename operation cannot be used to make the datafile accessible (since the datafile requires media recovery that is precluded by the results of RESETLOGS). In this case, the tablespace containing the datafile must be dropped.

In contrast, if a datafile indicated in the control file is not present in the data dictionary, Oracle removes references to it from the new control file. In both cases, Oracle includes an explanatory message in the alert log to let you know what it found.

### Handling Errors During CREATE CONTROLFILE

If Oracle 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 and repeat the procedure from Step 4, using the correct filenames.

## Dropping Control Files

You can drop control files from the database. For example, you might want to do so if the location of a control file is inappropriate. Remember that the database must have at least two control files at all times.

1. Shut down the database.
2. Edit the CONTROL_FILES parameter in the database's initialization parameter file to delete the old control file's name.
3. Restart the database.

**WARNING: 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.**

# 6

# Managing the Online Redo Log

This chapter explains how to manage the online redo log and includes the following topics:

- What Is the Online Redo Log?
- Planning the Online Redo Log
- Creating Online Redo Log Groups and Members
- Renaming and Relocating Online Redo Log Members
- Dropping Online Redo Log Groups and Members
- Forcing Log Switches
- Verifying Blocks in Redo Log Files
- Clearing an Online Redo Log File
- Listing Information about the Online Redo Log

> **See Also:** For more information about managing the online redo logs of the instances when using Oracle Parallel Server, see *Oracle8i Parallel Server Administration, Deployment, and Performance.*
>
> To learn how checkpoints and the redo log impact instance recovery, see *Oracle8i Designing and Tuning for Performance.*

# What Is the Online Redo Log?

The most crucial structure for recovery operations is the online redo log, which consists of two or more pre-allocated files that store all changes made to the database as they occur. Every instance of an Oracle database has an associated online redo log to protect the database in case of an instance failure.

**Note:** Oracle does not recommend backing up the online redo log.

## Redo Threads

Each database instance has its own online *redo log groups*. These online redo log groups, multiplexed or not, are called an instance's *thread* of online redo. In typical configurations, only one database instance accesses an Oracle database, so only one thread is present. When running the Oracle Parallel Server, however, two or more instances concurrently access a single database; each instance has its own thread.

This chapter describes how to configure and manage the online redo log when the Oracle Parallel Server is *not* used. Hence, the thread number can be assumed to be 1 in all discussions and examples of statements.

## Online Redo Log Contents

Online 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 rollback segment data block, and the transaction table of the rollback segments.

Redo entries record data that you can use to reconstruct all changes made to the database, including the rollback segments. Therefore, the online redo log also protects rollback data. When you recover the database using redo data, Oracle 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 and are written to one of the online redo log files by the Oracle background process Log Writer (LGWR). Whenever a transaction is committed, LGWR writes the transaction's redo records from the redo log buffer of the SGA to an online redo log file, and a *system change number* (SCN) is assigned to identify the redo records for each committed transaction. Only once 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 an online 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 an online redo log file, even though some redo records may not be committed. If necessary, Oracle can roll back these changes.

## How Oracle Writes to the Online Redo Log

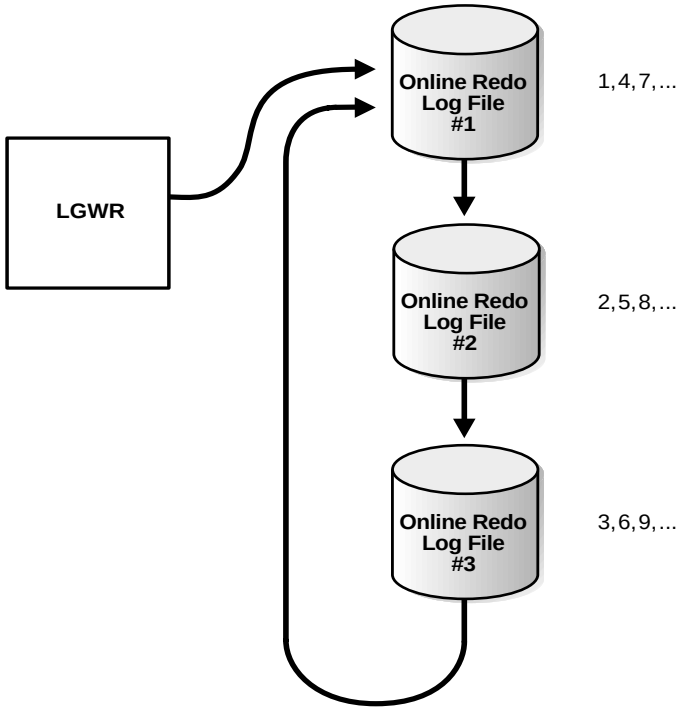
The online redo log of a database consists of two or more online redo log files. Oracle requires a minimum of two files to guarantee that one is always available for writing while the other is being archived (if in ARCHIVELOG mode).

LGWR writes to online redo log files in a circular fashion; when the current online redo log file fills, LGWR begins writing to the next available online redo log file. When the last available online redo log file is filled, LGWR returns to the first online redo log file and writes to it, starting the cycle again. Figure 6–1 illustrates the circular writing of the online redo log file. The numbers next to each line indicate the sequence in which LGWR writes to each online redo log file.

Filled online redo log files are available to LGWR for re-use depending on whether archiving is enabled:

- If archiving is disabled (NOARCHIVELOG mode), a filled online redo log file is available once the changes recorded in it have been written to the datafiles.
- If archiving is enabled (ARCHIVELOG mode), a filled online redo log file is available to LGWR once the changes recorded in it have been written to the datafiles *and* once the file has been archived.

***Figure 6–1 Circular Use of Online Redo Log Files by LGWR***




## Active (Current) and Inactive Online Redo Log Files

At any given time, Oracle uses only one of the online redo log files to store redo records written from the redo log buffer. The online redo log file that LGWR is actively writing is called the *current* online redo log file.

Online redo log files that are required for instance recovery are called *active* online redo log files. Online redo log files that are not required for instance recovery are called *inactive*.

If you have enabled archiving, Oracle cannot re-use or overwrite an active online log file until ARC*n* has archived its contents. If archiving is disabled, when the last online redo log file fills, writing continues by overwriting the first available active file.

### Log Switches and Log Sequence Numbers

A *log switch* is the point at which Oracle ends writing to one online redo log file and begins writing to another. A log switch always occurs when the current online redo log file is completely filled and writing must continue to the next online redo log file. You can also force log switches manually.

Oracle assigns each online redo log file a new *log sequence number* every time that a log switch occurs and LGWR begins writing to it. If Oracle archives online redo log files, the archived log retains its log sequence number. The online 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, Oracle properly applies redo log files in ascending order by using the log sequence number of necessary archived and online redo log files.

## Planning the Online Redo Log

This section describes guidelines you should consider when configuring a database instance's online redo log, and includes the following topics:

- Multiplexing Online Redo Log Files
- Placing Online Redo Log Members on Different Disks
- Setting the Size of Online Redo Log Members
- Choosing the Number of Online Redo Log Files

### Multiplexing Online Redo Log Files

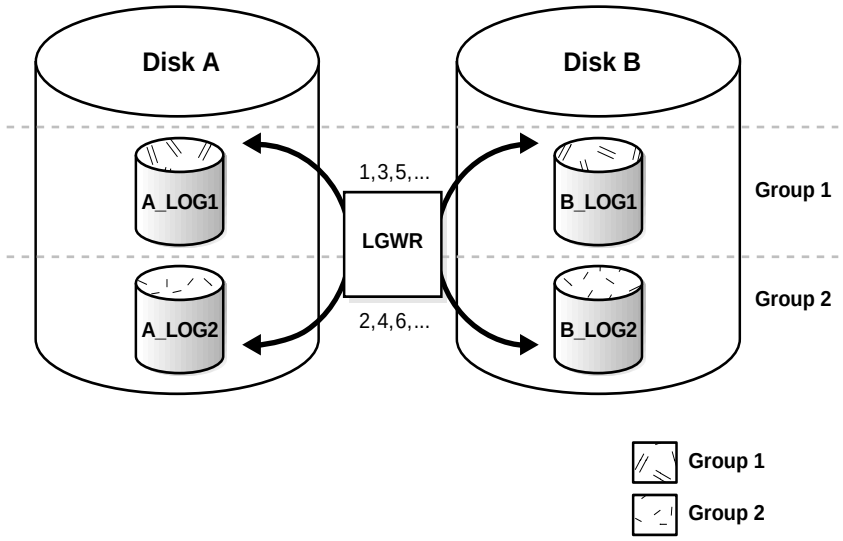
Oracle provides the capability to *multiplex* an instance's online redo log files to safeguard against damage to its online redo log files. When multiplexing online redo log files, LGWR concurrently writes the same redo log information to multiple identical online redo log files, thereby eliminating a single point of redo log failure.

---

**Note:** Oracle recommends that you multiplex your redo log files; the loss of the log file data can be catastrophic if recovery is required.

---

*Figure 6–2 Multiplexed Online Redo Log Files*




The corresponding online redo log files are called *groups*. Each online redo log file in a group is called a *member*. In Figure 6–2, 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.

Notice that each member of a group is concurrently active, or, concurrently written to by LGWR, as indicated by the identical log sequence numbers assigned by LGWR. In Figure 6–2, first LGWR writes to A_LOG1 in conjunction with B_LOG1, then A_LOG2 in conjunction with B_LOG2, etc. LGWR never writes concurrently to members of different groups (for example, to A_LOG1 and B_LOG2).

### Responding to Online Redo Log Failure

Whenever LGWR cannot write to a member of a group, Oracle marks that member as stale and writes an error message to the LGWR trace file and to the database's alert file to indicate the problem with the inaccessible files. LGWR reacts differently when certain online redo log members are unavailable, depending on the reason for the unavailability.

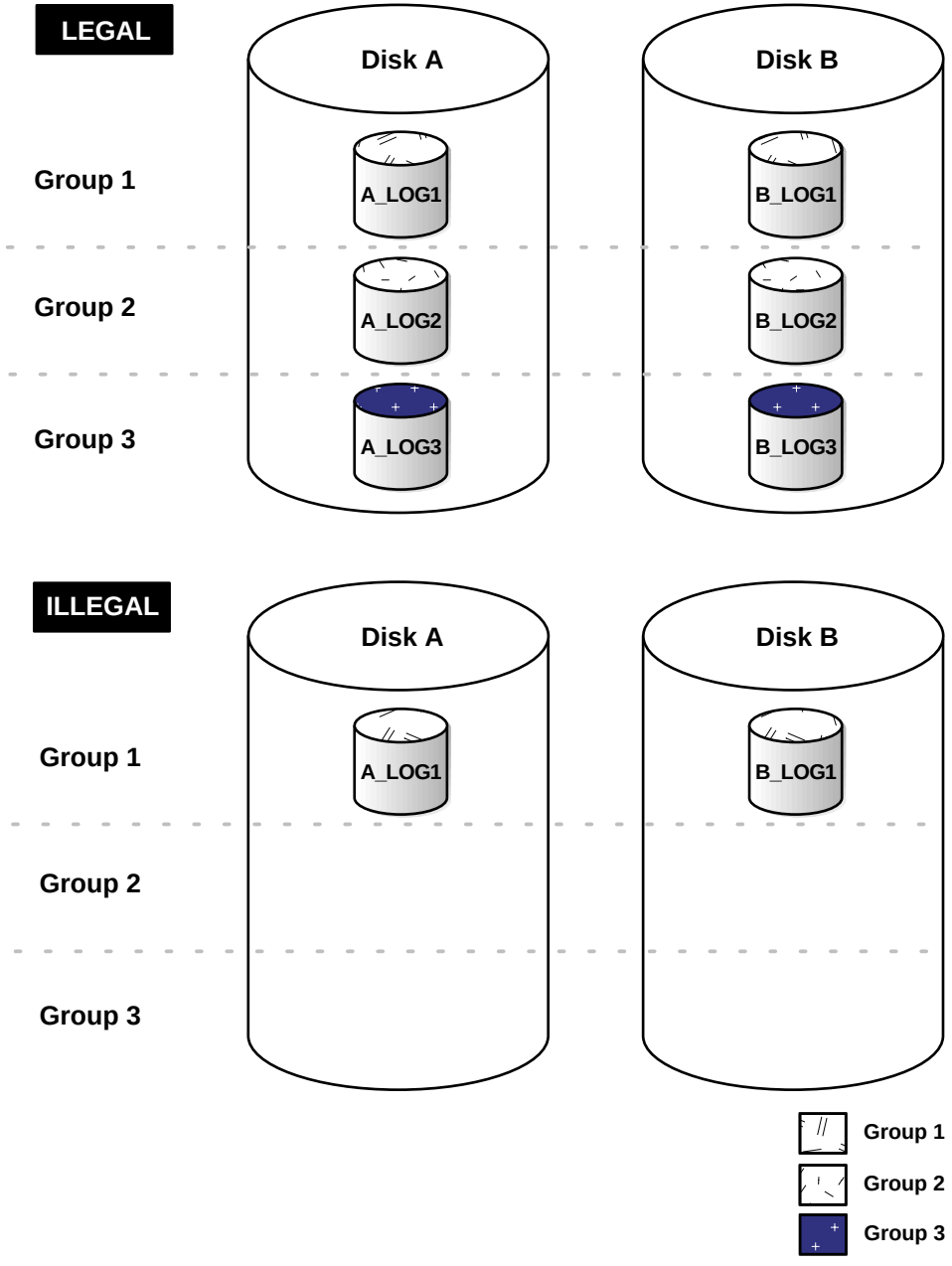
| If | Then |
|---|---|
| LGWR can successfully write to at least one member in a group | Writing proceeds as normal; LGWR simply writes to the available members of a group and ignores the unavailable members. |
| LGWR cannot access the next group at a log switch because the group needs to be archived | 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 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 an online redo log file.<br>If the database checkpoint has moved beyond the lost redo log (which is not the current log in this example), media recovery is not necessary since Oracle has saved the data recorded in the redo log to the datafiles. Simply drop the inaccessible redo log group. If Oracle did not archive the bad log, use ALTER DATABASE CLEAR UNARCHIVED LOG to disable archiving before the log can be dropped. |
| If all members of a group suddenly become inaccessible to LGWR while it is writing to them | Oracle 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 only need to turn the drive back on and let Oracle perform instance recovery. |

### Legal and Illegal Configurations

To safeguard against a single point of online redo log failure, a multiplexed online redo log is ideally symmetrical: all groups of the online redo log have the same number of members. Nevertheless, Oracle does not *require* that a multiplexed online redo log be symmetrical. For example, one group can have only one member, while other groups have two members. This configuration protects against disk failures that temporarily affect some online redo log members but leave others intact.

The only requirement for an instance's online redo log is that it have at least two groups. Figure 6–3 shows legal and illegal multiplexed online redo log configurations. The second configuration is illegal because it has only one group.

*Figure 6–3 Legal and Illegal Multiplexed Online Redo Log Configuration*



## Placing Online Redo Log Members on Different Disks

When setting up a multiplexed online redo log, place members of a group on different 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 online redo log members across disks to eliminate contention between the LGWR and ARC*n* background processes. For example, if you have two groups of duplexed online redo log members, place each member on a different disk and set your archiving destination to a fifth disk. Consequently, there is never contention between LGWR (writing to the members) and ARC*n* (reading the members).

Datafiles and online redo log files should also be on different disks to reduce contention in writing data blocks and redo records.

> **See Also:** For more information about how the online redo log affects backup and recovery, see *Oracle8i Backup and Recovery Guide*.

## Setting the Size of Online Redo Log Members

When setting the size of online redo log files, consider whether you will be archiving the redo log. Online 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 online redo log group can fit on a tape and 49% of the tape's storage capacity remains unused. In this case, it is better to decrease the size of the online redo log files slightly, so that two log groups could be archived per tape.

With multiplexed groups of online redo logs, all members of the same 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.

> **See Also:** The default size of online redo log files is operating system-dependent; for more details see your operating system-specific Oracle documentation.

## Choosing the Number of Online Redo Log Files

The best way to determine the appropriate number of online redo log files for a database instance is to test different configurations. The optimum configuration has

the fewest groups possible without hampering LGWR's 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 if the current online redo log configuration is satisfactory is to examine the contents of the LGWR trace file and the database's 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 online redo log files before setting up or altering the configuration of an instance's online redo log. The following parameters limit the number of online 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 online redo log files per database; group values can range from 1 to MAXLOGFILES. The only way to override this upper limit is to re-create the database or its control file; thus, it is important to consider this limit *before* creating a database. If MAXLOGFILES is not specified for the CREATE DATABASE statement, Oracle uses an operating system default value.
- The LOG_FILES initialization parameter (in the initialization parameter file) can temporarily decrease the maximum number of groups of online redo log files for the duration of the current instance. Nevertheless, LOG_FILES cannot override MAXLOGFILES to increase the limit. If LOG_FILES is not set in the database's parameter file, Oracle uses an operating system-specific default value.
- The MAXLOGMEMBERS parameter used in the CREATE DATABASE statement determines the maximum number of members per group. As with MAXLOGFILES, the only way to override this upper limit is to re-create the database or control file; thus, it is important to consider this limit *before* creating a database. If no MAXLOGMEMBERS parameter is specified for the CREATE DATABASE statement, Oracle uses an operating system default value.

  **See Also:** For the default and legal values of the MAXLOGFILES and MAXLOGMEMBERS parameters, and the LOG_FILES initialization parameter, see your operating system-specific Oracle documentation.

# Creating Online Redo Log Groups and Members

Plan the online redo log of a database and create all required groups and members of online redo log files during database creation. However, there are situations where you might want to create additional groups or members of online redo log files after database creation. For example, adding groups to an online redo log can correct redo log group availability problems.

To create new online redo log groups and members, you must have the ALTER DATABASE system privilege. A database can have up to MAXLOGFILES groups.

## Creating Online Redo Log Groups

To create a new group of online 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. To reuse an existing operating system file, you do not have to indicate the file size.

---

You can also specify the number that identifies the group using GROUP option:

```
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 space in the control files of the database.

## Creating Online Redo Log Members

In some cases, it might not be necessary to create a complete group of online 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 online redo log members for an existing group, use the SQL statement ALTER DATABASE with the ADD LOG MEMBER parameter.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 parameter, 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.

---

## Renaming and Relocating Online Redo Log Members

You can rename online redo log members to change their locations. This procedure is necessary, for example, if the disk currently used for some online redo log files is going to be removed, or if datafiles and a number of online redo log files are stored on the same disk and should be separated to reduce contention.

To rename online 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 renaming any online redo log members, ensure that the new online redo log files already exist.

**WARNING: The following steps only modify the internal file pointers in a database's control files; they do not physically rename or create any operating system files. Use your computer's operating system to copy the existing online redo log files to the new location.**

### To Rename Online Redo Log Members

1. Back up the database.

   Before making any structural changes to a database, such as renaming or relocating online redo log members, completely back up the database (including the control file) in case you experience any problems while performing this operation.

2. Copy the online redo log files to the new location.

   Operating system files, such as online 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 without exiting SQL*Plus by using the HOST command.

3. Rename the online redo log members.

   Use the ALTER DATABASE statement with the RENAME FILE clause to rename the database's online redo log files.

4. Open the database for normal operation.

   The online redo log alterations take effect the next time that the database is opened. Opening the database may require shutting down the current instance (if the database was previously opened by the current instance) or just opening the database using the current instance.

5. Back up the control file.

   As a precaution, after renaming or relocating a set of online redo log files, immediately back up the database's control file.

The following example renames the online redo log members. However, first assume that:

- The database is currently mounted by, but closed to, the instance.
- The log files are located on two disks: `diska` and `diskb`.
- The online 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 online 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`.

The files `/diska/logs/log1a.rdo` and `/diska/logs/log2a.rdo` on `diska` must be copied to the new files `/diskc/logs/log1c.rdo` and `/diskc/logs/log2c.rdo` on `diskc`.

```
ALTER DATABASE RENAME FILE
        '/diska/logs/log1a.rdo', '/diska/logs/log2a.rdo'
     TO '/diskc/logs/log1c.rdo', '/diskc/logs/log2c.rdo';
```

# Dropping Online Redo Log Groups and Members

In some cases, you may want to drop an entire group of online redo log members. For example, you want to reduce the number of groups in an instance's online redo log. In a different case, you may want to drop one or more specific online redo log members. For example, if a disk failure occurs, you may need to drop all the online redo log files on the failed disk so that Oracle does not try to write to the inaccessible files. In other situations, particular online redo log files become unnecessary; for example, a file might be stored in an inappropriate location.

## Dropping Log Groups

To drop an online redo log group, you must have the ALTER DATABASE system privilege. Before dropping an online redo log group, consider the following restrictions and precautions:

- An instance requires at least two groups of online redo log files, regardless of the number of members in the groups. (A group is one or more members.)
- You can drop an online redo log group only if it is not the active group. If you need to drop the active group, first force a log switch to occur; see "Forcing Log Switches" on page 6-16.

- Make sure an online redo log group is archived (if archiving is enabled) before dropping it. To see whether this has happened, use the SQL*Plus ARCHIVE LOG statement with the LIST parameter.

Drop an online 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 an online redo log group is dropped from the database, 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 an online redo log group, make sure that the drop completed successfully, and then use the appropriate operating system command to delete the dropped online redo log files.

## Dropping Online Redo Log Members

To drop an online redo log member, you must have the ALTER DATABASE system privilege.

Consider the following restrictions and precautions before dropping individual online redo log members:

- It is permissible to drop online redo log files so that a multiplexed online redo log becomes temporarily asymmetric. For example, if you use duplexed groups of online 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 online redo log.
- An instance always requires at least two valid groups of online redo log files, regardless of the number of members in the groups. (A group is 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's status, use the V$LOGFILE view. A redo log file becomes INVALID if Oracle cannot access it. It becomes STALE if Oracle 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 an online redo log member only if it is *not* part of an active 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 an online redo log member belongs is archived (if archiving is enabled) before dropping the member. To see whether this has happened, use the SQL*Plus ARCHIVE LOG statement with the LIST parameter.

To drop specific inactive online redo log members, use the SQL 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 an online 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 an online redo log file, make sure that the drop completed successfully, and then use the appropriate operating system command to delete the dropped online redo log file.

For information on dropping a member of an active group, see the following section, "Forcing Log Switches".

> **See Also:** For more information about SQL*Plus command syntax, see the *SQL*Plus User's Guide and Reference.*

## Forcing Log Switches

A log switch occurs when LGWR stops writing to one online redo log group and starts writing to another. By default, a log switch occurs automatically when the current online redo log file group fills.

You can force a log switch to make the currently active group inactive and available for online 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 online redo log files that take a long time to fill.

To force a log switch, you must have the ALTER SYSTEM privilege. To force a log switch, use either the SQL statement ALTER SYSTEM with the SWITCH LOGFILE option.

The following statement forces a log switch:

```
ALTER SYSTEM SWITCH LOGFILE;
```

**See Also:** For information on forcing log switches with the Oracle Parallel Server, see *Oracle8i Parallel Server Administration, Deployment, and Performance.*

## Verifying Blocks in Redo Log Files

You can configure Oracle to use checksums to verify blocks in the redo log files. Set the initialization parameter LOG_BLOCK_CHECKSUM to TRUE to enable redo log block checking. The default value of LOG_BLOCK_CHECKSUM is FALSE.

If you enable redo log block checking, Oracle computes a *checksum* for each redo log block written to the current log. Oracle writes the checksums in the header of the block.

Oracle uses the checksum to detect corruption in a redo log block. Oracle tries to verify the redo log block when it writes the block to an archive log file and when the block is read from an archived log during recovery.

If Oracle detects a corruption in a redo log block while trying to archive it, the system tries to read the block from another member in the group. If the block is corrupted in all members the redo log group, then archiving cannot proceed.

## Clearing an Online Redo Log File

If you have enabled redo log block checking, Oracle verifies each block before archiving it. If a particular redo log block is corrupted in all members of a group, archiving stops. Eventually all the redo logs become filled and database activity is halted until archiving can resume.

In this situation, use the SQL statement ALTER DATABASE ... CLEAR LOGFILE to clear the corrupted redo logs and avoid archiving them. The cleared redo logs are available for use even though they were not archived.

The following statement clears the log files in redo log group number 3:

```
ALTER DATABASE CLEAR UNARCHIVED LOGFILE GROUP 3;
```

### Restrictions

You can clear a redo log file whether it is archived or not. When it is not archived, however, you must include the keyword UNARCHIVED in your ALTER DATABASE CLEAR LOGFILE statement.

If you clear a log file that is needed for recovery of a backup, then you can no longer recover from that backup. Oracle 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 clause UNRECOVERABLE DATAFILE 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.

> **See Also:** For a complete description of the ALTER DATABASE statement, see the *Oracle8i SQL Reference.*

## Listing Information about the Online Redo Log

Use the V$LOG, V$LOGFILE, and V$THREAD views to see information about the online redo log of a database; the V$THREAD view is of particular interest for Parallel Server administrators.

The following query returns information about the online redo log of a database used without the Parallel Server:

```
SELECT group#, bytes, members FROM sys.v$log;

GROUP#        BYTES        MEMBERS
----------    ----------   --------
        1         81920          2
        2         81920          2
```

To see the names of all of the member of a group, use a query similar to the following:

```
SELECT * FROM sys.v$logfile
   WHERE group# = 2;

GROUP#         STATUS       MEMBER
----------    ----------  ---------
```

```
2                 LOG2A
2       STALE     LOG2B
2                 LOG2C
```

If STATUS is blank for a member, then the file is in use.

# 7

# Managing Archived Redo Logs

This chapter describes how to archive redo data. It includes the following topics:

- What Is the Archived Redo Log?
- Choosing Between NOARCHIVELOG and ARCHIVELOG Mode
- Controlling the Archiving Mode
- Specifying the Archive Destination
- Specifying the Mode of Log Transmission
- Managing Archive Destination Failure
- Tuning Archive Performance
- Displaying Archived Redo Log Information
- Controlling Trace Output Generated by the Archivelog Process
- Using LogMiner to Analyze Online and Archived Redo Logs

> **See Also:** If you are using Oracle with the Parallel Server, see *Oracle8i Parallel Server Administration, Deployment, and Performance* for additional information about archiving in the OPS environment,

# What Is the Archived Redo Log?

Oracle allows you to save filled groups of online redo log files, known as *archived redo logs*, to one or more offline destinations. *Archiving* is the process of turning online redo logs into archived redo logs. The background process ARC*n* automates archiving operations. You can use archived logs to:

- Recover a database.
- Update a standby database.
- Gain information about the history of a database via the LogMiner utility.

An archived redo log file is a copy of one of the identical filled members of an online redo log group: it includes the redo entries present in the identical members of a group and also preserves the group's unique log sequence number. For example, if you are multiplexing your online redo logs, and if Group 1 contains member files A_LOG1 and B_LOG1, then ARC*n* will archive one of these identical members. Should A_LOG1 become corrupted, then ARC*n* can still archive the identical B_LOG1.

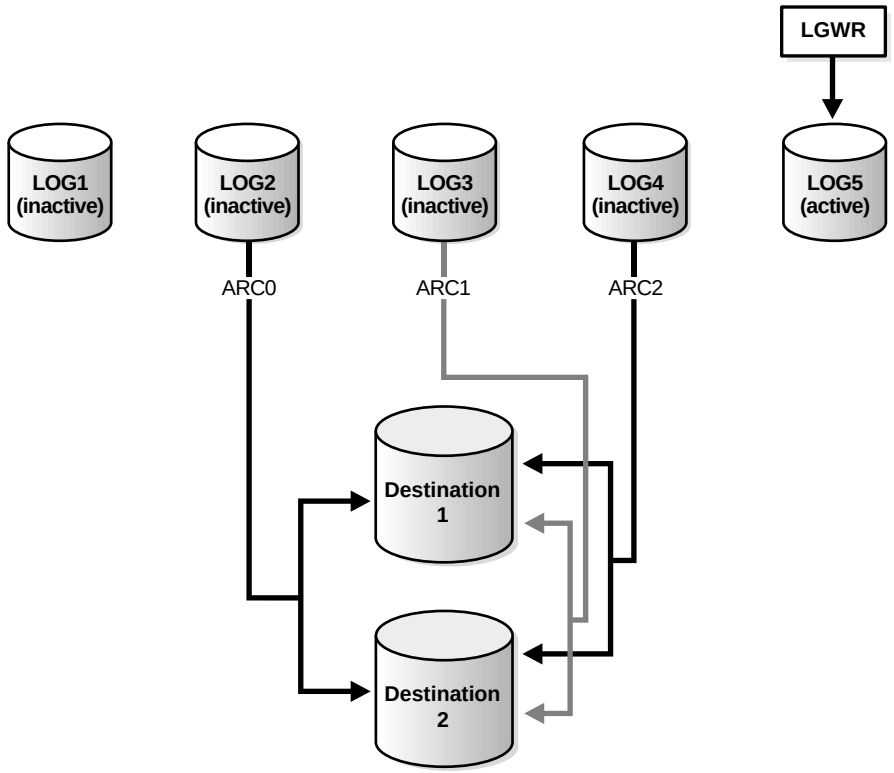
If you enable archiving, LGWR is not allowed to reuse and hence overwrite an online redo log group until it has been archived. Therefore, the archived redo log contains a copy of every group created since you enabled archiving. Figure 7–1 shows how ARC*n* archives redo logs.

---

**WARNING: Oracle recommends that you do not copy a current online log. If you do, and then restore that copy, the copy will appear at the end of the redo thread. Since additional redo may have been generated in the thread, when you attempt to execute recovery by supplying the redo log copy, recovery will erroneously detect the end of the redo thread and prematurely terminate, possibly corrupting the database. The best way to back up the contents of the current online log is always to archive it, then back up the archived log.**

---

*Figure 7–1 Archival of online redo logs*




# 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 includes the following topics:

- Running a Database in NOARCHIVELOG Mode
- Running a Database in ARCHIVELOG Mode

## Running a Database in NOARCHIVELOG Mode

When you run your database in NOARCHIVELOG mode, you disable the archiving of the online redo log. The database's 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.

The choice of whether to enable the archiving of filled groups of online 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. Note that the archiving of filled online redo log files can require you to perform extra administrative operations.

NOARCHIVELOG mode protects a database only from instance failure, but not from media failure. Only the most recent changes made to the database, which are stored in the groups of the online redo log, are available for instance recovery. In other words, if you are using NOARCHIVELOG mode, you can only *restore* (not recover) the database to the point of the most recent full database backup. You cannot recover subsequent transactions.

Also, in NOARCHIVELOG mode you cannot perform online tablespace backups. Furthermore, you cannot use online tablespace backups previously taken while the database operated in ARCHIVELOG mode. You can only use whole database backups taken while the database is closed to restore a database operating in NOARCHIVELOG mode. 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

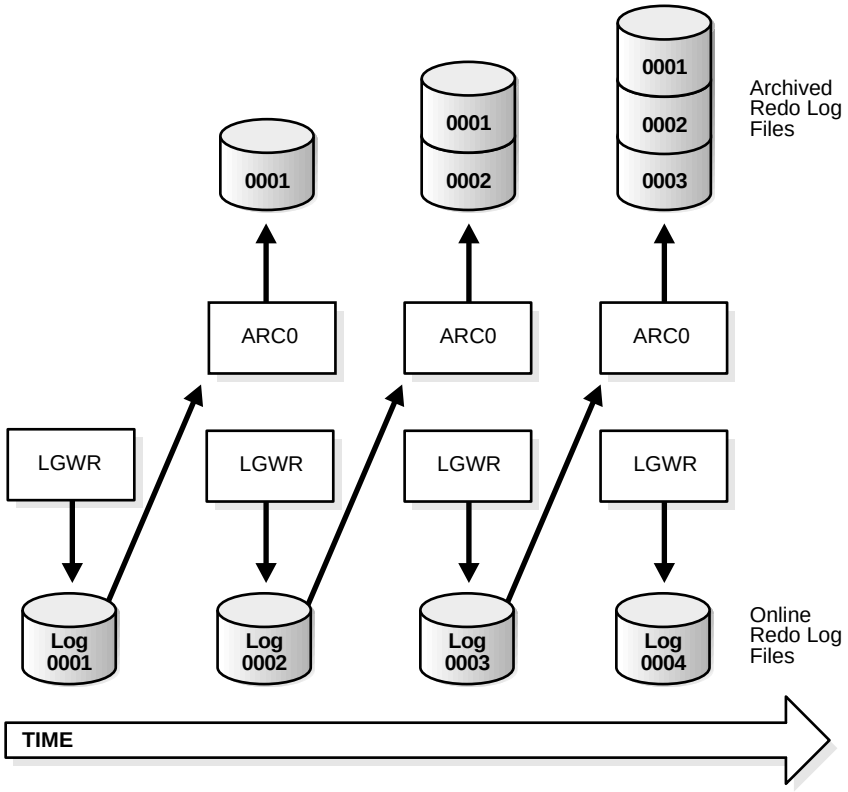
When you run a database in ARCHIVELOG mode, you enable the archiving of the online redo log. The database control file indicates that a group of filled online redo log files cannot be used by LGWR until the group is archived. A filled group is immediately available for archiving after a redo log switch 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.
- You can use a backup taken while the database is open and in normal system use if you keep an archived log.
- You can keep a standby database current with its original database by continually applying the original's archived redo logs to the standby.

Decide how you plan to archive filled groups of the online redo log. You can configure an instance to archive filled online redo log files automatically, or you can archive manually. For convenience and efficiency, automatic archiving is usually best. Figure 7–2 illustrate how the process archiving the filled groups (ARC0 in this illustration) generates the database's online redo log.

***Figure 7–2 Online Redo Log File Use in ARCHIVELOG Mode***




If *all* databases in a distributed database operate in ARCHIVELOG mode, you can perform coordinated distributed database recovery. If *any* database in a distributed database uses NOARCHIVELOG mode, however, 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.

You can also configure Oracle to verify redo log blocks when they are archived. This is discussed in "Verifying Blocks in Redo Log Files" on page 6-17.

# Controlling the Archiving Mode

This section describes ways of controlling the mode in which archiving is performed, and includes the following topics:

- Setting the Initial Database Archiving Mode
- Changing the Database Archiving Mode
- Enabling Automatic Archiving
- Disabling Automatic Archiving
- Performing Manual Archiving

> **See Also:** If a database is automatically created during Oracle installation, the initial archiving mode of the database is operating system specific. See the Oracle installation documentation specific to your operating system for additional information on controlling archiving modes.

## Setting the Initial Database Archiving Mode

You set a database's 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 then. After creating the database, decide whether to change from the initial archiving mode.

## Changing the Database Archiving Mode

To switch a database's archiving mode between NOARCHIVELOG and ARCHIVELOG mode, use the SQL statement ALTER DATABASE with the ARCHIVELOG or NOARCHIVELOG option. The following statement switches the database's archiving mode from NOARCHIVELOG to ARCHIVELOG:

```
ALTER DATABASE ARCHIVELOG;
```

Before switching the database's archiving mode, perform the following operations:

1. Shut down the database instance.

   An open database must be closed and dismounted and any associated instances shut down before you can switch the database's archiving mode. You cannot disable archiving 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.

3. Start a new instance and mount but do not open the database.

   To enable or disable archiving, the database must be mounted but not open.

   **Note:** If you are using the Oracle Parallel Server, you must mount the database exclusively, using one instance, to switch the database's archiving mode. See *Oracle8i Parallel Server Administration, Deployment, and Performance* for more information about switching the archiving mode when using the Oracle Parallel Server.

4. Switch the database's archiving mode.

After using the ALTER DATABASE statement to switch a database's archiving mode, open the database for normal operation. If you switched to ARCHIVELOG mode, you must also set additional archiving options specifying whether or not to enable Oracle to archive groups of online redo log files automatically as they fill.

## Enabling Automatic Archiving

If your operating system permits, you can enable automatic archiving of the online redo log. Under this option, no action is required to copy a group after it fills; Oracle automatically archives it. For this convenience alone, automatic archiving is the method of choice for archiving. However, if automatic archiving is enabled, you can still perform manual archiving as described in "Performing Manual Archiving" on page 7-9.

You can enable automatic archiving before or after instance startup. To enable automatic archiving after instance startup, you must be connected to Oracle with administrator privileges.

Always specify an archived redo log destination and file name format when enabling automatic archiving, as described in "Specifying Archive Destinations" on page 7-10.

**WARNING: Oracle does not automatically archive log files unless the database is also in ARCHIVELOG mode.**

### Enabling Automatic Archiving at Instance Startup

To enable automatic archiving of filled groups each time an instance is started, include the initialization parameter LOG_ARCHIVE_START in the database's initialization parameter file and set it to TRUE:

```
LOG_ARCHIVE_START=TRUE
```

The new value takes effect the next time you start the database.

### Enabling Automatic Archiving After Instance Startup

To enable automatic archiving of filled online redo log groups without shutting down the current instance, use the SQL statement ALTER SYSTEM with the ARCHIVE LOG START parameter; you can optionally include the archiving destination.

```
ALTER SYSTEM ARCHIVE LOG START;
```

If you use the ALTER SYSTEM method, you do not need to shut down the instance to enable automatic archiving. If an instance is shut down and restarted after automatic archiving is enabled, however, the instance is reinitialized using the settings of the initialization parameter file, which may or may not enable automatic archiving.

## Disabling Automatic Archiving

You can disable automatic archiving of the online redo log groups at any time. Once you disable automatic archiving, however, you must manually archive groups of online redo log files in a timely fashion. If you run a database in ARCHIVELOG mode and disable automatic archiving, and if all groups of online redo log files are filled but not archived, then LGWR cannot reuse any inactive groups of online redo log groups to continue writing redo log entries. Therefore, database operation is temporarily suspended until you perform the necessary archiving.

You can disable automatic archiving at or after instance startup. To disable automatic archiving after instance startup, you must be connected with administrator privilege and have the ALTER SYSTEM privilege.

### Disabling Automatic Archiving at Instance Startup

To disable the automatic archiving of filled online redo log groups each time a database instance is started, set the LOG_ARCHIVE_START initialization parameter of a database's initialization parameter file to FALSE:

```
LOG_ARCHIVE_START=FALSE
```

The new value takes effect the next time the database is started.

### Disabling Automatic Archiving after Instance Startup

To disable the automatic archiving of filled online redo log groups without shutting down the current instance, use the SQL statement ALTER SYSTEM with the ARCHIVE LOG STOP parameter. The following statement stops archiving:

```
ALTER SYSTEM ARCHIVE LOG STOP;
```

If ARC*n* is archiving a redo log group when you attempt to disable automatic archiving, ARC*n* finishes archiving the current group, but does not begin archiving the next filled online redo log group.

The instance does not have to be shut down to disable automatic archiving. If an instance is shut down and restarted after automatic archiving is disabled, however, the instance is reinitialized using the settings of the initialization parameter file, which may or may not enable automatic archiving.

## Performing Manual Archiving

If you operate your database in ARCHIVELOG mode, then you must archive inactive groups of filled online redo log files. You can manually archive groups of the online redo log whether or not automatic archiving is enabled:

- If automatic archiving is not enabled, then you must manually archive groups of filled online redo log files in a timely fashion. If all online redo log groups are filled but not archived, LGWR cannot reuse any inactive groups of online redo log members to continue writing redo log entries. Therefore, database operation is temporarily suspended until the necessary archiving is performed.
- If automatic archiving is enabled, but you want to rearchive an inactive group of filled online redo log members to another location, you can use manual archiving. Note that the instance can decide to reuse the redo log group before you have finished manually archiving, and thereby overwrite the files; if this happens, Oracle will put an error message in the ALERT file.

To archive a filled online redo log group manually, connect with administrator privileges. Use the SQL statement ALTER SYSTEM with the ARCHIVE LOG clause to manually archive filled online redo log files. The following statement archives all unarchived log files:

```
ALTER SYSTEM ARCHIVE LOG ALL;
```

**See Also:** With both manual or automatic archiving, you specify a thread only when you are using the Oracle Parallel Server. See *Oracle8i Parallel Server Administration, Deployment, and Performance* for more information.

# Specifying the Archive Destination

When archiving redo logs, determine the destination to which you will archive and familiarize yourself with the various destination states. Develop a practice of using fixed views, listed in "Displaying Archived Redo Log Information" on page 7-22, to access archive information.

The following topics are discussed in this section

- Specifying Archive Destinations
- Understanding Archive Destination States

## Specifying Archive Destinations

You must decide whether to make a *single* destination for the logs or *multiplex* them, i.e., archive the logs to more than one location. You specify your choice by setting initialization parameters according to one of the following methods.

| Method | Initialization Parameter | Host | Example |
|---|---|---|---|
| 1 | LOG_ARCHIVE_DEST_*n*<br>(where *n* is an integer from 1 to 5) | Local or remote | LOG_ARCHIVE_DEST_1 ='LOCATION = /disk1/arc'<br>LOG_ARCHIVE_DEST_2 = 'SERVICE = standby1' |
| 2 | LOG_ARCHIVE_DEST and<br>LOG_ARCHIVE_DUPLEX_DEST | Local only | LOG_ARCHIVE_DEST = '/disk1/arc'<br>LOG_ARCHIVE_DUPLEX_DEST ='/disk2/arc' |

### Method1: Using the LOG_ARCHIVE_DEST_n Parameter

The first method is to use the LOG_ARCHIVE_DEST_*n* parameter (where *n* is an integer from 1 to 5) to specify from one to five different destinations for archival. Each numerically-suffixed parameter uniquely identifies an individual destination.

You specify the location for LOG_ARCHIVE_DEST_*n* using these keywords:

| Keyword | Indicates | Example |
|---|---|---|
| LOCATION | A local filesystem location. | LOG_ARCHIVE_DEST_1= 'LOCATION=/disk1/arc' |
| SERVICE | Remote archival via Net8 service name. | LOG_ARCHIVE_DEST_2 = 'SERVICE=standby1' |

If you use the LOCATION keyword, specify a valid pathname for your operating system. If you specify SERVICE, Oracle 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. Note that the service name must have an associated database SID, so that Oracle 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 this method:

1. Use SQL*Plus to shut down the database.

   ```
   SHUTDOWN IMMEDIATE;
   ```

2. Edit the LOG_ARCHIVE_DEST_*n* parameter to specify from one to five archiving locations. The LOCATION keyword specifies an O/S-specific pathname. 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. Edit the LOG_ARCHIVE_FORMAT initialization parameter, using `%S` to include the log sequence number as part of the file name and `%t` to include the thread number. Use capital letters (`%S` and `%T`) to pad the file name to the left with zeroes. For example, enter:

   ```
   LOG_ARCHIVE_FORMAT = arch%s.arc
   ```

   These settings will generate archived logs as follows for log sequence numbers 100, 101, and 102:

   ```
   /disk1/archive/arch100.arc, /disk1/archive/arch101.arc, /disk1/archive/arch102.arc
   ```

```
/disk2/archive/arch100.arc, /disk2/archive/arch101.arc, /disk2/archive/arch102.arc
/disk3/archive/arch100.arc, /disk3/archive/arch101.arc, /disk3/archive/arch102.arc
```

### Method 2: Using LOG_ARCHIVE_DEST and LOG_ARCHIVE_DUPLEX_DEST

The second method, which allows you to specify a maximum of two locations, is to use the LOG_ARCHIVE_DEST parameter to specify a *primary* archive destination and the LOG_ARCHIVE_DUPLEX_DEST to determine an optional *secondary* location. Whenever Oracle archives a redo log, it archives it to every destination specified by either set of parameters.

Perform the following steps to use method 2.

1. Use SQL*Plus to shut down the database.

   ```
   SHUTDOWN IMMEDIATE;
   ```

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. Edit the LOG_ARCHIVE_FORMAT parameter, using `%S` to include the log sequence number as part of the file name and `%t` to include the thread number. Use capital letters (`%S` and `%T`) to pad the file name to the left with zeroes. For example, enter:

   ```
   LOG_ARCHIVE_FORMAT = arch_%t_%s.arc
   ```

   For example, the above settings will generate archived logs as follows for log sequence numbers 100 and 101 in thread 1:

   ```
   /disk1/archive/arch_1_100.arc, /disk1/archive/arch_1_101.arc
   /disk2/archive/arch_1_100.arc, /disk2/archive/arch_1_100.arc
   ```

> **See Also:** For information about archiving to standby databases, see the *Oracle8i Backup and Recovery Guide* and *Oracle8i Standby Database Concepts and Administration.*

## Understanding Archive Destination States

The LOG_ARCHIVE_DEST_STATE_*n* (where *n* is an integer from 1 to 5) initialization parameter identifies the status of the specified destination. The

destination parameters can have two values: ENABLE and DEFER. ENABLE indicates that Oracle can use the destination, whereas DEFER indicates that it should not.

Each archive destination has three variable characteristics:

- *Valid/Invalid*, which indicates whether the disk location or service name information is specified.
- *Enabled/Disabled*, which indicates whether Oracle should use the destination information.
- *Active/Inactive*, which indicates whether there was a problem accessing the destination.

Several destination states are possible, and are reflected in the status of the destination. To obtain the current status and other information about each destination for an instance, query the V$ARCHIVE_DEST view. You will access the most recently entered parameter definition—which does not necessarily contain the complete archive destination data.

The characteristics determining a locations status that appear in the view are shown in Table 7–1. Note that for a destination to be used, its characteristics must be valid, enabled, and active.

***Table 7–1 Destination Status*** **(Page 1 of 2)**

| | Characteristics | | | |
|---|---|---|---|---|
| **STATUS** | **Valid** | **Enabled** | **Active** | **Meaning** |
| 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. |
| 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. |

*Table 7–1 Destination Status* **(Page 2 of 2)**

| | Characteristics | | | |
|---|---|---|---|---|
| **STATUS** | **Valid** | **Enabled** | **Active** | **Meaning** |
| BAD PARAM | N / A | N / A | N / A | A parameter error occurred; refer to error data. Usually this state is only seen when LOG_ARCHIVE_START is not set. |

**See Also:** For detailed information about V$ARCHIVE_DEST as well as the archive destination parameters, see the *Oracle8i Reference*.

# Specifying the Mode of Log Transmission

There are two modes of transmitting archived logs to their destination: *normal archiving transmission* and *standby transmission* mode. Normal transmission involves transmitting files to a local disk. Standby transmission involves transmitting files via 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, since in this configuration archiving does not contend with other files required by the instance and completes quickly so the group can become available to LGWR. Specify the destination with either the LOG_ARCHIVE_DEST_*n* or LOG_ARCHIVE_DEST parameters.

Ideally, you should permanently move archived redo log files and corresponding database backups from the local disk to inexpensive offline storage media such as tape. Because a primary value of archived logs is database recovery, 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.

**WARNING: 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 in sync with your source database by automatically applying transmitted archive 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 by means of a *remote file server* (RFS) process.

Each ARC*n* process creates a corresponding RFS for each standby destination. For example, if three ARC*n* processes are archiving to two standby databases, then Oracle establishes six RFS connections.

You can transmit archived logs through a network to a remote location by using Net8. Indicate a remote archival by specifying a Net8 *service name* as an attribute of the destination. Oracle then translates the service name, which you set by means of the SERVICE_NAME parameter, through the `tnsnames.ora` file to a *connect descriptor*. The descriptor contains the information necessary for connecting to the remote database. Note that the service name must have an associated database SID, so that Oracle 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's 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:** For a detailed description of standby databases, see the relevant chapter in the *Oracle8i Standby Database Concepts and Administration*.
>
> For information about Net8, see the *Net8 Administrator's Guide*.

# Managing Archive Destination Failure

Sometimes archive destinations can fail, causing problems when you operate in automatic archiving mode. To minimize the problems associated with destination failure, Oracle8*i* provides you with options, as described in the sections below.

- Specifying the Minimum Number of Successful Destinations
- Re-Archiving to a Failed Destination

## Specifying the Minimum Number of Successful Destinations

The optional initialization parameter LOG_ARCHIVE_MIN_SUCCEED_DEST=*n* (where *n* is an integer from 1 to 5, or 1 to 2 if you choose to use duplexing) determines the minimum number of destinations to which Oracle must successfully archive a redo log group before it can reuse online log files. The default value is 1.

### Specifying Mandatory and Optional Destinations

Using the LOG_ARCHIVE_DEST_*n* parameter, you can specify whether a destination has the attributes OPTIONAL (default) or MANDATORY. The LOG_ARCHIVE_MIN_SUCCEED_DEST=*n* parameter uses all MANDATORY destinations plus some number of OPTIONAL non-standby destinations to determine whether LGWR can overwrite the online log.

When determining how to set your parameters, note that:

- Not specifying MANDATORY 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 using LOG_ARCHIVE_MIN_SUCCEED_DEST=*n* at least one local destination will *operationally* be treated as MANDATORY, since the minimum value for LOG_ARCHIVE_MIN_SUCCEED_DEST is 1.
- The failure of any MANDATORY destination, including a MANDATORY standby destination, makes the LOG_ARCHIVE_MIN_SUCCEED_DEST parameter irrelevant.
- The LOG_ARCHIVE_MIN_SUCCEED_DEST value cannot be greater than the number of destinations, nor greater than the number of MANDATORY destinations plus the number of OPTIONAL local destinations.
- If you DEFER a MANDATORY destination, and Oracle overwrites the online log without transferring the archived log to the standby site, then you must transfer the log to the standby manually.

You can also establish which destinations are mandatory or optional by using the LOG_ARCHIVE_DEST and LOG_ARCHIVE_DUPLEX_DEST parameters. Note the following rules:

- Any destination declared via LOG_ARCHIVE_DEST is mandatory.
- Any destination declared via LOG_ARCHIVE_DUPLEX_DEST is optional if LOG_ARCHIVE_MIN_SUCCEED_DEST = 1 and mandatory if LOG_ARCHIVE_MIN_SUCCEED_DEST = 2.

### Sample 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 1** In this scenario, you archive to three local destinations, each of which you declare as OPTIONAL. Table 7–2 illustrates the possible values for LOG_ARCHIVE_MIN_SUCCEED_DEST=*n* in this case.

***Table 7–2 LOG_ARCHIVE_MIN_SUCCEED_DEST Values for Scenario 1***

| Value | Meaning |
|---|---|
| 1 | Oracle can reuse log files only if at least one of the OPTIONAL destinations succeeds. |
| 2 | Oracle can reuse log files only if at least two of the OPTIONAL destinations succeed. |
| 3 | Oracle can reuse log files only if all of the OPTIONAL destinations succeed. |

*Table 7–2 LOG_ARCHIVE_MIN_SUCCEED_DEST Values for Scenario 1*

| | |
|---|---|
| 4 | ERROR: The value is greater than the number of destinations. |
| 5 | 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, Oracle must successfully archive to these locations when LOG_ARCHIVE_MIN_SUCCEED_DEST is set to 1, 2, or 3.

**Scenario 2** In this scenario, consider a case in which:

- You specify two MANDATORY destinations.
- You specify two OPTIONAL destinations.
- No destination is a standby database.

Table 7–3 shows the possible values for LOG_ARCHIVE_MIN_SUCCEED_DEST=*n*:

*Table 7–3 LOG_ARCHIVE_MIN_SUCCEED_DEST Values for Example 2*

| Value | Meaning |
|---|---|
| 1 | Oracle ignores the value and uses the number of MANDATORY destinations (in this example, 2). |
| 2 | Oracle can reuse log files even if no OPTIONAL destination succeeds. |
| 3 | Oracle can reuse logs only if at least one OPTIONAL destination succeeds. |
| 4 | Oracle can reuse logs only if both OPTIONAL destinations succeed. |
| 5 | ERROR: The value is greater than the number of destinations. |

This case shows that Oracle 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.

> **See Also:** For additional information about LOG_ARCHIVE_MIN_SUCCEED_DEST=*n* or any other initialization parameters that relate to archiving, see the *Oracle8i Reference*.

### Re-Archiving to a Failed Destination

Use the REOPEN attribute of the LOG_ARCHIVE_DEST_*n* parameter to determine whether and when ARC*n* attempts 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 option, in other words, 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 a limit on the number of attempts to reconnect and transfer archived logs. The REOPEN attempt either succeeds or fails, in which case the REOPEN information is reset.

If you specify REOPEN for an OPTIONAL destination, Oracle can overwrite online logs if there is an error. If you specify REOPEN for a MANDATORY destination, Oracle stalls the production database when it cannot successfully archive. This scenario requires you to:

- 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 that:

- 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 a REOPEN time was specified or defaulted, 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.

## Tuning Archive Performance

For most databases, ARC*n* has no effect on overall system performance. On some large database sites, however, archiving can have an impact on system performance. On one hand, if ARC*n* works very quickly, overall system

performance can be reduced while ARC*n* runs, since CPU cycles are being consumed in archiving. On the other hand, if ARC*n* runs extremely slowly, it has little detrimental effect on system performance, but it takes longer to archive redo log files, and can create a bottleneck if all redo log groups are unavailable because they are waiting to be archived.

Use the following methods to tune archiving:

- Specifying Multiple ARCn Processes
- Adjusting Archive Buffer Parameters

> **See Also:** For more information about tuning a database, see *Oracle8i Designing and Tuning for Performance*.

## Specifying Multiple ARC*n* Processes

Specify up to ten ARC*n* processes for each database instance. Enable the multiple processing feature at startup or at runtime by setting the initialization parameter LOG_ARCHIVE_MAX_PROCESSES=*n* (where *n* is any integer from 1 to 10). By default, the parameter is set to 1.

Because LGWR automatically increases the number of ARC*n* processes should the current number be insufficient to handle the current workload, the parameter is intended to allow you to specify the *initial* number of ARC*n* processes or to increase or decrease the current number. Assuming the initial number of ARCn processes was set to 4, the following statement will decrease the number of processes to 2.

```
ALTER SYSTEM SET LOG_ARCHIVE_MAX_PROCESSES=2
```

When decreasing the number of ARC*n* processes, it is not determinate exactly which process will be stopped. Also, you are not allowed to alter the value of the parameter to 0, so at least one ARC*n* process will always be active. Query the V$ARCHIVE_PROCESSES view to see information about the state of each archive process. Processes that have stopped will show as being in the IDLE state.

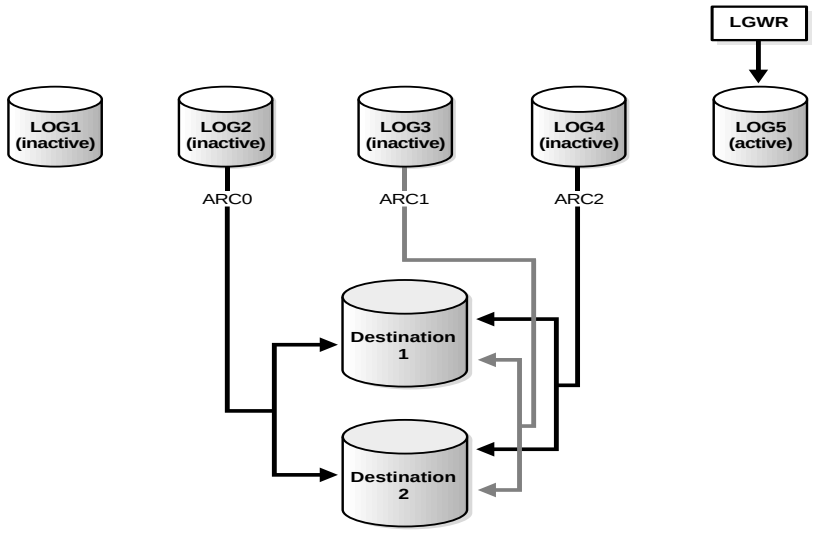
Creating multiple processes is especially useful when you:

- Use more than two online redo logs.
- Archive to more than one destination.

Multiple ARC*n* processing prevents the bottleneck that occurs when LGWR switches through the multiple online redo logs faster than a single ARC*n* process can write inactive logs to multiple destinations. Note that each ARC*n* process works on only one inactive log at a time, but must archive to each specified destination.

For example, if you maintain five online redo log files, then you may decide to start the instance using three ARC*n* processes. As LGWR actively writes to one of the log files, the ARC*n* processes can simultaneously archive up to three of the inactive log files to various destinations. As Figure 7–3 illustrates, each instance of ARC*n* assumes responsibility for a single log file and archives it to all of the defined destinations.

***Figure 7–3 Using Multiple Arch Processes***




## Adjusting Archive Buffer Parameters

This section describes aspects of using the archive buffer initialization parameters for tuning.

You can tune archiving to cause it to run either as slowly as possible without being a bottleneck or as quickly as possible without reducing system performance substantially. To do so, adjust the values of the initialization parameters LOG_ARCHIVE_BUFFERS (the number of buffers allocated to archiving) and LOG_ARCHIVE_BUFFER_SIZE (the size of each such buffer).

**Note:** When you change the value of LOG_ARCHIVE_BUFFERS or LOG_ARCHIVE_BUFFER_SIZE, the new value takes effect the next time you start the instance.

### Minimizing the Impact on System Performance

To make ARC*n* work as slowly as possible without forcing the system to wait for redo logs, begin by setting the number of archive buffers (LOG_ARCHIVE_BUFFERS) to 1 and the size of each buffer (LOG_ARCHIVE_BUFFER_SIZE) to the maximum possible.

If the performance of the system drops significantly while ARC*n* is working, make the value of LOG_ARCHIVE_BUFFER_SIZE lower until system performance is no longer reduced when ARC*n* runs.

**Note:** If you want to set archiving to be very slow, but find that Oracle frequently has to wait for redo log files to be archived before they can be reused, you can create additional redo log file groups. Adding groups can ensure that a group is always available for Oracle to use.

### Improving Archiving Speed

To improve archiving performance, use multiple archive buffers to force the ARC*n* processes to read the archive log at the same time that they write the output log. You can set LOG_ARCHIVE_BUFFERS to 2, but for a very fast tape drive you may want to set it to 3 or more. Then, set the size of the archive buffers to a moderate number, and increase it until archiving is as fast as you want it to be without impairing system performance.

**See Also:** For more information about the LOG_ARCHIVE parameters, see the *Oracle8i Reference*.

## Displaying Archived Redo Log Information

You can display information about the archived redo logs using the following:

- Fixed Views
- The ARCHIVE LOG LIST SQL Statement

## Fixed Views

There are several fixed views that contain useful information about archived redo logs.

| Fixed View | Description |
|---|---|
| V$DATABASE | Identifies whether the database is in ARCHIVELOG or NOARCHIVELOG mode. |
| V$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$ARCHIVE_DEST | Describes the current instance, all archive destinations, and the current value, mode, and status of these destinations. |
| V$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 online 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 online 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:** For more information on the data dictionary views, see the *Oracle8i Reference*.

## The ARCHIVE LOG LIST SQL Statement

The SQL statement ARCHIVE LOG LIST also shows archiving information for the connected instance:

```
ARCHIVE LOG LIST;

Database log mode                  ARCHIVELOG
Automatic archival                 ENABLED
Archive destination                destination
Oldest online log sequence         30
Next log sequence to archive       32
Current log sequence number        33
```

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 destination of the archived redo log (operating system specific).
- The oldest filled online redo log group has a sequence number of 30.
- The next filled online redo log group to archive has a sequence number of 32.
- The current online redo log file has a sequence number of 33.

You must archive all redo log groups with a sequence number equal to or greater than the *Next log sequence to archive*, yet less than the *Current log sequence number*. For example, the display above indicates that the online redo log group with sequence number 32 needs to be archived.

> **See Also:** For more information on the ARCHIVE_LOG_LIST statement, see the *Oracle8i SQL Reference*.

# Controlling Trace Output Generated by the Archivelog Process

As discussed in "Trace Files, the Alert Log, and Background Processes" on page 4-15, background processes always write to a trace file when appropriate. In the case of the archivelog process, it is possible to control the output that is generated.

The LOG_ARCHIVE_TRACE initialization parameter can be set to specify a *trace level*. The following values can be specified:

| Trace Level | Meaning |
|---|---|
| 0 | Disable archivelog tracing - default setting. |
| 1 | Track archival of REDO log file. |
| 2 | Track archival status per archivelog destination. |
| 4 | Track archival operational phase. |
| 8 | Track archivelog destination activity. |
| 16 | Track detailed archivelog destination activity. |
| 32 | Track archivelog destination parameter modifications. |
| 64 | Track ARCn process state activity |

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, and at this level, error conditions will still generate the appropriate alert and trace entries.

You may change the value of this parameter dynamically using the ALTER SYSTEM statement. For example:

```
ALTER SYSTEM SET ARCHIVE_LOG_TRACE=12
```

Changes initiated in this manner will take effect at the start of the next archiving operation.

**See Also:** The LOG_ARCHIVE_TRACE initialization parameter is discussed in *Oracle8i Reference*.

For information about using this parameter with a standby database, see *Oracle8i Standby Database Concepts and Administration.*

# Using LogMiner to Analyze Online and Archived Redo Logs

The Oracle utility LogMiner allows you to read information contained in online and archived redo logs based on selection criteria. LogMiner's fully relational SQL interface provides direct access to a complete historical view of a database—without forcing you to restore archived redo log files.

This section contains the following topics:



**See Also:** For detailed information about initialization parameters and LogMiner views mentioned in this section, see *Oracle8i Reference*.

For more information about LogMiner PL/SQL packages, see the *Oracle8i Supplied PL/SQL Packages Reference.*

## How Can You Use LogMiner?

LogMiner is especially useful for identifying and undoing logical corruption. LogMiner processes redo log files, translating their contents into SQL statements that represent the logical operations performed to the database. The V$LOGMNR_CONTENTS view then lists the reconstructed SQL statements that represent the original operations (SQL_REDO column) and the corresponding SQL statement to undo the operations (SQL_UNDO column). Apply the SQL_UNDO statements to roll back the original changes to the database.

Furthermore, you can use the V$LOGMNR_CONTENTS view to:

- Determine when a logical corruption to the database may have begun, pinpointing the time or SCN to which you need to perform incomplete recovery.
- Track changes to a specific table.
- Track changes made by a specific user.
- Map data access patterns.
- Use archived data for tuning and capacity planning.

## Restrictions

LogMiner has the following usage and compatibility requirements. LogMiner only:

- Runs in Oracle version 8.1 or later.
- Analyzes redo log files from any version 8.0 or later database that uses the same database character set and runs on the same hardware platform as the analyzing instance.

  **Note:** The block size (DB_BLOCK_SIZE) of the analyzing instance must be identical to the block size of the log producing instance. If this is not the case, you will receive an error indicating the archive log is corrupted (when it is probably not).

- Analyzes the contents of the redo log files completely with the aid of a dictionary created by a PL/SQL package. The dictionary allows LogMiner to translate internal object identifiers and data types to object name and external data formats.
- Obtains information about DML operations on conventional tables. It does not support operations on:
  - Index-organized tables
  - Clustered tables/indexes
  - Non-scalar data types
  - Chained rows

  Also, LogMiner does not handle direct path insert operations, even though such operations are logged. It does support conventional path insert through SQL*Loader.

## Creating a Dictionary File

LogMiner runs in an Oracle instance with the database either mounted or unmounted. LogMiner uses a *dictionary file*, which is a special file that indicates the database that created it as well as the time the file was created. The dictionary file is not required, but is recommended.

Without a dictionary file, the equivalent SQL statements will use Oracle internal object IDs for the object name and present column values as hex data. For example, instead of the SQL statement:

```
INSERT INTO emp(name, salary) VALUES ('John Doe', 50000);
```

LogMiner will display:

```
insert into Object#2581(col#1, col#2) values (hextoraw('4a6f686e20446f65'),
hextoraw('c306'));"
```

Create a dictionary file by mounting a database and then extracting dictionary information into an external file. You must create the dictionary file from the same database that generated the log files you want to analyze. Once created, you can use the dictionary file to analyze redo logs.

When creating the dictionary, specify the following:

- DICTIONARY_FILENAME to name the dictionary file.
- DICTIONARY_LOCATION to specify the location of the file.

**To Create a Dictionary File on an Oracle8*i* Database:**

1. Make sure to specify a directory for use by the PL/SQL procedure by setting the initialization parameter UTL_FILE_DIR. For example, set the following to use `/oracle/logs`:

   ```
   UTL_FILE_DIR = /oracle/logs
   ```

   If you do not reference this parameter, the procedure will fail.

2. Use SQL*Plus to mount and then open the database whose files you want to analyze. For example, enter:

   ```
   STARTUP
   ```

3. Execute the PL/SQL procedure DBMS_LOGMNR_D.BUILD. Specify both a file name for the dictionary and a directory pathname for the file. This procedure creates the dictionary file, which you should use to analyze log files. For

example, enter the following to create file `dictionary.ora` in `/oracle/logs`:

```
EXECUTE DBMS_LOGMNR_D.BUILD( -
DICTIONARY_FILENAME =>'dictionary.ora', -
DICTIONARY_LOCATION => '/oracle/logs');
```

**To Create a Dictionary File on an Oracle8 Database:**

Although LogMiner only runs on databases of release 8.1 or higher, you can use it to analyze redo logs from release 8.0 databases.

1. Use an O/S command to copy the `dbmslmd.sql` script, which is contained in the `$ORACLE_HOME/rdbms/admin` directory on the Oracle8*i* database, to the same directory in the Oracle8 database. For example, enter:

   ```
   % cp /8.1/oracle/rdbms/admin/dbmslmd.sql /8.0/oracle/rdbms/admin/dbmslmd.sql
   ```

2. Use SQL*Plus to mount and then open the database whose files you want to analyze. For example, enter:

   ```
   STARTUP
   ```

3. Execute the copied `dbmslmd.sql` script on the 8.0 database to create the DBMS_LOGMNR_D package. For example, enter:

   ```
   @dbmslmd.sql
   ```

4. Specify a directory for use by the PL/SQL package by setting the initialization parameter UTL_FILE_DIR. If you do not reference this parameter, the procedure will fail. For example, set the following to use `/8.0/oracle/logs`:

   ```
   UTL_FILE_DIR = /8.0/oracle/logs
   ```

5. Execute the PL/SQL procedure DBMS_LOGMNR_D.BUILD. Specify both a file name for the dictionary and a directory pathname for the file. This procedure creates the dictionary file, which you should use to analyze log files. For example, enter the following to create file `dictionary.ora` in `/8.0/oracle/logs`:

   ```
   EXECUTE DBMS_LOGMNR_D.BUILD(
   DICTIONARY_FILENAME =>'dictionary.ora',
   DICTIONARY_LOCATION => '/8.0/oracle/logs');
   ```

## Specifying Redo Logs for Analysis

Once you have created a dictionary file, you can begin analyzing redo logs. Your first step is to specify the log files that you want to analyze using the ADD_LOGFILE procedure. Use the following constants:

- NEW to create a new list.
- ADDFILE to add redo logs to a list.
- REMOVEFILE to remove redo logs from the list.

**To Use LogMiner:**

1. Use SQL*Plus to start an Oracle instance, with the database either mounted or unmounted. For example, enter:

   ```
   STARTUP
   ```

2. Create a list of logs by specifying the NEW option when executing the DBMS_LOGMNR.ADD_LOGFILE procedure. For example, enter the following to specify `/oracle/logs/log1.f`:

   ```
   EXECUTE DBMS_LOGMNR.ADD_LOGFILE( -
   LOGFILENAME => '/oracle/logs/log1.f', -
   OPTIONS => dbms_logmnr.NEW);
   ```

3. If desired, add more logs by specifying the ADDFILE option. For example, enter the following to add `/oracle/logs/log2.f`:

   ```
   EXECUTE DBMS_LOGMNR.ADD_LOGFILE( -
   LOGFILENAME => '/oracle/logs/log2.f', -
   OPTIONS => dbms_logmnr.ADDFILE);
   ```

4. If desired, remove logs by specifying the REMOVEFILE option. For example, enter the following to remove `/oracle/logs/log2.f`:

   ```
   EXECUTE DBMS_LOGMNR.ADD_LOGFILE( -
   LOGFILENAME => '/oracle/logs/log2.f', -
   OPTIONS => dbms_logmnr.REMOVEFILE);
   ```

## Using LogMiner

Once you have created a dictionary file and specified which logs to analyze, you can start LogMiner and begin your analysis. Use the following options to narrow the range of your search at start time:

| This option | Specifies |
|---|---|
| STARTSCN | The beginning of an SCN range. |
| ENDSCN | The termination of an SCN range. |
| STARTTIME | The beginning of a time interval. |
| ENDTIME | The end of a time interval. |
| DICTFILENAME | The name of the dictionary file. |

Once you have started LogMiner, you can make use of the following data dictionary views for analysis:

| This view | Displays information about |
|---|---|
| V$LOGMNR_DICTIONARY | The dictionary file in use. |
| V$LOGMNR_PARAMETERS | Current parameter settings for LogMiner. |
| V$LOGMNR_LOGS | Which redo log files are being analyzed. |
| V$LOGMNR_CONTENTS | The contents of the redo log files being analyzed. |

**To Use LogMiner:**

1. Issue the DBMS_LOGMNR.START_LOGMNR procedure to start LogMiner utility. For example, to start LogMiner using `/oracle/dictionary.ora`, issue:

   ```
   EXECUTE DBMS_LOGMNR.START_LOGMNR( -
   DICTFILENAME =>'/oracle/dictionary.ora');
   ```

   Optionally, set the STARTTIME and ENDTIME parameters to filter data by time. Note that the procedure expects date values: use the TO_DATE function to specify date and time, as in this example:

   ```
   EXECUTE DBMS_LOGMNR.START_LOGMNR( -
   DICTFILENAME => '/oracle/dictionary.ora', -
   STARTTIME => to_date('01-Jan-1998 08:30:00', 'DD-MON-YYYY HH:MI:SS') -
   ENDTIME => to_date('01-Jan-1998 08:45:00', 'DD-MON-YYYY HH:MI:SS'));
   ```

   Use the STARTSCN and ENDSCN parameters to filter data by SCN, as in this example:

   ```
   EXECUTE DBMS_LOGMNR.START_LOGMNR( -
   ```

```
    DICTFILENAME => '/oracle/dictionary.ora', -
    STARTSCN => 100, -
    ENDSCN => 150);
```

2. View the output via the V$LOGMNR_CONTENTS table. LogMiner returns all rows in SCN order, which is the same order applied in media recovery. For example, the following query lists information about operations:

```
SELECT operation, sql_redo FROM v$logmnr_contents;
OPERATION SQL_REDO
--------- ----------------------------------------------------------
INTERNAL
INTERNAL
START     set transaction read write;
UPDATE    update SYS.UNDO$ set NAME = 'RS0', USER# = 1, FILE# = 1, BLOCK# = 2450, SCNBAS =
COMMIT    commit;
START     set transaction read write;
UPDATE    update SYS.UNDO$ set NAME = 'RS0', USER# = 1, FILE# = 1, BLOCK# = 2450, SCNBAS =
COMMIT    commit;
START     set transaction read write;
UPDATE    update SYS.UNDO$ set NAME = 'RS0', USER# = 1, FILE# = 1, BLOCK# = 2450, SCNBAS =
COMMIT    commit;
11 rows selected.
```

**Analyzing Archived Redo Log Files from Other Databases** You can run LogMiner on an instance of a database while analyzing redo log files from a different database. To analyze archived redo log files from other databases, LogMiner must:

- Access a dictionary file that is both created from the same database as the redo log files and created with the same database character set.
- Run on the same hardware platform that generated the log files, although it does not need to be on the same system.
- Use redo log files that can be applied for recovery from Oracle version 8.0 and later.

## Using LogMiner: Scenarios

This section contains the following LogMiner scenarios:

- Tracking a User
- Calculating Table Access Statistics

### Tracking a User

In this example, you are interested in seeing all changes to the database in a specific time range by one of yours users: JOEDEVO. You perform this operation in the following steps:

- Step 1: Creating the Dictionary
- Step 2: Adding Logs and Limiting the Search Range
- Step 3: Starting LogMiner and Analyzing the Data

**Step 1: Creating the Dictionary** To use LogMiner to analyze JOEDEVO's data, you must create a dictionary file before starting LogMiner.

You decide to do the following:

- Call the dictionary file `orc1dict.ora`.
- Place the dictionary in directory `/user/local/dbs`.
- Set the initialization parameter UTL_FILE_DIR to `/user/local/dbs`.

```
# Set the initialization parameter UTL_FILE_DIR in the initialization parameter
file
UTL_FILE_DIR = /user/local/dbs

# Start SQL*Plus and then connect to the database
CONNECT system/manager

# Open the database to create the dictionary file
STARTUP

# Create the dictionary file
EXECUTE DBMS_LOGMNR_D.BUILD( -
DICTIONARY_FILENAME => 'orcldict.ora', -
DICTIONARY_LOCATION => '/usr/local/dbs');

# The dictionary has been created and can be used later
SHUTDOWN;
```

**Step 2: Adding Logs and Limiting the Search Range** Now that the dictionary is created, you decide to view the changes that happened at a specific time. You do the following:

- Create a list of log files for use and specify log `log1orc1.ora`.
- Add log `log2orc1.ora` to the list.

- Start LogMiner and limit the search to the range between 8:30 a.m. and 8:45 a.m. on January 1, 1998.

```
# Start SQL*Plus, connect as SYSTEM, then start the instance
CONNECT system/manager
STARTUP NOMOUNT

# Supply the list of logfiles to the reader. The Options flag is set to indicate
# this is a new list.

EXECUTE DBMS_LOGMNR.ADD_LOGFILE(OPTIONS => dbms_logmnr.NEW, -
LOGFILENAME => 'log1orc1.ora');

# Add a file to the existing list. The Options flag is clear to indicate that
# you are adding a file to the existing list

EXECUTE DBMS_LOGMNR.ADD_LOGFILE(OPTIONS => dbms_logmnr.ADDFILE, -
LOGFILENAME => 'log2orc1.ora');
```

**Step 3: Starting LogMiner and Analyzing the Data** At this point the V$LOGMNR_CONTENTS table is available for queries. You decide to find all changes made by user JOEDEVO to the salary table. As you discover, JOEDEVO requested two operations: he deleted his old salary and then inserted a new, higher salary. You now have the data necessary to undo this operation (and perhaps to justify firing JOEDEVO!).

```
# Start the LogMiner. Limit the search to the specified time range.
EXECUTE DBMS_LOGMNR.START_LOGMNR( -
DICTFILENAME => 'orcldict.ora', -
STARTTIME => to_date('01-Jan-1998 08:30:00', 'DD-MON-YYYY HH:MI:SS') -
ENDTIME => to_date('01-Jan-1998 08:45:00', 'DD-MON-YYYY HH:MI:SS'));

SELECT sql_redo, sql_undo FROM v$logmnr_contents
WHERE username = 'JOEDEVO' AND tablename = 'SALARY';

# The following data is displayed (properly formatted)

SQL_REDO                                    SQL_UNDO
--------                                    --------
delete * from SALARY                        insert into SALARY(NAME,EMPNO, SAL)
where EMPNO = 12345                         values ('JOEDEVO', 12345,500)
and ROWID = 'AAABOOAABAAEPCABA';

insert into SALARY(NAME, EMPNO, SAL)        delete * from SALARY
values('JOEDEVO',12345,2500)                where EMPNO = 12345
```

```
                                                and ROWID = 'AAABOOAABAAEPCABA';
2 rows selected
```

### Calculating Table Access Statistics

The redo logs generated by Oracle RDBMS contain the history of all changes made to the database. Mining the redo logs can thus generate a wealth of information that can be used for tuning the database. In this example, you manage a direct marketing database and want to determine how productive the customer contacts have been in generating revenue for a two week period in August.

First, you start LogMiner and specify a range of times:

```
EXECUTE DBMS_LOGMNR.START_LOGMNR( -
STARTTIME => '07-Aug-98', -
ENDTIME => '15-Aug-98', -
DICTFILENAME => '/usr/local/dict.ora');
```

Next, you query V$LOGMNR_CONTENTS to determine which tables have been modified in the time range you specified:

```
SELECT seg_owner, seg_name, count(*) AS Hits FROM
v$logmnr_contents WHERE seg_name NOT LIKE '%$' GROUP BY
seg_owner, seg_name;

SEG_OWNER          SEG_NAME          Hits
---------          --------          ----
CUST               ACCOUNT            384
SCOTT              EMP                 12
SYS                DONOR               12
UNIV               DONOR              234
UNIV               EXECDONOR          325
UNIV               MEGADONOR           32
```

# 8

# Managing Job Queues

This chapter describes how to use job queues to schedule the periodic execution of PL/SQL code, and includes the following topics:

- SNP Background Processes
- Managing Job Queues
- Viewing Job Queue Information

# SNP Background Processes

To maximize performance and accommodate many users, a multi-process Oracle system uses some additional processes called *background processes*. Background processes consolidate functions that would otherwise be handled by multiple Oracle programs running for each user process. Background processes asynchronously perform I/O and monitor other Oracle processes to provide increased parallelism for better performance and reliability.

*SNP* background processes execute job queues. You can schedule routines, which are any PL/SQL code, to be performed periodically using the job queue. To schedule a job, you submit it to the job queue and specify the frequency at which the job is to be run. You can also alter, disable, or delete jobs you have submitted.

You must have at least one SNP process running to execute queued jobs in the background. SNP processes periodically wake up and execute any queued jobs that are due to be run. SNP background processes differ from other Oracle background processes, in that the failure of an SNP process does not cause the instance to fail. If an SNP process fails, Oracle restarts it.

SNP background processes will not execute jobs if the system has been started in restricted mode. However, you can use the ALTER SYSTEM statement to turn this behavior on and off as follows:

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

When you ENABLE a restricted session, SNP background processes do not execute jobs; when you DISABLE a restricted session, SNP background processes execute jobs.

> **See also:** For more information on SNP background processes, see *Oracle8i Concepts*.

## Multiple SNP processes

An instance can have up to 36 SNP processes, named SNP0 to SNP9, and SNPA to SNPZ. If an instance has multiple SNP processes, the task of executing queued jobs can be shared across these processes, thus improving performance. Note, however, that each job is run at any point in time by only one process. A single job cannot be shared simultaneously by multiple SNP processes.

### Starting up SNP processes

Job queue initialization parameters enable you to control the operation of the SNP background processes. When you set these parameters in the initialization parameter file for an instance, they take effect the next time you start the instance.

The JOB_QUEUE_PROCESSES parameter specifies the number of job queue process per instance. Different instances can have different values. This initialization parameter can be altered dynamically using the ALTER SYSTEM statement as shown in the following example.

```
ALTER SYSTEM SET JOB_QUEUE_PROCESSES = 10;
```

The JOB_QUEUE_INTERVAL parameter specifies the interval between wake ups for the SNP processes. Different instances can have different values.

> **See Also:** For a description of these initialization parameters, see the *Oracle8i Reference,*

## Managing Job Queues

This section describes the various aspects of managing job queues and includes the following topics:

- The DBMS_JOB Package
- Submitting a Job to the Job Queue
- How Jobs Execute
- Removing a Job from the Job Queue
- Altering a Job
- Broken Jobs
- Forcing a Job to Execute
- Terminating a Job

### The DBMS_JOB Package

To schedule and manage jobs in the job queue, use the procedures in the DBMS_JOB package. There are no database privileges associated with using job queues. Any user who can execute the job queue procedures can use the job queue.

The following procedures of the DBMS_JOB package and are included in this section as noted.

| Procedure | Description |
|---|---|
| SUBMIT | Submits a job to the job queue. See "Submitting a Job to the Job Queue" on page 8-4. |
| REMOVE | Removes a specified job from the job queue. See "Removing a Job from the Job Queue" on page 8-10 |
| CHANGE | Alters a specified job that has already been submitted to the job queue. You can alter the job description, the time at which the job will be run, or the interval between executions of the job. See "Altering a Job" on page 8-11. |
| WHAT | Alters the job description for a specified job. See "Altering a Job" on page 8-11. |
| NEXT_DATE | Alters the next execution time for a specified job. See "Altering a Job" on page 8-11. |
| INTERVAL | Alters the interval between executions for a specified job. See "Altering a Job" on page 8-11. |
| BROKEN | Disables job execution. If a job is marked as broken, Oracle does not attempt to execute it. See "Broken Jobs" on page 8-12. |
| RUN | Forces a specified job to run. See "Forcing a Job to Execute" on page 8-13. |

**See Also:** Syntax information for the DBMS_JOB package can be found in the *Oracle8i Supplied PL/SQL Packages Reference.*

For using the DBMS_JOB package in an Oracle Parallel Server environment, where other options are available, see *Oracle8i Parallel Server Administration, Deployment, and Performance.*

## Submitting a Job to the Job Queue

To submit a new job to the job queue, use the SUBMIT procedure in the DBMS_JOB package. You specify the following parameters with the SUBMIT procedure:

| Parameter | Description |
|---|---|
| JOB | An output parameter, this is the identifier assigned to the job you created. You must use this job number whenever you want to alter or remove the job. See "Job Numbers" on page 8-7. |

| Parameter | Description |
|---|---|
| WHAT | This is the PL/SQL code you want to have executed. See "Job Definitions" on page 8-7. |
| NEXT_DATE | This is the next date when the job will be run. The default value is SYSDATE. |
| INTERVAL | This is the date function that calculates the next time to execute the job. The default value is NULL. INTERVAL must evaluate to a future point in time or NULL. See "Job Execution Interval" on page 8-8. |
| NO_PARSE | This is a flag. If NO_PARSE is set to FALSE (the default), Oracle parses the procedure associated with the job. If NO_PARSE is set to TRUE, Oracle parses the procedure associated with the job the first time that the job is executed. If, for example, you want to submit a job before you have created the tables associated with the job, set NO_PARSE to TRUE. |

As an example, let's submit a new job to the job queue. The job calls the procedure DBMS_DDL.ANALYZE_OBJECT to generate optimizer statistics for the table DQUON.ACCOUNTS. The statistics are based on a sample of half the rows of the ACCOUNTS table. The job is run every 24 hours.

```
VARIABLE jobno number;
BEGIN
   DBMS_JOB.SUBMIT(:jobno,
      'dbms_ddl.analyze_object(''TABLE'',
      ''DQUON'', ''ACCOUNTS'',
      ''ESTIMATE'', NULL, 50);',
      SYSDATE, 'SYSDATE + 1');
   COMMIT;
END;
/
Statement processed.
PRINT jobno
JOBNO
----------
14144
```

## Job Environment

When you submit a job to the job queue or alter a job's definition, Oracle records the following environment characteristics:

- The current user

- The user submitting or altering a job
- The current schema (may be different from current user of submitting user if ALTER SESSION SET CURRENT_SCHEMA statement has been issued)
- MAC privileges (if appropriate)

Oracle also records the following NLS parameters:

- NLS_LANGUAGE
- NLS_TERRITORY
- NLS_CURRENCY
- NLS_ISO_CURRENCY
- NLS_NUMERIC_CHARACTERS
- NLS_DATE_FORMAT
- NLS_DATE_LANGUAGE
- NLS_SORT

Oracle restores these environment characteristics every time a job is executed. NLS_LANGUAGE and NLS_TERRITORY parameters are defaults for unspecified NLS parameters.

You can change a job's environment by using the DBMS_SQL package and the ALTER SESSION statement.

> **See Also:** For more information on the DBMS_SQL package, see the *Oracle8i Supplied PL/SQL Packages Reference*.
>
> For use of the ALTER SESSION statement to alter a job's environment, see *Oracle8i SQL Reference*.

### Jobs and Import/Export

Jobs can be exported and imported. Thus, if you define a job in one database, you can transfer it to another database. When exporting and importing jobs, the job's number, environment, and definition remain unchanged.

> **Note:** If the job number of a job you want to import matches the number of a job already existing in the database, you will not be allowed to import that job. Submit the job as a new job in the database.

### Job Owners

When you submit a job to the job queue, Oracle identifies you as the owner of the job. Only a job's owner can alter the job, force the job to run, or remove the job from the queue.

### Job Numbers

A queued job is identified by its job number. When you submit a job, its job number is automatically generated from the sequence SYS.JOBSEQ.

Once a job is assigned a job number, that number does not change. Even if the job is exported and imported, its job number remains the same.

### Job Definitions

The job definition is the PL/SQL code specified in the WHAT parameter of the SUBMIT procedure.

Normally, the job definition is a single call to a procedure. The procedure call can have any number of parameters.

> **Note:** In the job definition, use two single quotation marks around strings. Always include a semicolon at the end of the job definition.

There are special parameter values that Oracle recognizes in a job definition. These are shown below.

| Parameter | Mode | Description |
|---|---|---|
| JOB | IN | The number of the current job. |
| NEXT_DATE | IN / OUT | The date of the next execution of the job. The default value is SYSDATE. |
| BROKEN | IN / OUT | Status of job, broken or not broken. The IN value is FALSE. |

The following are examples of valid job definitions:

```
'myproc(''10-JAN-99'', next_date, broken);'
'scott.emppackage.give_raise(''JFEE'', 3000.00);'
'dbms_job.remove(job);'
```

### Job Execution Interval

The INTERVAL date function is evaluated immediately before a job is executed. If the job completes successfully, the date calculated from INTERVAL becomes the new NEXT_DATE. If the INTERVAL date function evaluates to NULL and the job completes successfully, the job is deleted from the queue.

If a job should be executed periodically at a set interval, use a date expression similar to `'SYSDATE + 7'` in the INTERVAL parameter. For example, if you set the execution interval to `'SYSDATE + 7'` on Monday, but for some reason (such as a network failure) the job is not executed until Thursday, `'SYSDATE + 7'` then executes every Thursday, not Monday.

If you always want to automatically execute a job at a specific time, regardless of the last execution (for example, every Monday), the INTERVAL and NEXT_DATE parameters should specify a date expression similar to `'NEXT_DAY(TRUNC(SYSDATE), ''MONDAY'')'`.

Below are shown some common date expressions used for job execution intervals.

| Date Expression | Evaluation |
|---|---|
| `'SYSDATE + 7'` | Exactly seven days from the last execution |
| `'SYSDATE + 1/48'` | Every half hour |
| `'NEXT_DAY(TRUNC(SYSDATE), ''MONDAY'') + 15/24'` | Every Monday at 3PM |
| `'NEXT_DAY(ADD_MONTHS(TRUNC(SYSDATE, ''Q''), 3), ''THURSDAY'')'` | First Thursday of each quarter |

**Note:** When specifying NEXT_DATE or INTERVAL, remember that date literals and strings must be enclosed in single quotation marks. Also, the value of INTERVAL must be enclosed in single quotation marks.

### Database Links and Jobs

If you submit a job that uses a database link, the link must include a username and password. Anonymous database links will not succeed.

## How Jobs Execute

SNP background processes execute jobs. To execute a job, the process creates a session to run the job.

When an SNP process runs a job, the job is run in the same environment in which it was submitted and with the owner's default privileges.

When you force a job to run using the procedure DBMS_JOB.RUN, the job is run by your user process. When your user process runs a job, it is run with your default privileges only. Privileges granted to you through roles are unavailable.

### Job Queue Locks

Oracle uses job queue locks to ensure that a job is executed one session at a time. When a job is being run, its session acquires a job queue (JQ) lock for that job. You can use the locking views in the data dictionary to examine information about locks currently held by sessions.

The following query lists the session identifier, lock type, and lock identifiers for all sessions holding JQ locks:

```
SELECT sid, type, id1, id2
   FROM v$lock
   WHERE type = 'JQ';

      SID TY       ID1       ID2
--------- -- --------- ---------
       12 JQ         0     14144
1 row selected.
```

In the query above, the identifier for the session holding the lock is 12. The ID1 lock identifier is always 0 for JQ locks. The ID2 lock identifier is the job number of the job the session is running. This view can be joined with the DBA_JOBS_RUNNING view to obtain more information about the job. See "Viewing Job Queue Information" on page 8-14 for more information about views.

### Job Execution Errors

When a job fails, information about the failure is recorded in a trace file and the alert log. Oracle writes message number ORA-12012 and includes the job number of the failed job.

The following can prevent the successful execution of queued jobs:

- Not having any SNP background processes to run the job

- A network or instance failure
- An exception when executing the job

If a job returns an error while Oracle is attempting to execute it, Oracle tries to execute it again. The first attempt is made after one minute, the second attempt after two minutes, the third after four minutes, and so on, with the interval doubling between each attempt. When the retry interval exceeds the execution interval, Oracle continues to retry the job at the normal execution interval. However, if the job fails 16 times, Oracle automatically marks the job as broken and no longer tries to execute it.

---

**Note:** If there is one SNP process, unless the time to execute all ready jobs exceeds the interval for job J, job J will execute at most once every JOB_QUEUE_INTERVAL. You will not see the exponential backoff described above.

For example, if `JOB_QUEUE_INTERVAL = 600` (10 minutes), but the interval for executing the job is specified as 3 minutes, there will be no exponential backoff observed since the SNP process will not "wake up" again to retry the job until it reaches its 10 minute interval. In effect, the job will execute once every 10 minutes, for up to 16 tries.

Also, because the exponential backoff is limited by the interval for job J, you will not see any exponential backoff if the interval for job J is less than or equal to one minute.

---

Thus, if you can correct the problem that is preventing a job from running before the job has failed sixteen times, Oracle will eventually run that job again.

**See Also:** For more information about the locking views, see the *Oracle8i Reference.*

For more information about locking, see *Oracle8i Concepts.*

## Removing a Job from the Job Queue

To remove a job from the job queue, use the REMOVE procedure in the DBMS_JOB package.

The following statement removes job number 14144 from the job queue:

```
DBMS_JOB.REMOVE(14144);
```

**Restrictions:**

- You can remove currently executing jobs from the job queue. However, the job will not be interrupted, and the current execution will be completed.
- You can remove only jobs you own. If you try to remove a job that you do not own, you receive a message that states the job is not in the job queue.

## Altering a Job

To alter a job that has been submitted to the job queue, use the procedures CHANGE, WHAT, NEXT_DATE, or INTERVAL in the DBMS_JOB package.

**Restriction:**

- You can alter only jobs that you own. If you try to alter a job that you do not own, you receive a message that states the job is not in the job queue.

### CHANGE

You can alter any of the user-definable parameters associated with a job by calling the DBMS_JOB.CHANGE procedure.

In this example, the job identified as 14144 is now executed every three days:

```
DBMS_JOB.CHANGE(14144, null, null, 'SYSDATE + 3');
```

If you specify NULL for WHAT, NEXT_DATE, or INTERVAL when you call the procedure CHANGE, the current value remains unchanged.

---

**Note:** When you change a job's definition using the WHAT parameter in the procedure CHANGE, Oracle records your current environment. This becomes the new environment for the job.

---

### WHAT

You can alter the definition of a job by calling the DBMS_JOB.WHAT procedure.

The following example changes the definition of the job identified as 14144:

```
DBMS_JOB.WHAT(14144, 'scott.emppackage.give_raise(''RBAYLIS'', 6000.00);'
```

**Note:** When you execute procedure WHAT, Oracle records your current environment. This becomes the new environment for the job.

### NEXT_DATE

You can alter the next date that Oracle executes a job by calling the DBMS_JOB.NEXT_DATE procedure, as shown in the following example:

```
DBMS_JOB.NEXT_DATE(14144, 'SYSDATE + 1');
```

### INTERVAL

The following example illustrates changing the execution interval for a job by calling the DBMS_JOB.INTERVAL procedure:

```
DBMS_JOB.INTERVAL(14144, 'NULL');
```

In this case, the job will not run again after it successfully executes.

## Broken Jobs

A job is labeled as either broken or not broken. Oracle does not attempt to run broken jobs. However, you can force a broken job to run by calling the procedure DBMS_JOB.RUN.

### How a Job Becomes Broken

When you submit a job it is considered not broken.

There are two ways a job can break:

- Oracle has failed to successfully execute the job after 16 attempts.
- You have marked the job as broken, using the procedure DBMS_JOB.BROKEN:

  ```
  DBMS_JOB.BROKEN(14144, TRUE)
  ```

Once a job has been marked as broken, Oracle will not attempt to execute the job until you either mark the job as not broken, or force the job to be executed by calling the procedure DBMS_JOB.RUN.

The following example marks job 14144 as not broken and sets its next execution date to the following Monday:

```
DBMS_JOB.BROKEN(14144, FALSE, NEXT_DAY(SYSDATE, 'MONDAY'));
```

**Restriction:**

- You can mark as broken only jobs that you own. If you try to mark a job you do not own, you receive a message stating that the job is not in the job queue.

### Running Broken Jobs

If a problem has caused a job to fail 16 times, Oracle marks the job as broken. Once you have fixed this problem, you can run the job by either:

- Forcing the job to run by calling DBMS_JOB.RUN
- Marking the job as not broken by calling DBMS_JOB.BROKEN and waiting for Oracle to execute the job

If you force the job to run by calling the procedure DBMS_JOB.RUN, Oracle runs the job immediately. If the job succeeds, then Oracle labels the job as not broken and resets its count of the number of failed executions for the job.

Once you reset a job's broken flag (by calling either RUN or BROKEN), job execution resumes according to the scheduled execution intervals set for the job.

## Forcing a Job to Execute

There may be times when you would like to manually execute a job. For example, if you have fixed a broken job, you may want to test the job immediately by forcing it to execute. To force a job to be executed immediately, use the procedure RUN in the DBMS_JOB package.

When you run a job using DBMS_JOB.RUN, Oracle recomputes the next execution date. For example, if you create a job on a Monday with a NEXT_DATE value of `'SYSDATE'` and an INTERVAL value of `'SYSDATE + 7'`, the job is run every 7 days starting on Monday. However, if you execute RUN on Wednesday, the next execution date will be the next Wednesday.

The following statement runs job 14144 in your session and recomputes the next execution date:

```
DBMS_JOB.RUN(14144);
```

---

**Note:** When you force a job to run, the job is executed in your current session. Running the job reinitializes your session's packages.

---

**Restrictions:**

- You can only run jobs that you own. If you try to run a job that you do not own, you receive a message that states the job is not in the job queue.
- The procedure RUN contains an implicit commit. Once you execute a job using RUN, you cannot roll back.

## Terminating a Job

You can terminate a running job by marking the job as broken, identifying the session running the job, and disconnecting that session. You should mark the job as broken, so that Oracle does not attempt to run the job again.

After you have identified the session running the job (via V$SESSION), you can disconnect the session using the SQL statement ALTER SYSTEM.

For examples of viewing information about jobs and sessions, see the following section, "Viewing Job Queue Information".

> **See Also:** For more information on V$SESSION, see the *Oracle8i Reference*.

# Viewing Job Queue Information

You can view information about jobs in the job queue via the data dictionary views listed below:

| View | Description |
|---|---|
| DBA_JOBS | Lists all the jobs in the database. |
| USER_JOBS | Lists all jobs owned by the user. |
| DBA_JOBS_RUNNING | Lists all jobs in the database that are currently running. This view can be joined with V$LOCK to identify jobs that have locks. |

For example, you can display information about a job's status and failed executions. The following sample query creates a listing of the job number, next execution time, failures, and broken status for each job you have submitted:

```
SELECT job, next_date, next_sec, failures, broken
   FROM user_jobs;
```

```
JOB      NEXT_DATE  NEXT_SEC  FAILURES  B
-------  ---------  --------  --------  -
   9125  01-NOV-98  00:00:00         4  N
  14144  24-OCT-99  16:35:35         0  N
  41762  01-JAN-00  00:00:00        16  Y
3 rows selected.
```

You can also display information about jobs currently running. The following sample query lists the session identifier, job number, user who submitted the job, and the start times for all currently running jobs:

```
SELECT sid, r.job, log_user, r.this_date, r.this_sec
  FROM dba_jobs_running r, dba_jobs j
  WHERE r.job = j.job;

SID        JOB        LOG_USER      THIS_DATE  THIS_SEC
-----  ----------   -------------   ---------  --------
   12       14144   JFEE            24-OCT-94  17:21:24
   25        8536   SCOTT           24-OCT-94  16:45:12
2 rows selected.
```

> **See Also:** For more information on data dictionary views, see the *Oracle8i Reference.*

# Part III

## Database Storage

Part III describes some of the underlying database structures which support the creation of database objects and preserve transaction integrity. It includes the following chapters:

- Chapter 9, "Managing Tablespaces"
- Chapter 10, "Managing Datafiles"
- Chapter 11, "Managing Rollback Segments"

# 9

# Managing Tablespaces

This chapter describes the various aspects of tablespace management, and includes the following topics:

- Guidelines for Managing Tablespaces
- Creating Tablespaces
- Managing Tablespace Allocation
- Altering Tablespace Availability
- Read-Only Tablespaces
- Dropping Tablespaces
- Using the DBMS_SPACE_ADMIN Package
- Transporting Tablespaces Between Databases
- Viewing Information About Tablespaces

# Guidelines for Managing Tablespaces

Before working with tablespaces of an Oracle database, familiarize yourself with the guidelines provided in the following sections:

- Use Multiple Tablespaces
- Specify Tablespace Storage Parameters
- Assign Tablespace Quotas to Users

> **See Also:** For a complete discussion of database structure, space management, tablespaces, and datafiles, see *Oracle8i Concepts*.

## Use Multiple Tablespaces

Using multiple tablespaces allows you more flexibility in performing database operations. For example, when a database has multiple tablespaces, you can perform the following tasks:

- Separate user data from data dictionary data to reduce contention among dictionary objects and schema objects for the same datafiles.
- Separate one application's data from another's to prevent multiple applications from being affected if a tablespace must to be taken offline.
- Store different tablespaces' datafiles on separate disk drives to reduce I/O contention.
- Separate rollback segment data from user data, preventing a single disk failure from causing permanent loss of data.
- Take individual tablespaces offline while others remain online, providing better overall availability.
- Reserve a tablespace for a particular type of database use, such as high update activity, read-only activity, or temporary segment storage; thus allowing you to optimize usage of the tablespace.
- Back up individual tablespaces.

Some operating systems set a limit on the number of files that can be simultaneously open; these limits can affect the number of tablespaces that can be simultaneously online. To avoid exceeding your operating system's limit, plan your tablespaces efficiently. Create only enough tablespaces to fill 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 the autoextend option set on, rather than many small datafiles.

Review your data in light of these factors and decide how many tablespaces you will need for your database design.

## Specify Tablespace Storage Parameters

When you create a new tablespace, you can specify default storage parameters for objects that will be created in the tablespace. Storage parameters specified when an object is created override the default storage parameters of the tablespace containing the object. If you do not specify storage parameters when creating an object, the object's segment automatically uses the default storage parameters for the tablespace.

Set the default storage parameters for a tablespace to account for the size of a typical object that the tablespace will contain (you estimate this size). You can specify different storage parameters for an unusual or exceptional object when creating that object. You can also alter your default storage parameters at a later time.

---

**Note:** If you do not specify the default storage parameters for a new tablespace, the default storage parameters of Oracle for your operating system become the tablespace's default storage parameters.

---

Storage parameters are discussed in more detail in "Managing Tablespace Allocation" on page 9-10.

## Assign Tablespace Quotas to Users

Grant to users who will be creating tables, clusters, snapshots, 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's segment. The security administrator is responsible for granting the required privileges to create objects to database users and for assigning tablespace quotas, as necessary, to database users.

To learn more about assigning tablespace quotas to database users, see "Assigning Tablespace Quotas" on page 22-17.

# Creating Tablespaces

Before you can create a tablespace you must create a database to contain it. The first tablespace in any database is always the SYSTEM tablespace, and the first datafiles of any database are automatically allocated in the SYSTEM tablespace during database creation. Creating a database was discussed in Chapter 2.

The steps for creating tablespaces vary by operating system. In all cases, however, you should create through your operating system a directory structure in which your datafiles will be allocated. On most operating systems you indicate the size and fully specified filenames when creating a new tablespace or altering a tablespace by adding datafiles. In each situation Oracle automatically allocates and formats the datafiles as specified. However, on some operating systems, you must create the datafiles before installation.

---

**Note:** No data can be inserted into any tablespace until the current instance has acquired at least two rollback segments (including the SYSTEM rollback segment). Rollback segments are discussed in Chapter 11, "Managing Rollback Segments".

---

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.

Prior to Oracle8*i*, all tablespaces were created as *dictionary-managed*. Dictionary-managed tablespaces rely on SQL dictionary tables to track space utilization. Beginning with Oracle8*i*, you can now create *locally managed* tablespaces, which use bitmaps (instead of SQL dictionary tables) to track used and free space. For compatibility with earlier releases, dictionary-managed has been preserved as the default type of tablespace, but Oracle recommends that you now use locally managed tablespaces.

You can also create temporary tablespaces, which can be either dictionary-managed or locally managed. Each type of tablespace is discussed separately in the following sections:

- Dictionary-Managed Tablespaces
- Locally Managed Tablespaces
- Temporary Tablespaces

**See Also:** See the Oracle installation documentation for your operating system for information about tablespaces that are created at installation.

For more information about the syntax and use of the CREATE TABLESPACE, CREATE TEMPORARY TABLESPACE, ALTER TABLESPACE, and ALTER DATABASE statements, see *Oracle8i SQL Reference*.

## Dictionary-Managed Tablespaces

For backwards compatibility, dictionary-managed remains the default method of space management in a tablespace. Oracle updates the appropriate tables in the data dictionary whenever an extent is allocated, or freed for reuse.

### Creating a Dictionary-Managed Tablespace

As an example, let's create the tablespace TBSA, with the following characteristics:

- The data of the new tablespace is contained in a single datafile, 50M in size.
- The default storage parameters for any segments created in this tablespace are explicitly set.

The following statement creates the tablespace TBSA:

```
CREATE TABLESPACE tbsa
    DATAFILE '/u02/oracle/data/tbsa01.dbf' SIZE 50M
    DEFAULT STORAGE (
        INITIAL 50K
        NEXT 50K
        MINEXTENTS 2
        MAXEXTENTS 50
        PCTINCREASE 0);
```

**Note:** If you do not fully specify the filename for a datafile, Oracle creates the datafile in the default database directory or the current directory, depending upon your operating system. Oracle recommends you always specify a fully qualified name.

### Altering a Dictionary-Managed Tablespace

Reasons for issuing an ALTER TABLESPACE statement include, but are not limited to:

- Changing default storage parameters. See "Altering Storage Settings for Tablespaces" on page 9-12.
- Coalescing free space in a tablespace. See "Coalescing Free Space in Dictionary-Managed Tablespaces" on page 9-12.
- Altering a tablespace's availability (ONLINE / OFFLINE). See "Altering Tablespace Availability" on page 9-15.
- Making a tablespace read-only or read-write. See "Read-Only Tablespaces" on page 9-17.
- Adding or renaming a datafile, or enabling / disabling the autoextension of the size of a datafile in the tablespace. See Chapter 10, "Managing Datafiles".

Still other situations for altering a tablespace may be found elsewhere in this book.

## Locally Managed Tablespaces

Locally managed tablespaces track all extent information in the tablespace itself, using bitmaps, resulting in the following benefits:

- Improved concurrency and speed of space operations, as space allocations and deallocations predominantly modify locally managed resources (bitmaps stored in header files) rather than requiring centrally managed resources such as enqueues.
- Improved performance, because recursive operations that are sometimes required during dictionary-managed space allocation are eliminated.
- Readable standby databases are allowed, as locally managed temporary tablespaces (used for sorts, etc.) are locally managed and thus do not generate any rollback or redo.
- Simplified space allocation—when the AUTOALLOCATE clause is specified, appropriate extent size is automatically selected.
- Reduced user reliance on the data dictionary because necessary information is stored in file headers and bitmap blocks.

Additionally, the DBMS_SPACE_ADMIN package, discussed in "Using the DBMS_SPACE_ADMIN Package" on page 9-23, provides maintenance procedures for locally managed tablespaces.

### Creating a Locally Managed Tablespace

To create a locally managed tablespace, you specify LOCAL in the extent management clause of the CREATE TABLESPACE statement. You then have two options. You can have Oracle manage extents for you automatically with the AUTOALLOCATE option, or you can specify that the tablespace is managed with uniform extents of a specific size (UNIFORM SIZE).

If the tablespace is expected to contain objects of varying sizes requiring different extent sizes and having many extents, then AUTOALLOCATE is the best choice. If it is not important to you to have a lot of control over space allocation and deallocation, AUTOALLOCATE presents a simplified way for you to manage a tablespace. Some space may be wasted but the benefit of having Oracle manage your space most likely outweighs this.

On the other hand, 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. It ensures that you will never have an unusable amount of space in your tablespace.

The following statement creates a locally managed tablespace named LMTBSB, where AUTOALLOCATE causes Oracle to automatically manage extent size.

```
CREATE TABLESPACE lmtbsb DATAFILE '/u02/oracle/data/lmtbsb01.dbf' SIZE 50M
    EXTENT MANAGEMENT LOCAL AUTOALLOCATE;
```

Alternatively, this tablespace could be created specifying the UNIFORM clause. In this example, a 128K extent size is specified. Each 128K extent (which is equivalent to 64 Oracle blocks) is represented by a bit in the bitmap for this file.

```
CREATE TABLESPACE lmtbsb DATAFILE '/u02/oracle/data/lmtbsb01.dbf' SIZE 50M
    EXTENT MANAGEMENT LOCAL UNIFORM SIZE 128K;
```

You cannot create a locally managed system tablespace.

---

**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 you do not specify the SIZE parameter in the extent management clause when UNIFORM is specified, the default extent size is 1MB. Therefore, in this case, the size specified for the datafile must be larger (at least one block plus space for the bitmap) than 1MB.

---

### Altering a Locally Managed Tablespace

You can alter a locally managed tablespace for many of the same reasons as a dictionary-managed tablespace. However, altering storage parameters is not an option and coalescing free extents is unnecessary for locally managed tablespaces. You also cannot alter a locally managed tablespace to a locally managed temporary tablespace.

## Temporary Tablespaces

If you wish to improve the concurrence of multiple sort operations, reduce their overhead, or avoid Oracle space management operations altogether, you can create *temporary tablespaces*.

Within a temporary tablespace, all sort operations for a given instance and tablespace share a single *sort segment*. Sort segments exist for every instance that performs sort operations within a given tablespace. The sort segment is created by the first statement that uses a temporary tablespace for sorting, after startup, and is released only at shutdown. An extent cannot be shared by multiple transactions.

You can view the allocation and deallocation of space in a temporary tablespace sort segment via the V$SORT_SEGMENT view, and the V$SORT_USAGE view identifies the current sort users in those segments.

You cannot explicitly create objects in a temporary tablespace. Assigning temporary tablespace to users is discussed in Chapter 22, "Managing Users and Resources".

> **See Also:** For more information about the V$SORT_SEGMENT and V$SORT_USAGE views, see the *Oracle8i Reference.*
>
> A discussion on tuning sorts is contained in *Oracle8i Designing and Tuning for Performance.*

### Creating a Dictionary-Managed Temporary Tablespace

To identify a tablespace as temporary during tablespace creation, specify the TEMPORARY keyword on the CREATE TABLESPACE statement. The following statement creates a temporary dictionary-managed tablespace.

```
CREATE TABLESPACE sort
     DATAFILE '/u02/oracle/data/sort01.dbf' SIZE 50M
        DEFAULT STORAGE (
        INITIAL 2M
        NEXT 2M
        MINEXTENTS 1
        PCTINCREASE 0)
```

```
TEMPORARY;
```

To change an existing permanent dictionary-managed tablespace to a temporary tablespace, use the ALTER TABLESPACE statement. For example:

```
ALTER TABLESPACE tbsa TEMPORARY;
```

You may issue the ALTER TABLESPACE statement against a dictionary-managed temporary tablespace using many of the same keywords and clauses as for a permanent dictionary-managed tablespace. Any restrictions are noted in the *Oracle8i SQL Reference*.

---

**Note:** You can take dictionary-managed temporary tablespaces offline. Returning them online does not affect their temporary status.

---

### 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. Therefore, they can be used in standby or read-only databases.

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. See "Viewing Information About Tablespaces" on page 9-39 for a summary of views relating to tablespaces.

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) 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;
```

Except for adding a tempfile, as illustrated in the following example, you cannot use the ALTER TABLESPACE statement for a locally managed temporary tablespace.

```
ALTER TABLESPACE lmtemp
   ADD TEMPFILE '/u02/oracle/data/lmtemp02.dbf' SIZE 2M REUSE;
```

> **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.

However, the ALTER DATABASE statement can be used to alter tempfiles.

The following statements take offline and bring online temporary files:

```
ALTER DATABASE TEMPFILE '/u02/oracle/data/lmtemp02.dbf' OFFLINE;
ALTER DATABASE TEMPFILE '/u02/oracle/data/lmtemp02.dbf' ONLINE;
```

The following statement resizes temporary file `u02/oracle/data/lmtemp02.dbf` to 4M:

```
ALTER DATABASE TEMPFILE '/u02/oracle/data/lmtemp02.dbf' RESIZE 4M;
```

The following statement drops a temporary file:

```
ALTER DATABASE TEMPFILE '/u02/oracle/data/lmtemp02.dbf' DROP;
```

It is also possible, but not shown, to AUTOEXTEND a tempfile and to rename (RENAME FILE) a tempfile.

## Managing Tablespace Allocation

When you create a tablespace, you determine what physical datafile(s) comprise the tablespace and, for dictionary-managed tablespaces, what the default storage characteristics for the tablespace will be. Both of these attributes of the tablespace can be changed later. The default storage characteristics of a tablespace are discussed here; managing datafiles is the subject of Chapter 10, "Managing Datafiles".

Over time, the free space in a dictionary-managed tablespace can become fragmented, making it difficult to allocate new extents. Ways of defragmenting this free space are also discussed below.

These sections follow:

## Storage Parameters in Locally Managed Tablespaces

When you allocate a locally managed tablespace, you cannot specify default storage parameters or minimum extent size. If AUTOALLOCATE is specified, the tablespace is system managed with the smallest extent size being 64K. If UNIFORM SIZE is specified, then the tablespace is managed with uniform size extents of the specified SIZE. The default SIZE is 1M.

When you allocate segments in a locally managed tablespace, the storage clause is interpreted differently than for dictionary-managed tablespaces. When an object is created in a locally managed tablespace, Oracle uses its INITIAL, NEXT, and MINEXTENTS parameters to calculate the initial size of the object's segment.

## Storage Parameters for Dictionary-Managed Tablespaces

Storage parameters affect both how long it takes to access data stored in the database and how efficiently space in the database is used.

> **See Also:** For a discussion of the effects of these parameters, see *Oracle8i Designing and Tuning for Performance.*
>
> For a complete description of storage parameters, see the *Oracle8i SQL Reference.*

### Specifying Default Storage Parameters

The following parameters influence segment storage allocation in a tablespace. They are referred to as storage parameters, and are contained in the *storage_clause* of the CREATE TABLESPACE statement.

| | |
|---|---|
| INITIAL | Defines the size in bytes (K or M) of the first extent in the segment. |
| NEXT | Defines the size of the second extent in bytes. (K or M) |
| PCTINCREASE | The percent by which each extent, after the second (NEXT) extent, grows. |

| | |
|---|---|
| MINEXTENTS | The number of extents allocated when a segment is first created in the tablespace. |
| MAXEXTENTS | Determines the maximum number of extents that a segment can have. Can also be specified as UNLIMITED. |

Another parameter on the CREATE TABLESPACE statement, MIMIMUM EXTENT, also influences segment allocation. If specified, it ensures that all free and allocated extents in the tablespace are at least as large as, and a multiple of, a specified number of bytes (K or M). This provides one means of controlling free space fragmentation in the tablespace.

### Altering Storage Settings for Tablespaces

You can change the default storage parameters of a tablespace to change the default specifications for *future* objects created in the tablespace. To change the default storage parameters for objects subsequently created in the tablespace, use the SQL statement ALTER TABLESPACE.

```
ALTER TABLESPACE users
    DEFAULT STORAGE (
       NEXT 100K
       MAXEXTENTS 20
       PCTINCREASE 0);
```

The INITIAL and MINEXTENTS keywords cannot be specified in an ALTER statement. New values for the default storage parameters of a tablespace affect only future extents allocated for the segments within the tablespace.

## Coalescing Free Space in Dictionary-Managed Tablespaces

A free extent in a tablespace is comprised of a collection of contiguous free blocks. When allocating new extents to a tablespace segment, the free extent closest in size to the required extent is used. In some cases, when segments are dropped, their extents are deallocated and marked as free, but any adjacent free extents are not immediately recombined into larger free extents. The result is fragmentation that makes allocation of larger extents more difficult.

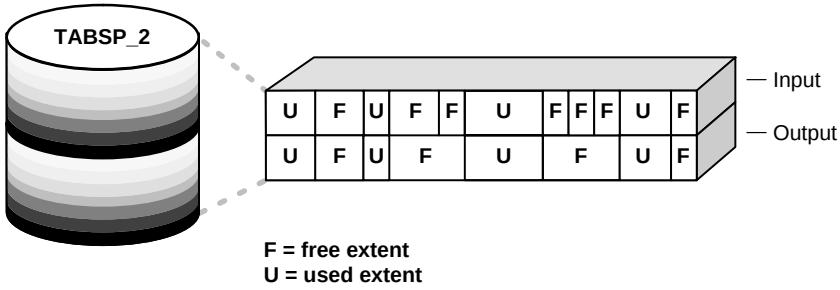
This fragmentation is addressed in several ways.

1. When attempting to allocate a new extent for a segment, Oracle will first try to find a free extent large enough for the new extent. If no large enough free extent is found, Oracle will then coalesce adjacent free extents in the tablespace and

look again. This coalescing is *always* performed by Oracle whenever it cannot find a free extent into which the new extent will fit.

2. The SMON background process periodically coalesces neighboring free extents. When the PCTINCREASE value for a tablespace in nonzero. If you set PCTINCREASE=0, no coalescing of free extents will occur. If you are concerned about the overhead of SMON's ongoing coalescing, an alternative is to set PCTINCREASE=0, and periodically coalesce free space as noted in (4).
3. When a segment is dropped or truncated, a limited form of coalescing is performed if the PCTINCREASE value for the segment is not zero. This is done even if PCTINCREASE=0 for the tablespace containing the segment.
4. You can use the ALTER TABLESPACE...COALESCE statement to manually coalesce any adjacent free extents.

The process of coalescing free space is illustrated in the following figure.




Coalescing free space is not necessary for locally managed tablespaces.

For detailed information on allocating extents and coalescing free space, see *Oracle8i Concepts.*

### Manually Coalescing Free Space

If you find that fragmentation of space in a tablespace is high (contiguous space on your disk appears as non-contiguous), you can coalesce any free space using the ALTER TABLESPACE...COALESCE statement. You must have the ALTER TABLESPACE system privilege to coalesce tablespaces.

You might want to use this statement if PCTINCREASE=0, or you can use it to supplement SMON and extent allocation coalescing. Note that if all extents within the tablespace are of the same size, coalescing is not necessary. This would be the case if the default PCTINCREASE value for the tablespace were set to zero, all

segments used the default storage parameters of the tablespace, and INITIAL=NEXT=MINIMUM EXTENT.

The following statement coalesces free space in the tablespace TABSP_4.

```
ALTER TABLESPACE tabsp_4 COALESCE;
```

Like other options of the ALTER TABLESPACE statement, the COALESCE option is exclusive: when specified, it must be the only option.

This statement does not coalesce free extents that are separated by data extents. If you observe that there are many free extents located between data extents, you must reorganize the tablespace (for example, by exporting and importing its data) to create useful free space extents.

### Monitoring Free Space

You can use the DBA_FREE_SPACE and DBA_FREE_SPACE_COALESCED views to monitor free space and to display statistics for coalescing activity. The following statement displays the free space in tablespace TABSP_4.

```
SELECT  block_id, bytes, blocks
FROM  dba_free_space
WHERE tablespace_name = 'TABSP_4'
ORDER BY block_id;

BLOCK_ID   BYTES      BLOCKS
---------- ---------- ----------
         2      16384          2
         4      16384          2
         6      81920         10
        16      16384          2
        27      16384          2
        29      16384          2
        31      16384          2
        33      16384          2
        35      16384          2
        37      16384          2
        39       8192          1
        40       8192          1
        41     196608         24
13 rows selected.
```

This view shows that there is adjacent free space in TABSP_4 (e.g., blocks starting with BLOCK_IDs 2, 4, 6, 16) that has not been coalesced. After coalescing the

tablespace using the ALTER TABLE statement shown previously, the results of this query would read:

```
 BLOCK_ID   BYTES      BLOCKS
---------- ---------- ----------
         2     131072         16
        27     311296         38
2 rows selected.
```

To display statistics about coalescing activity use the DBA_FREE_SPACE_ COALESCED view. It is also useful in determining if you need to coalesce space. For more information about either view, see *Oracle8i Reference*.

# Altering Tablespace Availability

You can take an online tablespace offline so that this portion of the database is temporarily unavailable for general use but the rest is open and available. 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, use the SQL statement ALTER TABLESPACE. You must have the ALTER TABLESPACE or MANAGE TABLESPACE system privilege to perform this action.

## 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.

When a tablespace is taken offline, Oracle takes all the associated files offline. The SYSTEM tablespace may never be taken offline.

You can specify any of the following options when taking a tablespace offline:

| | |
|---|---|
| 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. With normal offline priority, Oracle takes a checkpoint for all datafiles of the tablespace as it takes them offline. |
| TEMPORARY | A tablespace can be taken offline temporarily, even if there are error conditions for one or more files of the tablespace. With temporary offline priority, Oracle takes offline the datafiles that are not already offline, checkpointing them as it does so.<br><br>If no files are offline, but you use the temporary option, 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 Oracle's taking a checkpoint on any of the datafiles. With immediate offline priority, 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. |
| FOR RECOVER | Takes the production database tablespaces in the recovery set offline for tablespace point-in-time recovery. For additional information, see *Oracle8i Backup and Recovery Guide.* |

**WARNING: If you must take a tablespace offline, use the NORMAL option (the default) if possible; this guarantees that the tablespace will not require recovery to come back online, even if you reset the redo log sequence (using an ALTER DATABASE OPEN RESETLOGS statement after incomplete media recovery) before bringing the tablespace back online.**

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 options.

The following example takes the USERS tablespace offline normally:

```
ALTER TABLESPACE users OFFLINE NORMAL;
```

Before taking an online tablespace offline, consider the following:

- Verify that the tablespace contains no active rollback segments. Such a tablespace may not be taken offline. For more information, see "Taking Rollback Segments Offline" on page 11-11.
- You may want to alter the tablespace allocation of any users who have been assigned the tablespace as either a default of temporary tablespace, as they will not be able to access objects or sort areas in the tablespace while it is offline.

### 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.

---

**Note:** If a tablespace to be brought online was not taken offline "cleanly" (that is, using the NORMAL option of the ALTER TABLESPACE OFFLINE statement), you must first perform media recovery on the tablespace before bringing it online. Otherwise, Oracle returns an error and the tablespace remains offline.

---

The following statement brings the USERS tablespace online:

```
ALTER TABLESPACE users ONLINE;
```

## 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, but they also provide a means of completely protecting historical data so that no one can modify the data after the fact. Making a tablespace read-only prevents updates on all tables in the tablespace, regardless of a user's update privilege level.

Read-only tablespaces can also be transported to other databases. See Transporting Tablespaces Between Databases on page 9-26 for more information on that functionality.

> **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 may meet such requirements by using the transportable tablespace feature.

You can drop items, such as tables or indexes, from a read-only tablespace, but you cannot create or alter objects in the 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.

Since read-only tablespaces can never be updated, they can reside on CD-ROM or WORM (Write Once-Read Many) devices. See "Creating a Read-Only Tablespace on a WORM Device" on page 9-21.

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:** For more information about read-only tablespaces, see *Oracle8i Concepts*,

## Making a Tablespace Read-Only

All tablespaces are initially created as read-write. Use the READ ONLY keywords 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 must not contain any active rollback segments (this would be the normal situation, as a data tablespace should not contain rollback segments).

For this reason, the SYSTEM tablespace can never be made read-only, since it contains the SYSTEM rollback segment. Additionally, because any rollback segments of a read-only tablespace would not be accessible, you would have to drop the rollback segments before you made a tablespace read-only.

- The tablespace must not currently be involved in an online backup, since 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 might want to 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 will ensure that the data blocks in the tablespace can be subsequently accessed most efficiently. This eliminates the need for Oracle 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 do not have to wait for transactions to complete before issuing the ALTER TABLESPACE...READ ONLY statement. When the statement is issued, the target tablespace goes into a transitional read-only mode in which no further DML statements are allowed, though existing transactions that modified the tablespace will be allowed to commit or rollback. Once this occurs, the tablespace is quiesced, with respect to active transactions.

---

**Note:** This transitional read-only state only occurs if the value of the initialization parameter COMPATIBLE is 8.1.0 or greater. For parameter values 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 tablespace to quiesce, it is possible to identify the transactions which are preventing the read-only state from taking effect. The owners of these transactions can be notified and a decision can be made to terminate the transactions, if necessary. The following example illustrates how you might identify the blocking transactions.

- Identify the transaction entry for the ALTER TABLESPACE...READ ONLY statement.

```
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$TRANSACTION view. Displaying this view sorted by ascending start SCN lists the transactions in execution order. Knowing the transaction entry for the read-only statement, it can be located in the V$TRANSACTION view. All transactions with lesser or equal start SCN 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 since no changes can be made to it.

> **See Also:** For information about recovering a database with read-only datafiles, see the *Oracle8i Backup and Recovery Guide*.

## Making a Read-Only Tablespace Writable

Use the READ WRITE keywords in the ALTER TABLESPACE SQL 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 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 will not be detected at open time. It will only be discovered when there is an attempt to access it.
- ALTER DATABASE CHECK DATAFILES will not check read-only files.

- ALTER TABLESPACE <name> ONLINE and ALTER DATABASE DATAFILE <name> ONLINE will not check read-only files. They will be checked only upon the first access.
- V$RECOVER_FILE, V$BACKUP, and V$DATAFILE_HEADER will not access read-only files; read-only files will be indicated in the results list with the error "DELAYED OPEN", with zeroes for the values of other columns.
- V$DATAFILE will not access read-only files; read-only files will have a size of '0' listed.
- V$RECOVER_LOG will not access read-only files; logs they may need for recovery will not be added to the list.
- ALTER DATABASE NOARCHIVELOG will not access read-only files; it will proceed even if there is a read-only file that needs recovery.

**Notes:**

- The RECOVER DATABASE and ALTER DATABASE OPEN RESETLOGS will 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 controlfile is used, the read-only status of some files may be inaccurate. This may cause some of these operations to return unexpected results. Care should be taken in this situation.

## 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. Any tablespace in an Oracle database, except the SYSTEM tablespace, can be dropped. You must have the DROP TABLESPACE system privilege to drop a tablespace.

**WARNING: Once a tablespace has been dropped, the tablespace's data 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, only the file pointers in the control files of the associated database are dropped. The datafiles that constituted the dropped tablespace continue to exist. To free previously used disk space, delete the datafiles of the dropped tablespace using the appropriate commands of your operating system after completing this procedure.

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 an active rollback segment, you cannot drop the tablespace. For simplicity, take the tablespace offline before dropping it.

After a tablespace is dropped, the tablespace's entry remains in the data dictionary (see the DBA_TABLESPACES view), but the tablespace's status is changed to INVALID.

To drop a tablespace, use the SQL statement DROP TABLESPACE. 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 option. Use the CASCADE CONSTRAINTS option to drop all referential integrity constraints from tables outside the tablespace that refer to primary and unique keys of tables inside the tablespace.

## Using the DBMS_SPACE_ADMIN Package

The DBMS_SPACE_ADMIN package provides administrators with defect diagnosis and repair functionality for locally managed tablespaces. The DBMS_SPACE_ ADMIN package contains the following procedures:

| Procedure | Description |
|---|---|
| SEGMENT_VERIFY | Verifies the consistency of the extent map of the segment. |
| 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 extent map(s) of a given segment. |
| TABLESPACE_VERIFY | Verifies that the bitmaps and extent maps for the segments in the tablespace are in sync. |
| TABLESPACE_REBUILD_BITMAPS | Rebuilds the appropriate bitmap(s). |
| TABLESPACE_FIX_BITMAPS | Marks the appropriate DBA range (extent) as free or used in bitmap. |
| TABLESPACE_REBUILD_QUOTAS | Rebuilds quotas for given tablespace. |
| TABLESPACE_MIGRATE_FROM_LOCAL | Migrates a locally managed tablespace to dictionary-managed tablespace. |
| TABLESPACE_MIGRATE_TO_LOCAL | Migrates a tablespace from dictionary-managed format to locally managed format. |
| TABLESPACE_RELOCATE_BITMAPS | Relocates the bitmaps to the destination specified. |
| TABLESPACE_FIX_SEGMENT_STATES | Fixes the state of the segments in a tablespace in which migration was aborted. |

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 may result in lost and unrecoverable data if not used properly. You should work with Oracle Worldwide Support if you have doubts about these procedures.

---

**See Also:** For details about the DBMS_SPACE_ADMIN package and procedures, see the *Oracle8i Supplied PL/SQL Packages Reference*.

## Scenario 1

The TABLESPACE_VERIFY procedure discovers that a segment has allocated blocks that are marked "free" in the bitmap and vice versa. It also discovers overlap between segments.

In this scenario, perform the following tasks:

- Call the SEGMENT_DUMP procedure to dump the ranges that the administrator allocated to the segment.
- For each range, call the TABLESPACE_FIX_BITMAPS procedure with the TABLESPACE_EXTENT_MAKE_USED or TABLESPACE_EXTENT_MAKE_FREE option to mark the space as used or free.

## Scenario 2

You cannot drop a segment because the bitmap has segment blocks marked "free."

In this scenario, perform the following tasks:

- Call the SEGMENT_VERIFY procedure with the SEGMENT_VERIFY_EXTENTS_GLOBAL option. If no overlaps are reported, perform the following:
  - Call the SEGMENT_DUMP procedure with the SEGMENT_DUMP_EXTENT_MAP option to dump the ranges that the administrator allocated to the segment.
  - For each range, call the TABLESPACE_FIX_BITMAPS procedure with the TABLESPACE_EXTENT_MAKE_FREE option to mark the space as "free."
  - Call the SEGMENT_CORRUPT procedure with the SEGMENT_MARK_CORRUPT option to mark the segment as corrupt.
  - Call the SEGMENT_DROP_CORRUPT procedure to drop the SEG$ entry.

## Scenario 3

The TABLESPACE_VERIFY procedure has reported some overlapping. Some of the real data must be sacrificed based on previous internal errors.

After choosing the object to be sacrificed, say table T1, perform the following tasks:

- Make a list of all objects that T1 overlaps.
- Drop table T1. If necessary, follow up by calling the SEGMENT_DROP_CORRUPT procedure.

- Call the SEGMENT_VERIFY procedure on all objects that T1 overlapped. If necessary, call the TABLESPACE_FIX_BITMAPS procedure to mark appropriate bitmaps as used.
- Rerun the TABLESPACE_VERIFY procedure to verify the problem is resolved.

### Scenario 4

A set of bitmap blocks has media corruption.

In this scenario, perform the following tasks:

- Call the TABLESPACE_REBUILD_MAPS procedure, either on all bitmap blocks, or on a single block if only one is corrupt.
- Call the TABLESPACE_VERIFY procedure to verify that the bitmaps are consistent.

### Scenario 5

You migrate a dictionary-managed tablespace to a locally managed tablespace. You use the TABLESPACE_MIGRATE_TO_LOCAL procedure.

Let us 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). In this scenario, you allow the bitmap allocation unit to be chosen by the system, 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 a allocation unit size, it must be a factor of the unit size calculated by the system, otherwise an error message is issued.

## Transporting Tablespaces Between Databases

This section describes how to transport tablespaces between databases, and includes the following topics:

- Introduction to Transportable Tablespaces
- Limitations
- Procedure for Transporting Tablespaces Between Databases

## Introduction to Transportable Tablespaces

> **Note:** You must have the Oracle8*i* Enterprise Edition to generate a transportable tablespace set. However, you can use any edition of Oracle8*i* to plug a transportable tablespace set into an Oracle database.

You can use the *transportable tablespaces* feature to move a subset of an Oracle database and "plug" it in to another Oracle database, essentially moving tablespaces between the databases. Transporting tablespaces is particularly useful for:

- Moving data from OLTP systems to data warehouse staging systems
- Updating data warehouses and data marts from staging systems
- Loading data marts from central data warehouses
- Archiving OLTP and data warehouse systems efficiently
- Data publishing to internal and external customers

Moving data via transportable tablespaces can be much faster than performing either an export/import or unload/load of the same data, because transporting a tablespace only requires the copying of datafiles and integrating the tablespace structural information. You can also use transportable tablespaces to move index data, thereby avoiding the index rebuilds you would have to perform when importing or loading table data.

> **See Also:** For more details about transportable tablespaces and their use in data marts and data warehousing, see *Oracle8i Concepts*
>
> For information about using transportable tablespaces to perform media recovery, see the *Oracle8i Backup and Recovery Guide.*
>
> For information about transportable tablespace compatibility issues (between different Oracle releases), see *Oracle8i Migration.*

## Limitations

Be aware of the following limitations as you plan for transportable tablespace use:

- The source and target database must be on the same hardware platform. For example, you can transport tablespaces between Sun Solaris Oracle databases, or you can transport tablespaces between NT Oracle databases. However, you cannot transport a tablespace from a SUN Solaris Oracle database to an NT Oracle database.
- The source and target database must have the same database block size.
- 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.
- Transportable tablespaces do not support:
  - Snapshot / replication
  - Function-based indexes
  - Scoped REFs
  - Domain indexes (a new type of index provided by extensible indexing)
  - 8.0-compatible advanced queues with multiple recipients

## Procedure for Transporting Tablespaces Between Databases

To move or copy a set of tablespaces you must perform the following steps:

1. Pick a self-contained set of tablespaces.
2. Generate a transportable tablespace set.

   A *transportable tablespace set* consists of datafiles for the set of tablespaces being transported and a file containing structural information for the set of tablespaces.
3. Transport the tablespace set.

   Copy the datafiles and the export file to the target database. You can do this using any facility for copying flat files (for example, an O / S copying utility, ftp, or publishing on CDs)
4. Plug in the tablespace.

   Invoke Import to plug the set of tablespaces into the target database.

These steps are detailed below.

### Step 1: Pick a Self-Contained Set of Tablespaces

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. For example, if there is an index in the set of tablespaces for a table that is outside of the set of tablespaces, then the set of tablespaces is not self-contained.

The tablespace set you wish to copy must contain either all partitions of a partitioned table, or none of the partitions of a partitioned table. If you wish to transport a subset of a partition table, you must exchange the partitions into tables.

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. Some examples of self contained tablespace violations follow:

- An index inside the set of tablespaces is for a table outside of the set of tablespaces.
- A partitioned table is partially contained in the set of tablespaces.
- A table inside the set of tablespaces contains a LOB column that points to LOBs outside 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. You specify the list of tablespace names and indicate whether you wish to transport referential integrity constraints.

For example, suppose you want to determine whether tablespaces SALES_1 and SALES_2 are self-contained, with referential integrity constraints taken into consideration (indicated by TRUE). You can issue the following statement:

```
EXECUTE dbms_tts.transport_set_check('sales_1,sales_2', TRUE);
```

After invoking this PL/SQL routine, you can see all violations by selecting from the TRANSPORT_SET_VIOLATIONS view. If the set of tablespaces is self-contained, this view will be empty. The following query shows 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.

```
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
```

Object references (such as REFs) across the tablespace set are not considered violations. REFs are not checked by the TRANSPORT_SET_CHECK routine. When a tablespace containing dangling REFs is plugged into a database, queries following that dangling REF indicate user error.

> **See Also:** For more information about REFs, see the *Oracle8i Application Developer's Guide - Fundamentals.*
>
> For more information about the DBMS_TTS package, see *Oracle8i Supplied PL/SQL Packages Reference.*

### Step 2: Generate a Transportable Tablespace Set

After identifying the self-contained set of tablespaces you want to transport, generate a transportable tablespace set by performing the following tasks:

1. Make all tablespaces in the set you are copying read-only.

   ```
   ALTER TABLESPACE sales_1 READ ONLY;
   ```

2. Invoke the Export utility and specify which tablespaces are in the transportable set, as follows:

   ```
   EXP TRANSPORT_TABLESPACE=y TABLESPACES=(sales_1,sales_2)
      TRIGGERS=y/n CONSTRAINTS=y/n GRANTS=y/n FILE=expdat.dmp
   ```

   > **Note:** Although the Export utility is used, only data dictionary structural information is exported. Hence, this operation is even quicker for a large tablespace.

   When prompted, connect as "sys AS sysdba."

   You must always specify TABLESPACES. The FILE parameter specifies the name of the structural information export file to be created.

   If you set TRIGGERS=n, triggers are not exported. If you set TRIGGERS=y, triggers are exported without a validity check. Invalid triggers cause compilation errors during the subsequent import.

If you set GRANTS=y, all grants on the exported tables are exported too; otherwise, all GRANTS are ignored.

If you set CONSTRAINTS=y, referential integrity constraints are exported; otherwise, referential integrity constraints are ignored.

The default setting for all of these options is 'y.'

3. Copy the datafiles to a separate storage space or to the target database.
4. If necessary, put the tablespaces in the copied set back into read-write mode as follows:

```
ALTER TABLESPACE sales_1 READ WRITE;
```

If the tablespace sets being transported are not self-contained, export will fail and indicate that the transportable set is not self-contained. You must then return to Step 1 to resolve all violations.

> **See Also:** For information about using the Export utility, refer to *Oracle8i Utilities.*

### Step 3: Transport the Tablespace Set

Transport both the datafiles and the export file to a place accessible to the target database. You can use any facility for copying flat files (for example, an O/S copying utility, ftp, or publishing on CDs).

### Step 4: Plug In the Tablespace Set

To plug in a tablespace set, perform the following tasks:

1. Put the copied tablespace set datafiles in a location where the target database can access them.
2. Plug in the tablespaces and integrate the structural information using the following import statement:

```
IMP TRANSPORT_TABLESPACE=y DATAFILES=('/db/sales_jan','/db/sales_feb',...)
    TABLESPACES=(sales_1,sales_2) TTS_OWNERS=(dcranney,jfee)
    FROMUSER=(dcranney,jfee) TOUSER=(smith,williams) FILE=expdat.dmp
```

When prompted, connect as "sys AS sysdba."

Following are two more examples:

```
IMP TRANSPORT_TABLESPACE=y DATAFILES=('/db/staging1.f','/db/staging2.f')
```

```
IMP TRANSPORT_TABLESPACE=y DATAFILES='/db/staging.f' TABLESPACES=jan
    OWNERS=smith
```

You must specify DATAFILES.

TABLESPACES,TTS_OWNERS, FROMUSER and TOUSER are optional. The FILE parameter specifies the name of the structural information export file.

When you specify TABLESPACES, the supplied tablespace names are compared to those in the export file. Import returns an error if there is any mismatch. Otherwise, tablespace names are extracted from the export file.

TTS_OWNERS lists all users who own data in the tablespace set. When you specify TTS_OWNERS, the user names are compared to those in the export file. Import returns an error if there is any mismatch. Otherwise, owner names are extracted from the export file.

If you do not specify FROMUSER and TOUSER, all database objects (such as tables and indexes) will be created under the same user as in the source database. Those users must already exist in the target database. If not, import will return an error indicating that some required users do not exist in the target database.

You can use FROMUSER and TOUSER to change the owners of objects. For example, if you specify `FROMUSER=(dcranney,jfee) TOUSER=(smith, williams()` 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 plugged in. Similarly, objects owned by JFEE in the source database will be owned by WILLIAMS in the target database. In this case, the target database does not have to have users DCRANNEY and JFEE, but must have users SMITH and WILLIAMS.

After this statement successfully executes, all tablespaces in the set being copied remain in read-only mode. You should check the import logs to ensure no error has occurred. At this point, you can issue the ALTER TABLESPACE...READ WRITE statement to place the new tablespaces in read-write mode.

When dealing with a large number of datafiles, specifying the list of datafile names in the statement line can be a laborious process; it may even exceed the statement line limit. In this situation, you may use an import parameter file. For example, one of the statements in this step is equivalent to the following:

```
IMP PARFILE='par.f'
```

The file `par.f` contains the following:

```
TRANSPORT_TABLESPACE=y
DATAFILES=/db/staging.f
TABLESPACES=jan
TT_OWNERS=smith
```

To transport a tablespace between databases, both the source and target database must be running Oracle8*i*, with the initialization file compatibility parameter set to 8.1.

> **See Also:** For information about using the Import utility, refer to *Oracle8i Utilities.*

## Object Behaviors

Most objects, whether data in a tablespace or structural information associated with the tablespace, behave normally after being transported to a different database. However, the following objects are exceptions:

- ROWIDs
- REFs
- Privileges
- Partitioned Tables
- Objects
- Advanced Queues
- Indexes
- Triggers
- Snapshots / Replication

### ROWIDs

When a database contains tablespaces that have been plugged in (from other databases), the ROWIDs in that database are no longer unique. A ROWID is guaranteed unique only within a table.

### REFs

REFs are not checked when Oracle determines if a set of tablespaces is self-contained. As a result, a plugged-in tablespace may contain dangling REFs. Any query following dangling REFs returns a user error.

### Privileges

Privileges are transported if you specify GRANTS=y during export. During import, some grants may fail. For example, the user being granted a certain right may not exist, or a role being granted a particular right may not exist.

### Partitioned Tables

You cannot move a partitioned table via transportable tablespaces when only a subset of the partitioned table is contained in the set of tablespaces. You must ensure that all partitions in a table are in the tablespace set, or exchange the partitions into tables before copying the tablespace set. However, you should note that exchanging partitions with tables invalidates the global index of the partitioned table.

At the target database, you can exchange the tables back into partitions if there is already a partitioned table that exactly matches the column in the target database. If all partitions of that table come from the same foreign database, the exchange operation is guaranteed to succeed. If they do not, in rare cases, the exchange operation may return an error indicating that there is a data object number conflict.

If you receive a data object number conflict error when exchanging tables back into partitions, you can move the offending partition using the ALTER TABLE MOVE PARTITION statement. After doing so, retry the exchange operation.

If you specify the WITHOUT VALIDATION option of the exchange statement, the statement will return immediately because it only manipulates structural information. Moving partitions, however, may be slow because the data in the partition can be copied. See "Transporting and Attaching Partitions for Data Warehousing" on page 9-35 for an example using partitioned tables.

### Objects

A transportable tablespace set can contain:

- Tables
- Indexes
- Bitmap indexes
- Index-organized tables
- LOBs
- Nested tables
- Varrays

- Tables with user-defined type columns

If the tablespace set contains a pointer to a BFILE, you must move the BFILE and set the directory correctly in the target database.

### Advanced Queues

You can use transportable tablespaces to move or copy Oracle advanced queues, as long as these queues are not 8.0-compatible queues with multiple recipients. After a queue is transported to a target database, the queue is initially disabled. After making the transported tablespaces read-write in the target database, you can enable the queue by starting it up via the built-in PL/SQL routine DBMS_AQADM.START_QUEUE.

### Indexes

You can transport regular indexes and bitmap indexes. When the transportable set fully contains a partitioned table, you can also transport the global index of the partitioned table.

Function-based indexes and domain indexes are not supported. If they exist in a tablespace, you must drop them before you can transport the tablespace.

### Triggers

Triggers are exported without a validity check. In other words, Oracle does not verify that the trigger refers only to objects within the transportable set. Invalid triggers will cause a compilation error during the subsequent import.

### Snapshots/Replication

Transporting snapshot or replication structural information is not supported. If a table in the tablespace you want to transport is replicated, you must drop the replication structural information and convert the table into a normal table before you can transport the tablespace.

## Using Transportable Tablespaces

The following are some possible applications for transportable tablespaces.

### Transporting and Attaching Partitions for Data Warehousing

Typical enterprise data warehouses contain one or more large fact tables. These fact tables may be partitioned by date, making the enterprise data warehouse a

historical database. You can build indexes to speed up star queries. In fact, 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's worth 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 nonprefixed 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 wish 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 indexes 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 nonprefixed 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; 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 option; otherwise the statement will go 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 will always succeed. In general, however, if data in a partitioned table comes from different databases, it's possible that the exchange operation may fail. For example, if the JUL98 partition of SALES did not come from the same staging database, the above 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 may 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 plug it into an existing database without having to copy the datafiles from the CD to disk storage. For example, suppose on an NT machine D: drive is the CD drive. You can plug in a transportable set with datafile `catalog.f` and export file `expdat.dmp` as follows:

```
IMP TRANSPORT_TABLESPACE=y DATAFILES='D:\catalog.f' FILE='D:\expdat.dmp'
```

You can remove the CD while the database is still up. Subsequent queries to the tablespace will return an error indicating that Oracle 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, Oracle will indicate that it cannot find the removed datafile and will 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, Oracle reads the file only when someone queries the plugged-in tablespace. Thus, when plugging in a tablespace on 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.

You can mount the same tablespace read-only on multiple databases in either of the following ways:

- Plug the tablespaces into each of the databases you wish to mount the tablespace. Generate a transportable set in a single database. Put the datafiles in the transportable set on a disk accessible to all databases. Import the structural information into each database.
- Generate the transportable set in one of the databases and plug it into other databases. If you use this approach, it is assumed that the datafiles are already on the shared disk, and they belong to an existing tablespace in one of the databases. You can make the tablespace read-only, generate the transportable set, and then plug the tablespace in to other databases while the datafiles remain in the same location on the shared disk.

You can make the disk accessible by multiple computers via several ways. You may use either a clustered file system or raw disk, as that is required by Oracle Parallel Server. Because Oracle will only read these type of datafiles on shared disk, you can also use NFS. Be aware, however, that if a user queries the shared tablespace while NFS is down, the database may hang until the NFS operation times out.

Later, you can drop the read-only tablespace in some of the databases. Doing so will not modify the datafiles for the tablespace; thus the drop operation will not corrupt the tablespace. Do not make the tablespace read-write unless only one database is mounting the tablespace.

### Archive Historical Data via Transportable Tablespaces

Since a transportable tablespace set is a self-contained set of files that can be plugged into any Oracle database, you can archive old / historical data in an enterprise data warehouse via the transportable tablespace procedures described in this chapter.

> **See Also:** For more details, see the *Oracle8i Backup and Recovery Guide.*

### Using Transportable Tablespaces to Perform TSPITR

You can use transportable tablespaces to perform tablespace point-in-time recovery (TSPITR).

> **See Also:** For information about how to perform TSPITR using transportable tablespaces, see the *Oracle8i Backup and Recovery Guide.*

## Viewing Information About Tablespaces

The following data dictionary views provide useful information about the tablespaces of a database.

| View | Description |
|---|---|
| V$TABLESPACE | Name and number of all tablespaces from the controlfile. |
| DBA_TABLESPACES, USER TABLESPACES | Descriptions of all (or user accessible) tablespaces. |
| DBA_SEGMENTS, USER_SEGMENTS | Information about segments within all (or user accessible) tablespaces. |
| DBA_EXTENTS, USER_EXTENTS | Information about data extents within all (or user accessible) tablespaces. |
| DBA_FREE_SPACE, USER_FREE_SPACE | Information about free extents within all (or user accessible) tablespaces. |
| V$DATAFILE | Information about all datafiles, including tablespace number of owning tablespace. |

| View | Description |
|---|---|
| V$TEMPFILE | Information about all tempfiles, including tablespace number of owning tablespace. |
| DBA_DATA_FILES | Shows files (datafiles) belonging to tablespaces. |
| DBA_TEMP_FILES | Shows files (tempfiles) belonging to temporary tablespaces. |
| V$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$SORT SEGMENT | Information about every sort segment in a given instance. The view is only updated when the tablespace is of the TEMPORARY type. |
| V$SORT_USER | Temporary sort space usage by user and temporary / permanent tablespace. |

The following are just a few examples of using some of these views.

> **See Also:** A complete description of these views is contained in *Oracle8i Reference.*

### Listing Tablespaces and Default Storage Parameters: Example

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
```

### Listing the Datafiles and Associated Tablespaces of a Database: Example

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/RBS01.DBF                 1536  RBS
/U02/ORACLE/IDDB3/SYSTEM01.DBF              6586  SYSTEM
/U02/ORACLE/IDDB3/TEMP01.DBF                6400  TEMP
/U02/ORACLE/IDDB3/TESTTBS01.DBF             6400  TESTTBS
/U02/ORACLE/IDDB3/USERS01.DBF                384  USERS
```

### Statistics for Free Space (Extents) of Each Tablespace: Example

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 sys.dba_free_space
WHERE tablespace_name = 'SYSTEM'
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.

# 10

# Managing Datafiles

This chapter describes the various aspects of datafile management, and includes the following topics:

- Guidelines for Managing Datafiles
- Creating and Adding Datafiles to a Tablespace
- Changing a Datafile's Size
- Altering Datafile Availability
- Renaming and Relocating Datafiles
- Verifying Data Blocks in Datafiles
- Viewing Information About Datafiles

> **See Also:** Datafiles can also be created as part of database recovery from a media failure. For more information, see the *Oracle8i Backup and Recovery Guide.*

# Guidelines for Managing Datafiles

This section describes aspects of managing datafiles, and includes the following topics:

- Determine the Number of Datafiles
- Set the Size of Datafiles
- Place Datafiles Appropriately
- Store Datafiles Separate From Redo Log Files

Every datafile has two associated file numbers: an *absolute file number* and a *relative file number*.

An absolute file number uniquely identifies a datafile in the database. In earlier releases of Oracle, the absolute file number may have been referred to as simply, the "file number."

A relative file number 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 will differ from the absolute file number. You can locate relative file numbers in many data dictionary views.

## Determine the Number of Datafiles

At least one datafile is required for the SYSTEM tablespace of a database; a small system might have a single datafile. In general, keeping a few large datafiles is preferable to many small datafiles, because you can keep fewer files open at the same time.

You can add datafiles to tablespaces, subject to the following operating system-specific datafile limits:

- Operating system limit

  Each operating system sets a limit on the maximum number of open files per process. Regardless of all other limits, more datafiles cannot be created when the operating system limit of open files is reached.

- Oracle system limit

  Oracle imposes a maximum limit on the number of datafiles for any Oracle database opened by any instance. This limit is port-specific.

- Control file upper bound

  When you issue CREATE DATABASE or CREATE CONTROLFILE statements, the MAXDATAFILES parameter specifies an initial size of the datafile portion of the control file. Later, if you add a file whose number exceeds MAXDATAFILES but is less than or equal to the value specified by the DB_FILES initialization parameter, the control file automatically expands to allow the datafile portion to accommodate more files.

- Instance or SGA upper bound

  When starting an Oracle8 instance, the database's initialization parameter file indicates the amount of SGA space to reserve for datafile information; the maximum number of datafiles is controlled by the DB_FILES initialization parameter. This limit applies only for the life of the instance.

  **Note:** The default value of DB_FILES is operating system specific.

  With the Oracle Parallel Server, all instances must set the instance datafile upper bound to the same value.

When determining a value for DB_FILES, take the following into consideration:

- If the value of DB_FILES is too low, you will be unable to 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.

Theoretically, an Oracle database can have an unlimited number of datafiles. Nevertheless, you should consider the following when determining the number of datafiles:

- Performance is better with a small number of datafiles rather than a large number of small datafiles. A large number of files also increases the granularity of a recoverable unit.
- Operating systems often impose a limit on the number of files a process can open simultaneously. Oracle's DBWn processes can open all online datafiles. Oracle is also 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.

Oracle allows more datafiles in the database than 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.

The operating system specific limit on the maximum number of datafiles allowed in a tablespace is typically 1023 files.

> **See Also:** For more information on operating system limits, see your operating system-specific Oracle documentation.
>
> For information about Parallel Server operating system limits, see *Oracle8i Parallel Server Administration, Deployment, and Performance.*
>
> For more information about MAXDATAFILES parameter of the CREATE DATABASE or CREATE CONTROLFILE statement, see the *Oracle8i SQL Reference.*

## Set the Size of Datafiles

The first datafile (in the original SYSTEM tablespace) must be at least 7M to contain the initial data dictionary and rollback segment. If you install other Oracle products, they may require additional space in the SYSTEM tablespace (for online help, for example); see the installation instructions for these products.

## 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, it might be helpful to store table data in a tablespace on one disk drive, and index data in a tablespace on another disk drive. This way, when users query table information, both disk drives can work simultaneously, retrieving table and index data at the same time.

## Store Datafiles Separate From Redo Log Files

Datafiles should not be stored on the same disk drive that stores the database's 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 and Adding Datafiles to a Tablespace

Ideally, when creating a tablespace, you should estimate the potential size of the database objects and add sufficient files or devices, so as to ensure that data is spread evenly across all devices. Later, if needed, you can create and add datafiles to a tablespace to increase the total amount of disk space allocated for the tablespace, and consequently the database.

To add datafiles to a tablespace, you use the ALTER TABLESPACE...ADD DATAFILE statement. You must have the ALTER TABLESPACE system privilege to add datafiles to a tablespace.

The following statement creates a new datafile for the RB_SEGS tablespace:

```
ALTER TABLESPACE rb_segs
   ADD DATAFILE '/u02/oracle/rbdb1/rb_segs03.dbf' SIZE 1M;
```

If you add new datafiles to a tablespace and do not fully specify the filenames, Oracle 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.

## Changing a Datafile's Size

This section describes the various ways to alter the size of a datafile, and includes 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 files increase in specified increments up to a specified maximum.

Setting your datafiles to extend automatically results in the following:

- Reduces the need for immediate intervention when a tablespace runs out of space
- Ensures applications will not halt because of failures to allocate extents

To find out if 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
- CREATE TABLESPACE
- ALTER TABLESPACE

You can enable or disable automatic file extension for existing datafiles, or manually resize a datafile using the SQL statement ALTER DATABASE.

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:** For more information about the SQL statements for creating or altering datafiles, see the *Oracle8i SQL Reference.*

## Manually Resizing a Datafile

You can manually increase or decrease the size of a datafile using the ALTER DATABASE statement.

Because you can change the sizes of datafiles, you can 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.

Manually reducing the sizes of datafiles allows 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.

---

**See Also:** For more information about the implications resizing files has for downgrading, see *Oracle8i Migration*

## Altering Datafile Availability

This section describes ways to alter datafile availability, and includes the following topics:

- Bringing Datafiles Online or Taking Offline in ARCHIVELOG Mode
- Taking Datafiles Offline in NOARCHIVELOG Mode

In very rare situations, you might need to bring specific datafiles online (make them available) or take specific files offline (make them unavailable). For example, when Oracle has problems writing to a datafile, it can automatically take the datafile offline. You might need to take the damaged datafile offline or bring it online manually

---

**Note:** You can make all datafiles in a tablespace, other than the files in the SYSTEM tablespace, temporarily unavailable by taking the tablespace offline. You *must* leave these files in the tablespace to bring the tablespace back online.

For more information about taking a tablespace offline, see "Taking Tablespaces Offline" on page 9-15.

---

Offline datafiles cannot be accessed. Bringing online a datafile in a read-only tablespace makes the file readable. No one can write to the file unless its associated

tablespace is returned to the read-write state. The files of a read-only tablespace can independently be taken online or offline using the DATAFILE option of the ALTER DATABASE statement.

To bring a datafile online or take it offline, you must have the ALTER DATABASE system privilege. You can perform these operations only when the database is open in exclusive mode.

## 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 option 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.

---

**See Also:** For more information about bringing datafiles online during media recovery, see the *Oracle8i Backup and Recovery Guide.*

## 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 DROP clauses. This allows you to take the datafile offline and drop it immediately. It is useful, for example, if the datafile contains only data from temporary segments and has not been backed up and the database is in NOARCHIVELOG mode.

The following statement takes the specified datafile offline:

```
ALTER DATABASE DATAFILE '/u02/oracle/rbdb1/users03.dbf' OFFLINE DROP;
```

# Renaming and Relocating Datafiles

You can rename datafiles to either change their names or relocate them. Some options, and procedures which you can follow, are described in the following sections:

- Renaming and Relocating Datafiles for a Single Tablespace

  For example, renaming *filename1* and *filename2* in *tablespace1*, while the rest of the database is open.

- Renaming and Relocating Datafiles for Multiple Tablespaces

  For example, renaming *filename1* in *tablespace1* and *filename2* in *tablespace2*, while the database is mounted but closed.

> **Note:** To rename or relocate datafiles of the SYSTEM tablespace, you must use the second option, because you cannot take the SYSTEM tablespace offline.

When you rename and relocate datafiles with these procedures, only the pointers to the datafiles, as recorded in the database's control file, are changed; they do not physically rename any operating system files, nor do they copy files at the operating system level. Therefore, renaming and relocating datafiles involves several steps. Read the steps and examples carefully before performing these procedures.

## Renaming and Relocating Datafiles for a Single Tablespace

These are some procedures for renaming and relocating datafiles in a single tablespace. You must have the ALTER TABLESPACE system privilege to rename datafiles of a single tablespace.

### Renaming Datafiles in a Single Tablespace

To rename datafiles from a single tablespace, follow this procedure.

1. Take the non-SYSTEM tablespace that contains the datafiles offline.
2. Rename the datafiles using operating system statements.
3. Make sure that the new, fully specified filenames are different from the old filenames.

4. Use the ALTER TABLESPACE statement with the RENAME DATAFILE option to change the filenames within the database.

For example, the following statement renames the datafiles *filename1* and *filename2* to *filename3* and *filename4*, 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';
```

The new files must already exist; this statement does not create the files. Also, 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.

### Relocating and Renaming Datafiles in a Single Tablespace

Here is an example that illustrates the steps involved for relocating a datafile.

Assume the following conditions:

- An open database has a tablespace named USERS that is made up of datafiles located on the same disk of a computer.
- The datafiles of the USERS tablespace are to be relocated to a different disk drives.
- You are currently connected with administrator privileges to the open database.

These are the steps:

1. Identify the datafile names of interest.

   The following query of the data dictionary view DBA_DATA_FILES lists the datafile names and respective sizes (in bytes) of the USERS tablespace:

   ```
   SELECT file_name, bytes FROM sys.dba_data_files
   WHERE tablespace_name = 'USERS';

   FILE_NAME                                BYTES
   ---------------------------------------- ----------------
   /U02/ORACLE/RBDB1/USERS01.DBF            102400000
   /U02/ORACLE/RBDB1/USERS02.DBF            102400000
   ```

2. Back up the database.

Before making any structural changes to a database, such as renaming and relocating the datafiles of one or more tablespaces, always completely back up the database.

3. Take the tablespace containing the datafiles offline, or shut down the database and restart and mount it, leaving it closed. Either option closes the datafiles of the tablespace.
4. Copy the datafiles to their new locations and rename them using operating system commands.

   **Note:** You can execute an operating system command to copy a file by using the HOST command.

5. Rename the datafiles within Oracle.

   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.

   If the tablespace is offline but the database is open, use the ALTER TABLESPACE...RENAME DATAFILE statement. If the database is mounted but closed, use the ALTER DATABASE...RENAME FILE 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';
```

6. Bring the tablespace online, or shut down and restart the database.

   If the USERS tablespace is offline and the database is open, bring the tablespace back online. If the database is mounted but closed, open the database.

7. Back up the database. After making any structural changes to a database, always perform an immediate and complete backup.

## Renaming and Relocating Datafiles for Multiple Tablespaces

You can rename and relocate datafiles of one or more tablespaces using ALTER DATABASE statement with the RENAME FILE option. This option is the only choice if you want to rename or relocate datafiles of several tablespaces in one

operation, or rename or relocate datafiles of the SYSTEM tablespace. If the database must remain open, consider instead the procedure outlined in the previous section.

To rename datafiles of several tablespaces in one operation or to rename datafiles of the SYSTEM tablespace, you must have the ALTER DATABASE system privilege.

To rename datafiles in multiple tablespaces, follow these steps.

1. Ensure that the database is mounted but closed.
2. Copy the datafiles to be renamed to their new locations and new names, using operating system commands.
3. Make sure the new copies of the datafiles have different fully specified filenames from the datafiles currently in use.
4. Use ALTER DATABASE to rename the file pointers in the database's control file.

For example, the following statement renames the datafiles *filename1* and *filename2* to *filename3* and *filename4*, 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;
```

The new file must already exist; this statement does not create a file. Also, 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.

## Verifying Data Blocks in Datafiles

If you want to configure Oracle to use checksums to verify data blocks, set the initialization parameter DB_BLOCK_CHECKSUM to TRUE. The value of this parameter can be changed dynamically, or set in the initialization parameter file. The default value of DB_BLOCK_CHECKSUM is FALSE. Regardless of the setting of this parameter, checksums will always be used to verify data blocks in the system tablespace.

When you enable block checking, Oracle computes a checksum for each block written to disk. Checksums are computed for all data blocks, including temporary blocks.

The DBWn process calculates the checksum for each block and stores it in the block's header. Checksums are also computed by the direct loader.

The next time Oracle reads a data block, it uses the checksum to detect corruption in the block. If a corruption is detected, Oracle returns message ORA-01578 and writes information about the corruption to a trace file.

**WARNING: Setting DB_BLOCK_CHECKSUM to TRUE can cause performance overhead. Set this parameter to TRUE only under the advice of Oracle Support personnel to diagnose data corruption problems.**

## Viewing Information About Datafiles

The following data dictionary views provide useful information about the datafiles of a database:

| View | Description |
|---|---|
| DBA_DATA_FILES | Provides descriptive information about datafiles, including the tablespace to which it belong and the file id. The file id can be used to join with other views for detail information. |
| USER_EXTENTS, DBA_EXTENTS | Lists the extents comprising all segments in the database. Contains the file id of the datafile containing the extent. |
| USER_FREE_SPACE, DBA_FREE_SPACE | Lists the free extents in all tablespaces. Includes the file id of the datafile containing the extent. |
| 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.

Assume you are using a database that contains two tablespaces, SYSTEM and USERS. USERS is made up of two files, FILE1 (100MB) and FILE2 (200MB); the tablespace has been taken offline normally. Here, you query V$DATAFILE to view status information about datafiles of a database:

```
SELECT name,
    file#,
    status,
    checkpoint_change# "CHECKPOINT"
  FROM   v$datafile;
```

```
NAME                                FILE#     STATUS       CHECKPOINT
------------------------------      -----     -------       ----------
filename1                               1     SYSTEM              3839
filename2                               2     OFFLINE             3782
filename3                               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 written for a datafile's most recent checkpoint.

> **See Also:** For a complete description of these views, see *Oracle8i Reference.*

# 11

# Managing Rollback Segments

This chapter describes how to manage rollback segments, and includes the following topics:

- Guidelines for Managing Rollback Segments
- Creating Rollback Segments
- Altering Rollback Segments
- Explicitly Assigning a Transaction to a Rollback Segment
- Dropping Rollback Segments
- Monitoring Rollback Segment Information

> **See Also:** If you are using Oracle with the Parallel Server option, see *Oracle8i Parallel Server Administration, Deployment, and Performance* for information about creating rollback segments in that environment.

# Guidelines for Managing Rollback Segments

This section describes guidelines to consider before creating or managing the rollback segments of your databases, and includes the following topics:

- Use Multiple Rollback Segments
- Choose Between Public and Private Rollback Segments
- Specify Rollback Segments to Acquire Automatically
- Approximate Rollback Segment Sizes
- Create Rollback Segments with Many Equally Sized Extents
- Set an Optimal Number of Extents for Each Rollback Segment
- Place Rollback Segments in a Separate Tablespace

Every database contains one or more *rollback segments*, which are portions of the database that record the actions of transactions in the event that a transaction is rolled back. You use rollback segments to provide read consistency, roll back transactions, and recover the database.

> **See Also:** For additional information about rollback segments, see *Oracle8i Concepts*.

## Use Multiple Rollback Segments

Using multiple rollback segments distributes rollback segment contention across many segments and improves system performance. Multiple rollback segments are required in the following situations:

- When a database is created, a single rollback segment named SYSTEM is created in the SYSTEM tablespace. You can create any objects in non-SYSTEM tablespaces, but you cannot write to them until you have created and brought online at least one additional rollback segment in a non-SYSTEM tablespace (for non-SYSTEM objects).
- When many transactions are concurrently proceeding, more rollback information is generated at the same time. You can indicate the number of concurrent transactions you expect for the instance with the initialization parameter TRANSACTIONS, and the number of transactions you expect each rollback segment to have to handle with the initialization parameter TRANSACTIONS_PER_ROLLBACK_SEGMENT. Then, when an instance opens a database, it attempts to acquire at least TRANSACTIONS / TRANSACTIONS_PER_ROLLBACK_SEGMENT rollback segments to handle

the maximum amount of transactions. Therefore, after setting the parameters, create TRANSACTIONS/TRANSACTIONS_PER_ROLLBACK_ SEGMENT rollback segments.

An instance always acquires the SYSTEM rollback segment in addition to any other rollback segments it needs. However, if there are multiple rollback segments, Oracle tries to use the SYSTEM rollback segment only for special system transactions and distributes user transactions among other rollback segments. If there are too many transactions for the non-SYSTEM rollback segments, Oracle uses the SYSTEM segment.

> **See Also:** In order to start instances in an Oracle Parallel Server environment, you must give each instance access to its own rollback segment, in addition to the SYSTEM rollback segment. For additional details, see *Oracle8i Parallel Server Administration, Deployment, and Performance.*
>
> For information about the TRANSACTIONS and TRANSACTIONS_PER_ROLLBACK_SEGMENT initialization parameters, see the *Oracle8i Reference.*

## Choose Between Public and Private Rollback Segments

A *private rollback segment* is one that is acquired explicitly by an instance when the instance opens the database if it is named in the ROLLBACK_SEGMENTS parameter in the initialization parameter file. A private rollback segment can also be acquired by specifically bringing it online by manually issuing a statement to do so. *Public rollback segments* form a pool of rollback segments that any instance requiring a rollback segment can use.

A database with the Parallel Server option can have only public segments, as long as the number of segments is high enough that each instance opening the database can acquire at least one rollback segment in addition to its SYSTEM rollback segment. You may also use private rollback segments when using the Oracle Parallel Server.

If a database does not have the Parallel Server option, public and private rollback segments are identical.

## Specify Rollback Segments to Acquire Automatically

When an instance starts, it acquires by default TRANSACTIONS/TRANSACTIONS_PER_ROLLBACK_SEGMENT rollback

segments. If you want to ensure that the instance acquires particular rollback segments that have particular sizes or particular tablespaces, specify the rollback segments by name in the ROLLBACK_SEGMENTS parameter in the instance's parameter file.

The instance acquires all the rollback segments listed in this parameter, even if more than TRANSACTIONS / TRANSACTIONS_PER_ROLLBACK_SEGMENT segments are specified. The rollback segments can be either private or public.

## Approximate Rollback Segment Sizes

Total rollback segment size should be set based on the size of the most common transactions issued against a database. In general, short transactions experience better performance when the database has many smaller rollback segments, while long-running transactions, like batch jobs, perform better with larger rollback segments. Generally, rollback segments can handle transactions of any size easily; however, in extreme cases when a transaction is either very short or very long, a user might want to use an appropriately sized rollback segment.

If a system is running only short transactions, rollback segments should be small so that they are always cached in main memory. If the rollback segments are small enough, they are more likely to be cached in the SGA according to the LRU algorithm, and database performance is improved because less disk I / O is necessary. The main disadvantage of small rollback segments is the increased likelihood of the error "snapshot too old" when running a long query involving records that are frequently updated by other transactions. This error occurs because the rollback entries needed for read consistency are overwritten as other update entries wrap around the rollback segment. Consider this issue when designing an application's transactions, and make them short atomic units of work so that you can avoid this problem.

In contrast, long-running transactions work better with larger rollback segments, because the rollback entries for a long-running transaction can fit in preallocated extents of a large rollback segment.

When database systems applications concurrently issue a mix of very short and very long transactions, performance can be optimized if transactions are explicitly assigned to a rollback segment based on the transaction / rollback segment size. You can minimize dynamic extent allocation and truncation for rollback segments. This is not required for most systems and is intended for extremely large or small transactions.

To optimize performance when issuing a mix of extremely small and large transactions, make a number of rollback segments of appropriate size for each type

of transaction (such as small, medium, and large). Most rollback segments should correspond to the typical transactions, with a fewer number of rollback segments for the atypical transactions. Then set OPTIMAL for each such rollback segment so that the rollback segment returns to its intended size if it has to grow.

You should tell users about the different sets of rollback segments that correspond to the different types of transactions. Often, it is *not* beneficial to assign a transaction explicitly to a specific rollback segment; however, you can assign an atypical transaction to an appropriate rollback segment created for such transactions. For example, you can assign a transaction that contains a large batch job to a large rollback segment.

When a mix of transactions is not prevalent, each rollback segment should be 10% of the size of the database's largest table because most SQL statements affect 10% or less of a table; therefore, a rollback segment of this size should be sufficient to store the actions performed by most SQL statements.

Generally speaking, you should set a high MAXEXTENTS for rollback segments; this allows a rollback segment to allocate subsequent extents as it needs them.

## Create Rollback Segments with Many Equally Sized Extents

Each rollback segment's total allocated space should be divided among many equally sized extents. In general, optimal rollback I/O performance is observed if each rollback segment for an instance has 10 to 20 equally sized extents.

After determining the desired total initial size of a rollback segment and the number of initial extents for the segment, use the following formula to calculate the size of each extent of the rollback segment:

$T / n = s$

where:

$T$ = total initial rollback segment size, in bytes

$n$ = number of extents initially allocate

$s$ = calculated size, in bytes, of each extent initially allocated

After $s$ is calculated, create the rollback segment and specify the storage parameters INITIAL and NEXT as $s$, and MINEXTENTS to $n$. PCTINCREASE cannot be specified for rollback segments and therefore defaults to 0. Also, if the size $s$ of an extent is not an exact multiple of the data block size, it is rounded up to the next multiple.

### Set an Optimal Number of Extents for Each Rollback Segment

You should carefully assess the kind of transactions the system runs when setting the OPTIMAL parameter for each rollback segment. For a system that executes long-running transactions frequently, OPTIMAL should be large so that Oracle does not have to shrink and allocate extents frequently. Also, for a system that executes long queries on active data, OPTIMAL should be large to avoid "snapshot too old" errors. OPTIMAL should be smaller for a system that mainly executes short transactions and queries so that the rollback segments remain small enough to be cached in memory, thus improving system performance.

The V$ROLLNAME and V$ROLLSTAT dynamic performance views can be monitored to collect statistics useful in determining appropriate settings for OPTIMAL. See "Rollback Segment Statistics" on page 11-14.

### Place Rollback Segments in a Separate Tablespace

If possible, create one tablespace specifically to hold all rollback segments. This way, all rollback segment data is stored separately from other types of data. Creating this "rollback segment" tablespace can provide the following benefits:

- A tablespace holding rollback segments can always be kept online, thus maximizing the combined storage capacity of rollback segments at all times. Note that if some rollback segments are not available, the overall database operation can be affected.
- Because tablespaces with active rollback segments cannot be taken offline, designating a tablespace to hold all rollback segments of a database ensures that the data stored in other tablespaces can be taken offline without concern for the database's rollback segments.
- A tablespace's free extents are likely to be more fragmented if the tablespace contains rollback segments that frequently allocate and deallocate extents.

## Creating Rollback Segments

To create rollback segments, you must have the CREATE ROLLBACK SEGMENT system privilege. You use the CREATE ROLLBACK SEGMENT statement. The tablespace to contain the new rollback segments must be online. Rollback segments are usually created as part of the database creation script or process, but you may add more at a later time.

The following topics relating to creating rollback segments are included in this section:

## The CREATE ROLLBACK SEGMENT Statement

The following statement creates a rollback segment named RBS_02 in the RBSSPACE tablespace, using the default storage parameters of that tablespace. Since this is not a parallel server environment, it is not necessary to specify PRIVATE or PUBLIC. The default is PRIVATE.

```
CREATE ROLLBACK SEGMENT rbs_02 TABLESPACE rbsspace;
```

> **See Also:** For exact syntax, restrictions, and authorization requirements for the SQL statements used in managing rollback segments, see *Oracle8i SQL Reference*.

## Bringing New Rollback Segments Online

New rollback segments are initially offline. You must issue an ALTER ROLLBACK SEGMENT to bring them online and make it available for use by transactions of an instance. See "Changing the ONLINE / OFFLINE Status of Rollback Segments" on page 11-9 for more information.

If you create a private rollback segment, you should add the name of this new rollback segment to the ROLLBACK_SEGMENTS initialization parameter in the initialization parameter file for the database. Doing so enables the private rollback segment to be captured by the instance at instance start up. For example, if two new private rollback segments are created and named RBS_01 and RBS_02, the ROLLBACK_SEGMENTS parameter of the parameter file should be similar to the following:

```
ROLLBACK_SEGMENTS = (RBS_01, RBS_02)
```

> **See Also:** For information about the ROLLBACK_SEGMENTS initialization parameter, see the *Oracle8i Reference*.

## Setting Storage Parameters When Creating a Rollback Segment

Suppose you wanted to create a rollback segment RBS_01 with storage parameters and optimal size set as follows:

- The rollback segment is allocated an initial extent of 100K.

- The rollback segment is allocated the second extent of 100K.
- The optimal size of the rollback segment is 4M.
- The minimum number of extents and the number of extents initially allocated when the segment is created is 20.
- The maximum number of extents that the rollback segment can allocate, including the initial extent, is 100.

The following statement creates a rollback segment with these characteristics:

```
CREATE PUBLIC ROLLBACK SEGMENT rbs_01
                TABLESPACE rbsspace
                STORAGE (
      INITIAL 100K
      NEXT 100K
      OPTIMAL 4M
      MINEXTENTS 20
      MAXEXTENTS 100 );
```

You cannot set a value for the storage parameter PCTINCREASE. It is always 0 for rollback segments. The OPTIMAL storage parameter is unique to rollback segments. For a discussion of storage parameters see "Setting Storage Parameters" on page 12-8 and the *Oracle8i SQL Reference*.

Oracle makes the following recommendations:

- Set INITIAL and NEXT to the same value to ensure that all extents are the same size.
- Create a large number of initial extents to minimize the possibility of dynamic extension. MINEXTENTS = 20 is a good value.
- Avoid setting MAXEXTENTS = UNLIMITED as this could cause unnecessary extension of a rollback segment and possibly of data files due to a programming error. If you do specify UNLIMITED, be aware that extents for that segment must have a minimum of 4 data blocks. Also, if you later want to convert a rollback segment whose MAXEXTENTS are limited to UNLIMITED, that rollback segment cannot be converted if it has less than 4 data blocks in any extent. If you want to convert from limited to UNLIMITED, and have less than 4 data blocks in an extent, your only choice is to drop and re-create the rollback segment.

# Altering Rollback Segments

This section discusses various actions you can take to maintain your rollback segments. All of these maintenance activities use the ALTER ROLLBACK SEGMENT statement. You must have the ALTER ROLLBACK SEGMENT system privilege to use this statement.

The following topics are presented:

- Changing Rollback Segment Storage Parameters
- Shrinking a Rollback Segment Manually
- Changing the ONLINE / OFFLINE Status of Rollback Segments

## Changing Rollback Segment Storage Parameters

You can change some of a rollback segment's storage parameters after creating it. You may want to change the values of OPTIMAL or MAXEXTENTS. The following statement alters the maximum number of extents that the RBS_01 rollback segment can allocate.

```
ALTER ROLLBACK SEGMENT rbs_01
    STORAGE (MAXEXTENTS 120);
```

You can alter the settings for the SYSTEM rollback segment, including the OPTIMAL parameter, just as you can alter those of any rollback segment.

## Shrinking a Rollback Segment Manually

You can manually decrease the size of a rollback segment using the ALTER ROLLBACK SEGMENT statement. The rollback segment you are trying to shrink must be online.

The following statement shrinks rollback segment RBS1 to 100K:

```
ALTER ROLLBACK SEGMENT rbs1 SHRINK TO 100K;
```

This statement attempts to reduce the size of the rollback segment to the specified size, but will stop short if an extent cannot be deallocated because it is active.

## Changing the ONLINE/OFFLINE Status of Rollback Segments

This section describes aspects of bringing rollback segments online and taking them offline, and includes the following topics:

- Bringing Rollback Segments Online
- Taking Rollback Segments Offline

A rollback segment is either *online* and available to transactions, or *offline* and unavailable to transactions. Generally, rollback segments are online and available for use by transactions.

You may wish to take online rollback segments offline in the following situations:

- When you want to take a tablespace offline, and the tablespace contains rollback segments. You cannot take a tablespace offline if it contains rollback segments that transactions are currently using. To prevent associated rollback segments from being used, you can take them offline before taking the tablespace offline.
- You want to drop a rollback segment, but cannot because transactions are currently using it. To prevent the rollback segment from being used, you can take it offline before dropping it.

> **Note:** You cannot take the SYSTEM rollback segment offline.

You might later want to bring an offline rollback segment back online so that transactions can use it. When a rollback segment is created, it is initially offline, and you must explicitly bring a newly created rollback segment online before it can be used by an instance's transactions. You can bring an offline rollback segment online via any instance accessing the database that contains the rollback segment.

## Bringing Rollback Segments Online

You can bring online only a rollback segment whose current status (as shown in the DBA_ROLLBACK_SEGS data dictionary view) is OFFLINE or PARTLY AVAILABLE. To bring an offline rollback segment online, use the SQL statement ALTER ROLLBACK SEGMENT with the ONLINE option.

**Bringing a PARTLY AVAILABLE Rollback Segment Online** A rollback segment in the PARTLY AVAILABLE state contains data for an in-doubt or recovered distributed transaction, and yet to be recovered transactions. You can view its status in the data dictionary view DBA_ROLLBACK_SEGS as PARTLY AVAILABLE. The rollback segment usually remains in this state until the transaction is resolved either automatically by RECO, or manually by a DBA. However, you might find that all rollback segments are PARTLY AVAILABLE. In this case, you can bring a PARTLY AVAILABLE segment online, as described above.

Some resources used by the rollback segment for the in-doubt transaction remain inaccessible until the transaction is resolved. As a result, the rollback segment may have to grow if other transactions assigned to it need additional space.

As an alternative to bringing a PARTLY AVAILABLE segment online, you might find it easier to create a new rollback segment temporarily, until the in-doubt transaction is resolved.

**Bringing Rollback Segment Online Automatically** If you would like a rollback segment to be automatically brought online whenever you start up the database, add the segment's name to the ROLLBACK_SEGMENTS parameter in the database's parameter file.

**Bringing Rollback Segments Online: Example** The following statement brings the rollback segment USER_RS_2 online:

```
ALTER ROLLBACK SEGMENT user_rs_2 ONLINE;
```

After you bring a rollback segment online, its status in the data dictionary view DBA_ROLLBACK_SEGS is ONLINE. To see a query for checking rollback segment state, see "Displaying Rollback Segment Information" on page 11-14.

### Taking Rollback Segments Offline

To take an online rollback segment offline, use the ALTER ROLLBACK SEGMENT statement with the OFFLINE option. The rollback segment's status in the DBA_ROLLBACK_SEGS data dictionary view must be ONLINE, and the rollback segment must be acquired by the current instance.

The following example takes the rollback segment USER_RS_2 offline:

```
ALTER ROLLBACK SEGMENT user_rs_2 OFFLINE;
```

If you try to take a rollback segment that does not contain active rollback entries offline, Oracle immediately takes the segment offline and changes its status to "OFFLINE".

In contrast, if you try to take a rollback segment that contains rollback data for active transactions (local, remote, or distributed) offline, Oracle makes the rollback segment unavailable to future transactions and takes it offline after all the active transactions using the rollback segment complete. Until the transactions complete, the rollback segment cannot be brought online by any instance other than the one that was trying to take it offline. During this period, the rollback segment's status in the view DBA_ROLLBACK_SEGS remains PENDING OFFLINE; however, the

rollback segment's status in the view V$ROLLSTAT is PENDING OFFLINE. For information on viewing rollback segment status, see "Displaying Rollback Segment Information" on page 11-14.

The instance that tried to take a rollback segment offline and caused it to change to PENDING OFFLINE can bring it back online at any time; if the rollback segment is brought back online, it will function normally.

After you take a public or private rollback segment offline, it remains offline until you explicitly bring it back online *or* you restart the instance.

## Explicitly Assigning a Transaction to a Rollback Segment

A transaction can be explicitly assigned to a specific rollback segment using the SET TRANSACTION statement with the USE ROLLBACK SEGMENT clause. Transactions are explicitly assigned to rollback segments for the following reasons:

- The anticipated amount of rollback information generated by a transaction can fit in the current extents of the assigned rollback segment.
- Additional extents do not have to be dynamically allocated (and subsequently truncated) for rollback segments, which reduces overall system performance.

To assign a transaction to a rollback segment explicitly, the rollback segment must be online for the current instance, and the SET TRANSACTION USE ROLLBACK SEGMENT statement must be the first statement of the transaction. If a specified rollback segment is not online or a SET TRANSACTION USE ROLLBACK SEGMENT clause is not the first statement in a transaction, an error is returned.

For example, if you are about to begin a transaction that contains a significant amount of work (more than most transactions), you can assign the transaction to a large rollback segment, as follows:

```
SET TRANSACTION USE ROLLBACK SEGMENT large_rs1;
```

After the transaction is committed, Oracle will automatically assign the next transaction to any available rollback segment unless the new transaction is explicitly assigned to a specific rollback segment by the user.

## Dropping Rollback Segments

You can drop rollback segments when the extents of a segment become too fragmented on disk, or the segment needs to be relocated in a different tablespace.

Before dropping a rollback segment, make sure that status of the rollback segment is OFFLINE. If the rollback segment that you want to drop is any other status, you cannot drop it. If the status is INVALID, the segment has already been dropped.

To drop a rollback segment, use the DROP ROLLBACK SEGMENT statement. You must have the DROP ROLLBACK SEGMENT system privilege. The following statement drops the RBS1 rollback segment:

```
DROP ROLLBACK SEGMENT rbs1;
```

---

**Note:** If a rollback segment specified in ROLLBACK_SEGMENTS is dropped, make sure to edit the parameter files of the database to remove the name of the dropped rollback segment from the list in the ROLLBACK_SEGMENTS parameter. If this step is not performed before the next instance startup, startup fails because it cannot acquire the dropped rollback segment.

---

After a rollback segment is dropped, its status changes to INVALID. The next time a rollback segment is created, it takes the row vacated by a dropped rollback segment, if one is available, and the dropped rollback segment's row no longer appears in the DBA_ROLLBACK_SEGS view.

## Monitoring Rollback Segment Information

This section presents views that can be used to obtain and monitor rollback segment information, and provides information and examples relating to their use.

The following topics are presented:

- Displaying Rollback Segment Information
- Rollback Segment Statistics
- Displaying All Rollback Segments
- Displaying Whether a Rollback Segment Has Gone Offline

> **See Also:** For information about the dictionary and dynamic views discussed in this chapter, see the *Oracle8i Reference*.

## Displaying Rollback Segment Information

The DBA_ROLLBACK_SEGS data dictionary view stores information about the rollback segments of a database. For example, the following query lists the name, associated tablespace, and status of each rollback segment in a database:

```
SELECT segment_name, tablespace_name, status
       FROM sys.dba_rollback_segs;

SEGMENT_NAME  TABLESPACE_NAME     STATUS
------------- ---------------     ------
SYSTEM        SYSTEM              ONLINE
PUBLIC_RS     SYSTEM              ONLINE
USERS_RS      USERS               ONLINE
```

In addition, the following data dictionary views contain information about the segments of a database, including rollback segments:

- USER_SEGMENTS
- DBA_SEGMENTS

## Rollback Segment Statistics

The V$ROLLSTAT dynamic performance view can be queried to monitor rollback segment statistics. Refer to the *Oracle8i Reference* for a complete description of the columns and statistics contained in this view. It must be joined with the V$ROLLNAME view to map its segment number to its name.

Some specific columns of interest include:

| Name | Description |
|---|---|
| USN | Rollback segment number. If this view is joined with the V$ROLLNAME view, the rollback segment name can be determined. |
| WRITES | The number of bytes of entries written to the rollback segment. |
| XACTS | The number of active transactions. |
| GETS | The number of rollback segment header requests. |
| WAITS | The number of rollback segment header requests that resulted in waits. |
| OPTSIZE | The value of the optimal parameter for the rollback segment. |

| Name | Description |
|---|---|
| HWMSIZE | The highest value (high water mark), in bytes, of the rollback segment size reached during usage. |
| SHRINKS | The number of shrinks that the rollback segment has had to perform in order to stay at the optimal size. |
| WRAPS | The number of times a rollback segment entry has wrapped from one extent to another. |
| EXTENDS | The number of times that the rollback segment had to acquire a new extent. |
| AVESHRINK | The average number of bytes freed during a shrink. |
| AVEACTIVE | The average number of bytes in active extents in the rollback segment, measured over time. |

These statistics are reset at system startup.

Ad hoc querying of this view can help in determining the most advantageous setting for the OPTIMAL parameter. Assuming that an instance has equally sized rollback segments with comparably sized extents, OPTIMAL for a given rollback segment should be set slightly higher than AVEACTIVE. The following chart provides additional information on how to interpret the statistics given in this view.

| SHRINKS | AVESHRINK | Analysis and Recommendation |
|---|---|---|
| Low | Low | If AVEACTIVE is close to OPTSIZE, then the OPTIMAL setting is correct. Otherwise, OPTIMAL is too large (not many shrinks are being performed.) |
| Low | High | Excellent: a good setting for OPTIMAL. |
| High | Low | OPTIMAL is too small: too many shrinks are being performed. |
| High | High | Periodic long transactions are probably causing these statistics. Set the OPTIMAL parameter higher until SHRINK is low. |

## Displaying All Rollback Segments

The following query returns the name of each rollback segment, the tablespace that contains it, and its size:

```
SELECT segment_name, tablespace_name, bytes, blocks, extents
   FROM sys.dba_segments
   WHERE segment_type = 'ROLLBACK';

SEGMENT_NAME   TABLESPACE_NAME    BYTES      BLOCKS     EXTENTS
------------   ---------------   -------    ------     -------
SYSTEM         SYSTEM             409600       200           8
RB_TEMP        SYSTEM            1126400       550          11
RB1            RBS                614400       300           3
RB2            RBS                614400       300           3
RB3            RBS                614400       300           3
RB4            RBS                614400       300           3
RB5            RBS                614400       300           3
RB6            RBS                614400       300           3
RB7            RBS                614400       300           3
RB8            RBS                614400       300           3
10 rows selected.
```

## Displaying Whether a Rollback Segment Has Gone Offline

When you take a rollback segment offline, it does not actually go offline until all active transactions in it have completed. Between the time when you attempt to take it offline and when it actually is offline, its status in DBA_ROLLBACK_SEGS is PENDING OFFLINE and it is not used for new transactions. To determine whether any rollback segments for an instance are in this state, use the following query:

```
SELECT name, xacts "ACTIVE TRANSACTIONS"
      FROM v$rollname, v$rollstat
      WHERE status = 'PENDING OFFLINE'
        AND v$rollname.usn = v$rollstat.usn;

NAME         ACTIVE TRANSACTIONS
----------   -------------------
RS2                            3
```

If your instance is part of a Parallel Server configuration, this query displays information for rollback segments of the current instance only, not those of other instances.

# Part IV

# Schema Objects

Part IV describes the creation and maintenace of schema objects in the Oracle database. It includes the following chapters:

# 12

# Guidelines for Managing Schema Objects

This chapter describes guidelines for managing schema objects, and includes the following topics:

- Managing Space in Data Blocks
- Transaction Entry Settings (INITRANS and MAXTRANS)
- Setting Storage Parameters
- Deallocating Space
- Understanding Space Use of Datatypes

You should familiarize yourself with the concepts in this chapter before attempting to manage specific schema objects as described in Chapters 13–18.

# Managing Space in Data Blocks

This section describes the various aspects of managing space in data blocks. The PCTFREE and PCTUSED parameters are discussed, which allow you to:

- Increase the performance of writing and retrieving data
- Decrease the amount of unused space in data blocks
- Decrease the amount of row chaining between data blocks

The following topics are included:



> **See Also:** For more information on data blocks, see *Oracle8i Concepts*.
>
> For syntax and other details of the PCTFREE and PCTUSED statements, please refer to the *Oracle8i SQL Reference.*

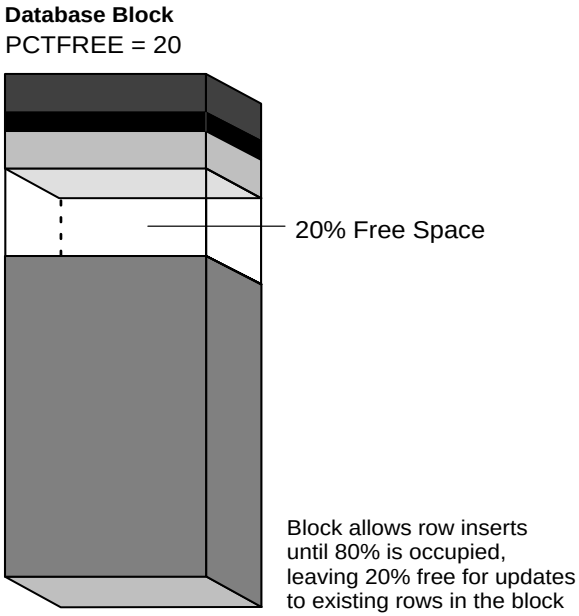
## The PCTFREE Parameter

The PCTFREE parameter is used to set the percentage of a block to be reserved for possible updates to rows that already are contained in that block. For example, assume that you specify the following parameter within a CREATE TABLE statement:

```
PCTFREE 20
```

This indicates that 20% of each data block used for this table's data segment will be kept free and available for possible updates to the existing rows already within each block. Figure 12–1illustrates PCTFREE.

***Figure 12–1 PCTFREE***




Notice that before the block reaches PCTFREE, the free space of the data block is filled by both the insertion of new rows and by the growth of the data block header.

## Specifying PCTFREE

The default for PCTFREE is 10 percent. You can use any integer between 0 and 99, inclusive, as long as the sum of PCTFREE and PCTUSED does not exceed 100.

A smaller PCTFREE has the following effects:

- Reserves less room for updates to expand existing table rows
- Allows inserts to fill the block more completely
- May save space, because the total data for a table or index is stored in fewer blocks (more rows or entries per block)

A small PCTFREE might be suitable, for example, for a segment that is rarely changed.

A larger PCTFREE has the following effects:

- Reserves more room for future updates to existing table rows

- May require more blocks for the same amount of inserted data (inserting fewer rows per block)
- May improve update performance, because Oracle does not need to chain row pieces as frequently, if ever

A large PCTFREE is suitable, for example, for segments that are frequently updated.

Ensure that you understand the nature of the table or index data before setting PCTFREE. Updates can cause rows to grow. New values might not be the same size as values they replace. If there are many updates in which data values get larger, PCTFREE should be increased. If updates to rows do not affect the total row width, PCTFREE can be low. Your goal is to find a satisfactory trade-off between densely packed data and good update performance.

**PCTFREE for Nonclustered Tables** If the data in the rows of a nonclustered table is likely to increase in size over time, reserve some space for these updates. Otherwise, updated rows are likely to be chained among blocks.

**PCTFREE for Clustered Tables** The discussion for nonclustered tables also applies to clustered tables. However, if PCTFREE is reached, new rows from *any* table contained in the same cluster key go into a new data block that is chained to the existing cluster key.

**PCTFREE for Indexes** You can specify PCTFREE only when initially creating an index.

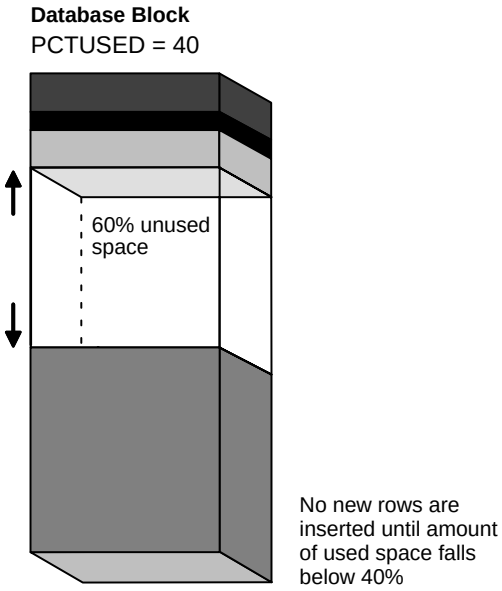
## The PCTUSED Parameter

After a data block becomes full as determined by PCTFREE, Oracle does not consider the block for the insertion of new rows until the percentage of the block being used falls below the parameter PCTUSED. Before this value is achieved, Oracle uses the free space of the data block only for updates to rows already contained in the data block. For example, assume that you specify the following parameter within a CREATE TABLE statement:

```
PCTUSED 40
```

In this case, a data block used for this table's data segment is not considered for the insertion of any new rows until the amount of used space in the block falls to 39% or less (assuming that the block's used space has previously reached PCTFREE). Figure 12–2 illustrates this.

***Figure 12–2 PCTUSED***




## Specifying PCTUSED

The default value for PCTUSED is 40 percent. After the free space in a data block reaches PCTFREE, no new rows are inserted in that block until the percentage of space used falls below PCTUSED. The percent value is for the block space available for data after overhead is subtracted from total space.

You can specify any integer between 0 and 99 (inclusive) for PCTUSED, as long as the sum of PCTUSED and PCTFREE does not exceed 100.

A smaller PCTUSED has the following effects:

- Reduces processing costs incurred during UPDATE and DELETE statements for moving a block to the free list when it has fallen below that percentage of usage
- Increases the unused space in a database

A larger PCTUSED has the following effects:

- Improves space efficiency
- Increases processing cost during INSERTs and UPDATEs

## Selecting Associated PCTUSED and PCTFREE Values

If you decide not to use the default values for PCTFREE or PCTUSED, keep the following guidelines in mind:

- The sum of PCTFREE and PCTUSED must be equal to or less than 100.
- If the sum equals 100, then Oracle attempts to keep no more than PCTFREE free space, and processing costs are highest.
- Block overhead is not included in the computation of PCTUSED or PCTFREE.
- The smaller the difference between 100 and the sum of PCTFREE and PCTUSED (as in PCTUSED of 75, PCTFREE of 20), the more efficient space usage is, at some performance cost.

### Examples of Choosing PCTFREE and PCTUSED Values

The following examples show how and why specific values for PCTFREE and PCTUSED are specified for tables.

| | | |
|---|---|---|
| Example 1 | Scenario: | Common activity includes UPDATE statements that increase the size of the rows. |
| | Settings: | PCTFREE = 20 |
| | | PCTUSED = 40 |
| Example 2 | Scenario: | Most activity includes INSERT and DELETE statements, and UPDATE statements that do not increase the size of affected rows. |
| | Settings: | PCTFREE = 5 |
| | | PCTUSED = 60 |
| | Explanation: | PCTFREE is set to 5 because most UPDATE statements do not increase row sizes. PCTUSED is set to 60 so that space freed by DELETE statements is used soon, yet processing is minimized. |
| Example 3 | Scenario: | The table is very large; therefore, storage is a primary concern. Most activity includes read-only transactions. |
| | Settings: | PCTFREE = 5 |
| | | PCTUSED = 40 |
| | Explanation: | PCTFREE is set to 5 because this is a large table and you want to completely fill each block. |

# Transaction Entry Settings (INITRANS and MAXTRANS)

The INITRANS and MAXTRANS transaction entry settings for the data blocks allocated for a table, cluster, or index should be set individually for each object based on the following criteria:

- 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 (to eliminate the overhead of having to allocate transaction entry space, as required when the object is in use) and allowing a higher MAXTRANS so that no user has to wait to access necessary data blocks.

> **See Also:** For syntax and specific details of the INITRANS and MAXTRANS parameters, refer to the *Oracle8i SQL Reference.*

### INITRANS

Specifies the number of DML transaction entries for which space should be initially reserved in the data block header. Space is reserved in the headers of all data blocks in the associated data or index segment. The default value is 1 for tables and 2 for clusters and indexes.

### MAXTRANS

As multiple transactions concurrently access the rows of the same data block, space is allocated for each DML transaction's 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. The MAXTRANS parameter limits the number of transaction entries that can concurrently use data in a data block. Therefore, you can limit the amount of free space that can be allocated for transaction entries in a data block using MAXTRANS.

The default value is an operating system-specific function of block size, not exceeding 255.

# Setting Storage Parameters

This section describes the storage parameters that you can set for various data structures. These storage parameters apply to the following types of structures and schema objects:

- Tablespaces (used as storage parameter defaults for all segments)
- Tables, partitions, clusters, snapshots, and snapshot logs (data segments)
- Indexes (index segments)
- Rollback segments

The following topics are discussed:



## Identifying the Storage Parameters

Every database has default values for storage parameters. But, you can specify new defaults for a tablespace, which override the system defaults to become the defaults for objects created in that tablespace only. These default storage values are specified in the DEFAULT STORAGE clause of a CREATE or ALTER TABLESPACE statement.

Furthermore, you can specify storage settings for each individual schema object, which override any default storage settings. To do so, you use the STORAGE clause of the CREATE or ALTER statement for the individual object.

Storage parameters are specified when you create a schema object, and may later be altered. 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. To set or change the value of a storage parameter, you must have the privileges necessary to use the appropriate CREATE or ALTER statement.

The following sections identify the storage parameters that you can specify.

> **See Also:** Detailed information about storage parameters, including information on how Oracle rounds values and usage restrictions, is contained in the *Oracle8i SQL Reference*.
>
> The settings for some storage values are operating system specific. Refer to your operating system-specific documentation for information on those values.

### INITIAL

The size, in bytes, of the first extent allocated when a segment is created. This parameter can not be specified on an ALTER statement.

| | |
|---|---|
| **Default:** | 5 data blocks |
| **Minimum:** | 2 data blocks (nonbitmapped segments), 3 data blocks (bitmapped segments) |
| **Maximum:** | Operating system specific |

### NEXT

The size, in bytes, of the next incremental extent to be allocated for a segment. The second extent is equal to the original setting for NEXT. From there forward, NEXT is set to the previous size of NEXT multiplied by (1 + PCTINCREASE / 100).

| | |
|---|---|
| **Default:** | 5 data blocks |
| **Minimum:** | 1 data block |
| **Maximum:** | Operating system specific |

### PCTINCREASE

The percentage by which each incremental extent grows over the last incremental extent allocated for a segment. If PCTINCREASE is 0, then all incremental extents are the same size. If PCTINCREASE is greater than zero, then each time NEXT is calculated, it grows by PCTINCREASE. PCTINCREASE cannot be negative.

The new NEXT equals 1 + PCTINCREASE/100, multiplied by the size of the last incremental extent (the old NEXT) and rounded *up* to the next multiple of a block size.

| | |
|---|---|
| **Default:** | 50 (%) |
| **Minimum:** | 0 (%) |
| **Maximum:** | Operating system specific |

### MINEXTENTS

The total number of extents to be allocated when the segment is created. This allows for a large allocation of space at creation time, even if contiguous space is not available.

| | |
|---|---|
| **Default:** | 1 (extent); 2(extents) for rollback segments |
| **Minimum:** | 1 (extent); 2 (extents) for rollback segments |
| **Maximum:** | Operating system specific |

### MAXEXTENTS

The total number of extents, including the first, that can ever be allocated for the segment.

| | |
|---|---|
| **Default:** | Depends on the data block size and operating system |
| **Minimum:** | 1 (extent); 2(extents) for rollback segments |
| **Maximum:** | Unlimited |

### FREELIST GROUPS

The number of groups of free lists for the database object you are creating. Oracle uses the instance number of Oracle Parallel Server instances to map each instance to one free list group.

| | |
|---|---|
| **Default:** | 1 |
| **Minimum:** | 1 |
| **Maximum:** | Depends on number of Oracle Parallel Server instances |

For information on the use of this parameter, see *Oracle8i Parallel Server Administration, Deployment, and Performance.*

### FREELISTS

Specifies the number of free lists for each of the free list groups for the schema object. Not valid for tablespaces.

| | |
|---|---|
| **Default:** | 1 |
| **Minimum:** | 1 |
| **Maximum:** | Depends on data block size |

The use of this parameter is discussed in *Oracle8i Designing and Tuning for Performance.*

### OPTIMAL

Relevant only to rollback segments. See Chapter 11, "Managing Rollback Segments" for information on the use of this parameter.

### BUFFER_POOL

Defines a default buffer pool (cache) for a schema object. Not valid for tablespaces or rollback segments. For information on the use of this parameter, see *Oracle8i Designing and Tuning for Performance.*

## Setting Default Storage Parameters for Segments in a Tablespace

You can set default storage parameters for each tablespace of a database. Any storage parameter that you do not explicitly set when creating or subsequently altering a segment in a tablespace automatically is set to the corresponding default storage parameter for the tablespace in which the segment resides.

When specifying MINEXTENTS at the tablespace level, any extent allocated in the tablespace is rounded to a multiple of the number of minimum extents. Basically, the number of extents is a multiple of the number of blocks.

## Setting Storage Parameters for Data Segments

You set the storage parameters for the data segment of a nonclustered table, snapshot, or snapshot log using the STORAGE clause of the CREATE or ALTER statement for tables, snapshots, or snapshot logs.

In contrast, you 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 and snapshots into the cluster. Storage parameters specified when creating or altering a *clustered* table or snapshot are ignored. The storage parameters set for the cluster override the table's storage parameters.

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 the ENABLE clause of the CREATE TABLE or ALTER TABLE statements or the STORAGE clause of the ALTER INDEX statement.

## Setting Storage Parameters for LOBs, Varrays, and Nested Tables

A table or snapshot may contain LOB, varray, or nested table column types. These entities can be stored in their own segments. LOBs 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.

Information about creating tables containing LOBs, varrays, and nested tables can be found in *Oracle8i Application Developer's Guide - Large Objects (LOBs), Oracle8i Application Developer's Guide - Fundamentals,* and the *Oracle8i SQL Reference.*

## Changing Values for Storage Parameters

You can alter default storage parameters for tablespaces and specific storage parameters for individual segments 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.

The INITIAL and MINEXTENTS storage parameters cannot be altered for an existing table, cluster, index, or rollback segment. 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

The storage parameters in effect at a given time are determined by the following types of SQL statements, listed in order of precedence:

1. ALTER TABLE / CLUSTER / SNAPSHOT / SNAPSHOT LOG / INDEX / ROLLBACK SEGMENT statement
2. CREATE TABLE / CLUSTER / SNAPSHOT / SNAPSHOT LOG / CREATE INDEX / ROLLBACK SEGMENT statement
3. ALTER TABLESPACE statement
4. CREATE TABLESPACE statement
5. Oracle default values

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 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.

---

### Storage Parameter Example

Assume the following statement has been executed:

```
CREATE TABLE test_storage
   ( . . . )
```

```
STORAGE (INITIAL 100K   NEXT 100K
   MINEXTENTS 2   MAXEXTENTS 5
   PCTINCREASE 50);
```

Also assume that the initialization parameter DB_BLOCK_SIZE is set to 2K. The following table shows how extents are allocated for the TEST_STORAGE table. Also shown is the value for the incremental extent, as can be seen in the NEXT column of the USER_SEGMENTS or DBA_SEGMENTS data dictionary views:

***Table 12–1 Extent Allocations***

| Extent# | Extent Size | Value for NEXT |
|---|---|---|
| 1 | 50 blocks or 102400 bytes | 50 blocks or 102400 bytes |
| 2 | 50 blocks or 102400 bytes | 75 blocks or153600 bytes |
| 3 | 75 blocks or 153600 bytes | 113 blocks or 231424 bytes |
| 4 | 115 blocks or 235520 bytes | 170 blocks or 348160 bytes |
| 5 | 170 blocks or 348160 bytes | No next value, MAXEXTENTS=5 |

If you change the NEXT or PCTINCREASE storage parameters with an ALTER statement (such as ALTER TABLE), the specified value replaces the current value stored in the data dictionary. For example, the following statement modifies the NEXT storage parameter of the TEST_STORAGE table before the third extent is allocated for the table:

```
ALTER TABLE test_storage STORAGE (NEXT 500K);
```

As a result, the third extent is 500K when allocated, the fourth is (500K*1.5)=750K, and so on.

## Deallocating Space

It is not uncommon to allocate space to a segment, only to find out later that it is not being used. For example, you may set PCTINCREASE to a high value, which could create a large extent that is only partially used. Or you could explicitly overallocate space by issuing the ALTER TABLE...ALLOCATE EXTENT statement. If you find that you have unused or overallocated space, you can release it so that the unused space can be used by other segments.

This section describes aspects of deallocating unused space.

## Viewing the High Water Mark

Prior to deallocation, you can use the DBMS_SPACE package, which contains a procedure (UNUSED_SPACE) that returns information about the position of the high water mark and the amount of unused space in a segment.

Within a segment, the high water mark indicates the amount of used space, or space that had been formatted to receive data.You cannot release space below the high water mark (even if there is no data in the space you wish to deallocate). However, if the segment is completely empty, you can release space using the TRUNCATE...DROP STORAGE statement.

> **See Also:** The DBMS_SPACE package is described in *Oracle8i Supplied PL/SQL Packages Reference.*

## Issuing Space Deallocation Statements

The following statements deallocate unused space in a segment (table, index or cluster). The KEEP clause is *optional*.

```
ALTER TABLE table DEALLOCATE UNUSED KEEP integer;
ALTER INDEX index DEALLOCATE UNUSED KEEP integer;
ALTER CLUSTER cluster DEALLOCATE UNUSED KEEP integer;
```

When you explicitly identify an amount of unused space to KEEP, this space is retained while the remaining unused space is deallocated. If the remaining number of extents becomes smaller than MINEXTENTS, the MINEXTENTS value changes to reflect the new number. If the initial extent becomes smaller, the INITIAL value changes to reflect the new size of the initial extent.

If you do not specify the KEEP clause, all unused space (everything above the high water mark) is deallocated, as long as the size of the initial extent and MINEXTENTS are preserved. Thus, even if the high water mark occurs within the MINEXTENTS boundary, MINEXTENTS remains and the initial extent size is not reduced.

> **See Also:** For details on the syntax and options associated with deallocating unused space, see the *Oracle8i SQL Reference*.
>
> You can verify that deallocated space is freed by looking at the DBA_FREE_SPACE view. For more information on this view, see the *Oracle8i Reference.*

## Deallocating Space Examples

This section provides some space deallocation examples.

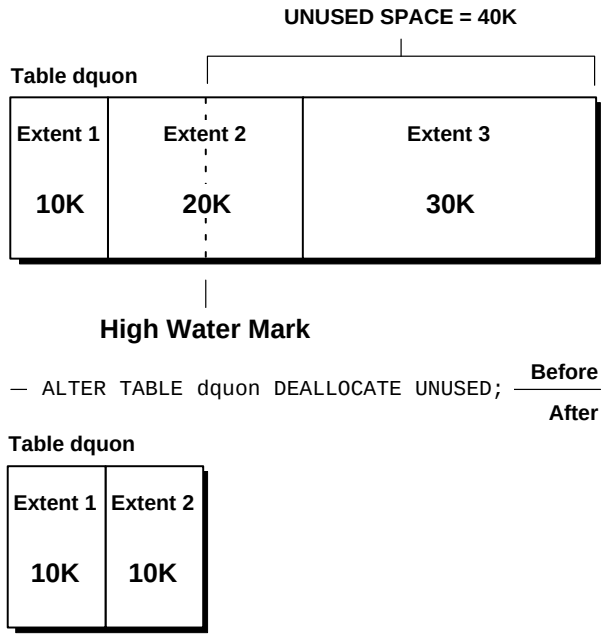
### Example 1:

A table consists of three extents. The first extent is 10K, the second is 20K, and the third is 30K. The high water mark is in the middle of the second extent, and there is 40K of unused space. Figure 12–3 illustrates the effect of issuing the following statement:

```
ALTER TABLE dquon DEALLOCATE UNUSED
```

All unused space is deallocated, leaving table DQUON with two remaining extents. The third extent disappears, and the second extent size is 10K.

***Figure 12–3 Deallocating All Unused Space***



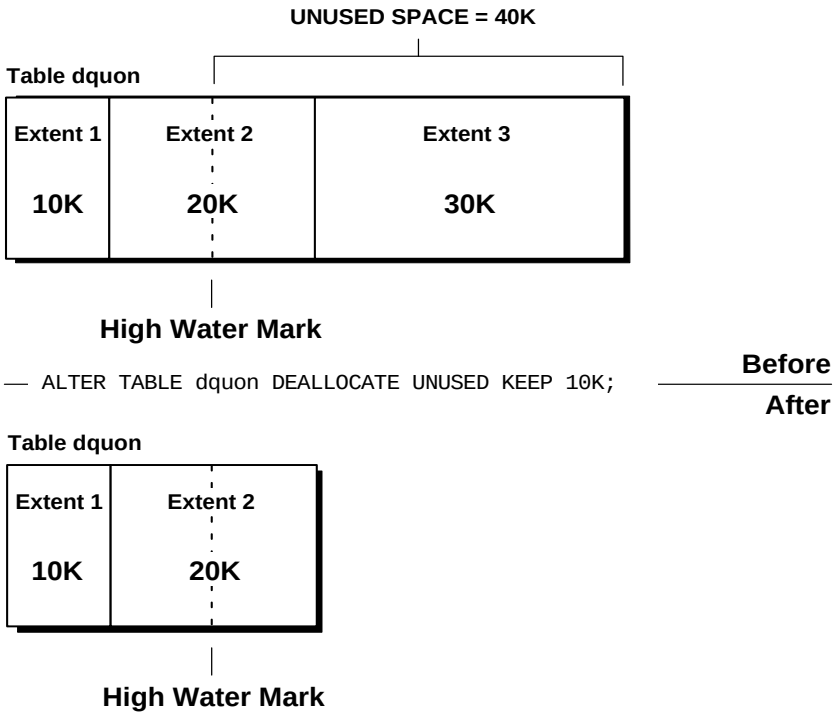

But, if you had issued the following statement specifying the KEEP keyword, then 10K above the high water mark would be kept, and the rest of the unused space would be deallocated from DQUON.

```
ALTER TABLE dquon DEALLOCATE UNUSED KEEP 10K;
```

In effect, the third extent is deallocated and the second extent remains intact.

Figure 12–4 illustrates this situation.

***Figure 12–4 Deallocating Unused Space, KEEP 10K***




Further, if you deallocate all unused space from DQUON and keep 20K, as specified in the following statement, the third extent is cut to 10K, and the size of the second extent remains the same.

```
ALTER TABLE dquon DEALLOCATE UNUSED KEEP 20K;
```

### Example 2:

Consider the situation illustrated by Figure 12–3. Extent 3 is completely deallocated, and the second extent is left with 10K. Further, the size of the next allocated extent defaults to the size of the last completely deallocated extent, which in this case, is 30K. If this is not what you want, you can explicitly set the size of the next extent

using the ALTER TABLE statement, specifying a new value for NEXT in the storage clause.

The following statement sets the next extent size for table DQUON to 20K.

```
ALTER TABLE dquon STORAGE (NEXT 20K)
```

**Example 3:**

To preserve the MINEXTENTS number of extents, DEALLOCATE can retain extents that were originally allocated to a segment. This capacity is influenced by the KEEP parameter and was explained earlier.

If table DQUON has a MINEXTENTS value of 2, the statements illustrated in Figure 12–3 and Figure 12–4 still yield the same results as shown, and further, the initial value of MINEXTENTS is preserved.

However, if the MINEXTENTS value is 3, then the statement illustrated in Figure 12–4 produces the same result as shown (the third extent is removed), but the value of MINEXTENTS is changed to 2. However, the statement illustrated in Figure 12–3 will not produce the same result. In this case, the statement has no effect.

## Understanding Space Use 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 *PL/SQL User's Guide and Reference* and *Oracle8i SQL Reference* contain extensive descriptions of datatypes and their space requirements.

# 13

# Managing Tables

This chapter describes the various aspects of managing tables, and includes the following topics:

- Guidelines for Managing Tables
- Creating Tables
- Altering Tables
- Dropping Tables
- Index-Organized Tables

Before attempting tasks described in this chapter, familiarize yourself with the concepts in Chapter 12, "Guidelines for Managing Schema Objects".

# Guidelines for Managing Tables

This section describes guidelines to follow when managing tables, and includes the following topics:



Use these guidelines to make managing tables as easy as possible.

## 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 setting storage parameters and defining clusters for tables, based on information from the application developer about how the application works and the types of data expected.

Working with your application developer, carefully plan each table so that the following occurs:

- Tables are normalized.
- Each column is of the proper datatype.
- Columns that allow nulls are defined last, to conserve storage space.
- Tables are clustered whenever appropriate, to conserve storage space and optimize performance of SQL statements.

## Specify How Data Block Space Is to Be Used

By specifying the PCTFREE and PCTUSED parameters during the creation of each table, you can affect the efficiency of space utilization and amount of space reserved

for updates to the current data in the data blocks of a table's data segment. The PCTFREE and PCTUSED parameters are discussed in "Managing Space in Data Blocks" on page 12-2.

## Specify Transaction Entry Parameters

By specifying the INITRANS and MAXTRANS parameters during the creation of each table, you can affect how much space is initially and can ever be allocated for transaction entries in the data blocks of a table's data segment. For information about setting the INITRANS and MAXTRANS parameters, see "Setting Storage Parameters" on page 12-8.

## Specify the Location of Each Table

If you have the proper privileges and tablespace quota, you can create a new table in any tablespace that is currently online. It is advisable to specify the TABLESPACE clause in a CREATE TABLE statement to identify the tablespace that will store the new table. 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, make sure 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
- decrease the time needed for database administration

The following situations illustrate how specifying incorrect storage locations for schema objects can affect a database:

- If users' objects are created in the SYSTEM tablespace, the performance of Oracle can be reduced, since both data dictionary objects and user objects must contend for the same datafiles.
- If an application's associated tables are arbitrarily stored in various tablespaces, the time necessary to complete administrative operations (such as backup and recovery) for that application's data can be increased.

Chapter 22, "Managing Users and Resources" contains information about assigning default tablespaces and tablespace quotas to users.

## Parallelize Table Creation

You can parallelize the creation of tables created with a subquery in the CREATE TABLE statement. Because multiple processes work together to create the table, performance of the table creation can improve.

> **See Also:** For information about parallel execution, including parallel table creation, see the following books:
>
> - *Oracle8i Designing and Tuning for Performance*
> - *Oracle8i Concepts*

## Consider Creating UNRECOVERABLE Tables

When you create an unrecoverable table, the table cannot be recovered from archived logs (because the needed redo log records are not generated for the unrecoverable table creation). Thus, if you cannot afford to lose the table, you should take a backup after the table is created. In some situations, such as for tables that are created for temporary use, this precaution may not be necessary.

You can create an unrecoverable table by specifying UNRECOVERABLE when you create a table with a subquery in the CREATE TABLE...AS SELECT statement. However, rows inserted afterwards are recoverable. In fact, after the statement is completed, all future statements are fully recoverable.

Creating an unrecoverable table 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.

In general, the relative performance improvement is greater for larger unrecoverable tables than for smaller tables. Creating small unrecoverable tables 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.

## Estimate Table Size and Set Storage Parameters

Estimating the sizes of tables before creating them is useful for the following reasons:

- You can use the combined estimated size of tables, along with estimates for indexes, rollback segments, 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 table to better manage the disk space that the table will use. When a table is created, you can set appropriate storage parameters and improve I/O performance of applications that use the table. For example, assume that you estimate the maximum size of a table before creating it. If you then set the storage parameters when you create the table, fewer extents will be allocated for the table's data segment, and all of the table's data will be stored in a relatively contiguous section of disk space. This decreases the time necessary for disk I/O operations involving this table.

Whether or not you estimate table size before creation, you can explicitly set storage parameters when creating each nonclustered table. (Clustered tables automatically use the storage parameters of the cluster.) 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. Storage parameters are discussed in "Setting Storage Parameters" on page 12-8.

If you explicitly set the storage parameters for the extents of a table's data segment, try to store the table's data in a small number of large extents rather than a large number of small extents.

## Plan for Large Tables

There are no limits on the physical size of tables and extents. You can specify the keyword UNLIMITED for MAXEXTENTS, thereby simplifying your planning for large objects, reducing wasted space and fragmentation, and improving space reuse. However, keep in mind that while Oracle allows an unlimited number of extents, when the number of extents in a table grows very large, you may see an impact on performance when performing any operation requiring that table.

---

**Note:** You cannot alter data dictionary tables to have MAXEXTENTS greater than the allowed block maximum.

---

If you have such tables in your database, consider the following recommendations:

- Separate the table from its indexes.

  Place indexes in separate tablespaces from other objects, and on separate disks if possible. If you ever need to drop and re-create an index on a very large table

(such as when disabling and enabling a constraint, or re-creating the table), indexes isolated into separate tablespaces can often find contiguous space more easily than those in tablespaces that contain other objects.

- Allocate sufficient temporary space.

  If applications that access the data in a very large table perform large sorts, ensure that enough space is available for large temporary segments (temporary segments always use the default STORAGE settings for their tablespaces).

## Table Restrictions

Before creating tables, make sure you are aware of the following restrictions:

- Tables containing new object types cannot be imported into a pre-Oracle8 database.
- You cannot move types and extent tables to a different schema when the original data still exists in the database.
- You cannot merge an exported table into a preexisting table having the same name in a different schema.
- Oracle has a limit on the total number of columns that a table (or attributes that an object type) can have. See the description of the ALTER TABLE statement in *Oracle8i SQL Reference* for this limit.

Additionally, when you create a table that contains user-defined type data, Oracle maps columns of user-defined type to relational columns for storing the user-defined type data. These "hidden" relational columns 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, the total number of columns that Oracle actually creates for the table may be more than those you specify, because Oracle creates hidden columns to store the user-defined type data.

The following formulas determine the total number of columns created for a table with user-defined type data:

### Number of columns in an object table:

```
num_columns(object_table) =
    num_columns(object_identifier)
  + num_columns(row_type)
  + number of top-level object columns in the object type of table
  + num_columns(object_type)
```

### Number of columns in a relational table:

```
num_columns(relational_table) =
    number of scalar columns in the table
  + number of object columns in the table
  + SUM [num_columns(object_type(i))]   i= 1 -> n
  + SUM [num_columns(nested_table(j))]  j= 1 -> m
  + SUM [num_columns(varray(k))]        k= 1 -> p
  + SUM [num_columns(REF(l))]           l= 1 -> q
```

where in the given relational table:

```
object_type(i) is the ith object type column and
   n is the total number of such object type columns
nested_table(j) is the jth nested_table column and
   m is the total number of such nested table columns
varray(k) is the kth varray column and
   p is the total number of such varray columns,
REF(l) is the lth REF column and
   q is the total number of such REF columns.
```

### Definitions:

```
num_columns(object identifier) = 1
num_columns(row_type)          = 1
num_columns(REF)               = 1, if REF is unscoped
                               = 1, if the REF is scoped and the object identifier
                                 is system generated and the REF has no
                                 referential constraint
                               = 2, if the REF is scoped and the object identifier
                                 is system generated and the REF has a
                                 referential constraint
                               = 1 + number of columns in the primary key,
                                 if the object identifier is primary key based
num_columns(nested_table)      = 2
num_columns(varray)            = 1
num_columns(object_type)       = number of scalar attributes in the object type
                               + SUM[num_columns(object_type(i))]     i= 1 -> n
                               + SUM[num_columns(nested_table(j))]    j= 1 -> m
                               + SUM[num_columns(varray(k))]          k= 1 -> p
                               + SUM[num_columns(REF(l))]             l= 1 -> q
```

where in the given object type:

```
object_type(i) is an embedded object type attribute and
   n is the total number of such object type attributes,
nested_table(j) is an embedded nested_table attribute and
   m is the total number of such nested table attributes,
varray(k) is an embedded varray attribute and
```

```
   p is the total number of such varray attributes,
REF(l) is an embedded REF attribute and
   q is the total number of such REF attributes.
```

The following are some examples of computing the number of columns for an object table, or a relational table with columns of REF, varray, nested table, or object type.

### Example 1:

```
CREATE TYPE physical_address_type AS OBJECT
        (no CHAR(4), street CHAR(31), city CHAR(5), state CHAR(3));
CREATE TYPE phone_type AS VARRAY(5) OF CHAR(15);
CREATE TYPE electronic_address_type AS OBJECT
        (phones phone_type, fax CHAR(12), email CHAR(31));
CREATE TYPE contact_info_type AS OBJECT
        (physical_address physical_address_type,
         electronic_address electronic_address_type);
CREATE TYPE employee_type AS OBJECT
        (eno NUMBER, ename CHAR(60),
         contact_info contact_info_type);

CREATE TABLE employee_object_table OF employee_type;
```

To calculate number of columns in employee object table, we first need to calculate number of columns required for employee_type:

```
num_columns(physical_address_type) =
     number of scalar attributes = 4
num_columns(phone_type) =
     num_columns(varray) = 1
num_columns(electronic_address_type) =
     number of scalar attributes
   + num_columns(phone_type)
   = 2 + 1 = 3
num_columns(contact_info_type) =
     num_columns(physical_address_type)
   + num_columns(electronic_address_type)
   = 3 + 4 = 7
num_columns(employee_type) =
     number of scalar attributes
   + num_columns(contact_info_type)
   = 2 + 7 = 9
```

Now, use the formula for object tables:

```
num_columns (employee_object_table) =
     num_columns(object_identifier)
   + num_columns(row_type)
```

```
   + number of top level object columns in employee_type
   + num_columns(employee_type)
   = 1 + 1 + 1 + 9 = 12
```

**Example 2:**

```
CREATE TABLE employee_relational_table (einfo employee_type);

num_columns (employee_relational_table) =
     number of object columns in table
   + num_columns(employee_type)
   = 1 + 9 = 10
```

**Example 3:**

```
CREATE TYPE project_type AS OBJECT (pno NUMBER, pname CHAR(30), budget NUMBER);

CREATE TYPE project_set_type AS TABLE OF project_type;

CREATE TABLE department
        (dno NUMBER, dname CHAR(30),
         mgr REF employee_type REFERENCES employee_object_table,
         project_set project_set_type)
NESTED TABLE project_set STORE AS project_set_nt;

num_columns(department) =
     number of scalar columns
   + num_columns(mgr)
   + num_columns(project_set)
   = 2 + 2 + 2  = 6
```

# 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. When user SCOTT issues the following statement, he creates a nonclustered table named EMP in his schema and stores it in the USERS tablespace:

```
CREATE TABLE        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),
        comm        NUMBER(7,2),
        deptno      NUMBER(3) NOT NULL
                     CONSTRAINT dept_fkey REFERENCES dept)
    PCTFREE 10
    PCTUSED 40
    TABLESPACE users
    STORAGE ( INITIAL 50K
              NEXT 50K
              MAXEXTENTS 10
              PCTINCREASE 25 );
```

In this example, integrity constraints are defined on several columns of the table. Integrity constraints are discussed in "Managing Integrity Constraints" on page 19-14. Several segment attributes are also explicitly specified for the table. These are explained in Chapter 12, "Guidelines for Managing Schema Objects".

It is also possible to create a temporary table. 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. You use the CREATE GLOBAL TEMPORARY TABLE statement to create a temporary table. The ON COMMIT keywords indicate if the data in the table is *transaction-specific* (the default) or *session-specific*:

- ON COMMIT DELETE ROWS specifies that the temporary table is transaction specific and Oracle will truncate the table (delete all rows) after each commit.
- ON COMMIT PRESERVE ROWS specifies that the temporary table is session specific and Oracle will truncate the table when you terminate the session.

This example creates a temporary table that is transaction specific:

```
CREATE GLOBAL TEMPORARY TABLE 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.

**See Also:** For exact syntax, authorization, or restrictions information for CREATE TABLE and other statements discussed in this chapter, see *Oracle8i SQL Reference.*

For more information on temporary tables, see *Oracle8i Concepts.*

## Altering Tables

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.

A table in an Oracle database can be altered for the following reasons:

- To add or drop columns, or modify an existing column's definition (datatype, length, default value, and NOT NULL integrity constraint)
- To modify data block space usage parameters (PCTFREE, PCTUSED)
- To modify transaction entry settings (INITRANS, MAXTRANS)
- To modify storage parameters
- To move the table to a new segment or tablespace
- To explicitly allocate an extent or deallocate unused space
- To modify the logging attributes of the table
- To modify the CACHE/NOCACHE attributes
- To add, modify or drop integrity constraints associated with the table
- To enable or disable integrity constraints or triggers associated with the table
- To modify the degree of parallelism for the table
- To rename a table
- To add or modify index-organized table characteristics
- To add of modify LOB columns
- To add or modify object type, nested table, or varray columns

You can increase the length of an existing column. However, you cannot decrease it unless there are no rows in the table. Furthermore, if you are modifying a table to increase the length of a column of datatype CHAR, realize that this may be a time consuming operation and may 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.

When altering the data block space usage parameters (PCTFREE and PCTUSED) of a table, note that new settings apply to all data blocks used by the table, including blocks already allocated and subsequently allocated for the table. However, the blocks already allocated for the table are not immediately reorganized when space usage parameters are altered, but as necessary after the change. The data block storage parameters are described in "Managing Space in Data Blocks" on page 12-2.

When altering the transaction entry settings (INITRANS, MAXTRANS) of a table, note that a new setting for INITRANS applies only to data blocks subsequently allocated for the table, while a new setting for MAXTRANS applies to all blocks (already and subsequently allocated blocks) of a table. To better understand these transaction entry setting parameters, see "Transaction Entry Settings (INITRANS and MAXTRANS)" on page 12-7.

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 "Setting Storage Parameters" on page 12-8.

You alter a table using the ALTER TABLE statement. The following statement alters the EMP table. It alters the data block storage parameters, and adds a new column named BONUS.

```
ALTER TABLE emp
      ADD (bonus NUMBER (7,2))
      PCTFREE 30
      PCTUSED 60;
```

Some of the other usages of the ALTER TABLE statement are presented in the following sections:

- Moving a Table to a New Segment or Tablespace
- Manually Allocating Storage for a Table
- Dropping Columns

**WARNING: Before altering a table, familiarize yourself with the consequences of doing so.**

**If a new column is added to a table, the column is initially null. You can add a column with a NOT NULL constraint to a table only if the table does not contain any rows.**

**If a view or PL/SQL program unit depends on a base table, the alteration of the base table may affect the dependent object. See** "Managing Object Dependencies" **on page 19-23** **for information about how Oracle manages dependencies.**

## Moving a Table to a New Segment or Tablespace

The ALTER TABLE...MOVE statement allows you to relocate data of a nonpartitioned table into a new segment, and optionally into a different tablespace for which you have quota. This statement also allows you to modify any of the table's storage attributes, including those which cannot be modified using ALTER TABLE.

The following statement moves the EMP table to a new segment specifying new storage parameters.

```
ALTER TABLE  emp MOVE
      STORAGE ( INITIAL 20K
                NEXT 40K
                MINEXTENTS 2
                MAXEXTENTS 20
                PCTINCREASE 0 );
```

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.

## Manually Allocating Storage for a Table

Oracle dynamically allocates additional extents for the data segment of a table, as required. However, you might want to allocate an additional extent for a table explicitly. For example, when using the Oracle Parallel Server, 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 statement with the ALLOCATE EXTENT option.

You can also explicitly deallocate unused space using the DEALLOCATE UNUSED clause of ALTER TABLE. This is described in "Deallocating Space" on page 12-14.

> **See Also:** For information about using the ALLOCATE EXTENT option in an OPS environment, see *Oracle8i Parallel Server Administration, Deployment, and Performance.*

## Dropping Columns

Oracle allows you to 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 recreate indexes and constraints. Users require the ALTER privilege on the target table or the ALTER ANY TABLE system privilege to issue any of the drop column related statements below.

You cannot drop all columns from a table, nor can you drop columns from a table owned by SYS. Any attempt to do so will result in an error. For additional restrictions and options, see *Oracle8i SQL Reference.*

### 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 EMP table.

This statement drops only the SAL column:

```
ALTER TABLE emp DROP COLUMN sal;
```

The following statement drops both the SAL and COMM columns:

```
ALTER TABLE emp DROP (sal, comm);
```

### 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 will not be 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 SAL and COMM columns as unused, execute the following statement.

```
ALTER TABLE emp SET UNUSED (sal, comm);
```

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
------------------------------ ------------------------------ ----------
SCOTT                          EMP                                 1
1 row selected.
```

### 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 example that follows the optional keyword CHECKPOINT is specified. This option 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 rollback segment space.

```
ALTER TABLE emp DROP UNUSED COLUMNS CHECKPOINT 250;
```

## Dropping Tables

To drop a table, the table must be contained in your schema or you must have the DROP ANY TABLE system privilege.

To drop a table that is no longer needed, use the DROP TABLE statement. The following statement drops the EMP table:

```
DROP TABLE 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, include the CASCADE option in the DROP TABLE statement, as shown below:

```
DROP TABLE emp CASCADE CONSTRAINTS;
```

---

**WARNING: 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 19-23 for information about how Oracle manages dependencies.**
- **All synonyms for a dropped table remain, but return an error when used.**
- **All extents allocated for a nonclustered 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.**

---

Instead of dropping a table, you might 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, etc.) or authorizations. The TRUNCATE statement is discussed in "Truncating Tables and Clusters" on page 19-10.

# Index-Organized Tables

This section describes aspects of managing index-organized tables, and includes the following topics:



## What are Index-Organized Tables

Index-organized tables are tables with data rows grouped according to the primary key. This clustering is achieved using a *B***-tree index*. B**-tree indexes are special types of index trees that differ from regular table B-tree indexes in that they store both the primary key and non-key columns. The attributes of index-organized tables are stored entirely within the physical data structures for the index.

### Why use Index-Organized Tables

Index-organized tables provide fast key-based access to table data for queries involving exact match and range searches. Changes to the table data (such as adding new rows, updating rows, or deleting rows) result only in updating the index structure (because there is no separate table storage area).

Also, storage requirements are reduced because key columns are not duplicated in the table and index. The remaining non-key columns are stored in the index structure.

Index-organized tables are particularly useful when you are using applications that must retrieve data based on a primary key. Index-organized tables are also 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.

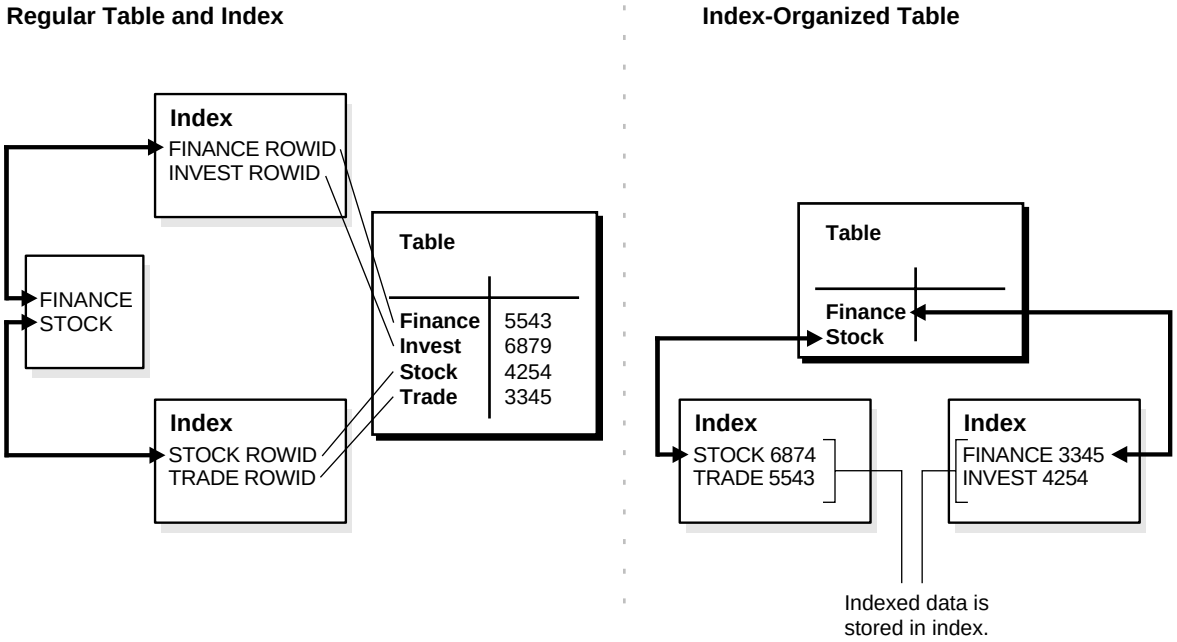
### Differences Between Index Organized and Regular Tables

Index-organized tables are like regular tables with a primary key index on one or more of its columns. However, instead of maintaining two separate storage spaces

for the table and B*tree index, an index-organized table only maintains a single B*tree index containing the primary key of the table and other column values.

The following figure illustrates the structural difference between regular tables and index-organized tables.

***Figure 13–1 Structure of Regular Table versus Index-Organized Table***




Index-organized tables are suitable for accessing data by way of primary key or any key that is a valid prefix of the primary key. There is no duplication of key values and storage requirements are reduced because a separate index structure containing the key values and ROWID is not created.

> **See Also:** For more details about index-organized tables, see *Oracle8i Concepts.*
>
> For details of the syntax involved in creating index-organized tables, see *Oracle8i SQL Reference.*

## Creating Index-Organized Tables

You use the CREATE TABLE statement to create index-organized tables, but you will need to provide the following 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). A primary key must be specified for index-organized tables.
- An optional row overflow specification clause (OVERFLOW), 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. An INCLUDING clause can also be specified to specify what (non-key) columns are to be stored in the 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 non-key column values that fit the specified threshold, and a pointer to the rest of the row.

The following example creates an index-organized table:

```
CREATE TABLE docindex(
        token char(20),
        doc_id NUMBER,
        token_frequency NUMBER,
        token_offsets VARCHAR2(512),
        CONSTRAINT pk_docindex PRIMARY KEY (token, doc_id))
    ORGANIZATION INDEX TABLESPACE ind_tbs
    PCTTHRESHOLD 20
    OVERFLOW TABLESPACE ovf_tbs;
```

The above example shows that the ORGANIZATION INDEX qualifier specifies an index-organized table, where the key columns and non-key columns reside in an index defined on columns that designate the primary key (TOKEN, DOC_ID) for the table.

Index-organized tables can store object types. For example, you can create an index-organized table containing a column of object type MYTYPE (for the purpose of this example) as follows:

```
CREATE TABLE iot (c1 NUMBER primary key, c2 mytype)
    ORGANIZATION INDEX;
```

However, you cannot create an index-organized table of object types. For example, the following statement would not be valid:

```
CREATE TABLE iot OF mytype ORGANIZATION INDEX;
```

### Using the AS Subquery

You can create an index-organized table using the AS subquery. Creating an index-organized table in this manner enables you to load the table in parallel by using the PARALLEL option.

The following statement creates an index-organized table (in parallel) by selecting rows from a conventional table, RT:

```
CREATE TABLE iot(i PRIMARY KEY, j) ORGANIZATION INDEX PARALLEL (DEGREE 2)
    AS SELECT * FROM rt;
```

### Using the Overflow Clause

The overflow clause specified in the earlier example indicates that any non-key columns of rows exceeding 20% of the block size are placed in a data segment stored in the OVF_TBS tablespace. The key columns should fit the specified threshold.

If an update of a non-key column causes the row to decrease in size, Oracle identifies the row piece (head or tail) to which the update is applicable and rewrites that piece.

If an update of a non-key column causes the row to increase in size, Oracle identifies the piece (head or tail) to which the update is applicable and rewrites that row piece. If the update's target turns out to be the head piece, note that this piece may again be broken into 2 to keep the row size below the specified threshold.

The non-key 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 non-key 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:** For details about this use of the ANALYZE statement, see *Oracle8i SQL Reference*.

**Using the INCLUDING clause** In addition to specifying PCTTHRESHOLD, you can use the INCLUDING <*column_name*> clause to control which non-key columns are stored with the key columns. Oracle accommodates all non-key columns up to the column specified in the INCLUDING clause in the index leaf block, provided it does not exceed the specified threshold. All non-key columns beyond the column specified in the INCLUDING clause are stored in the overflow area.

---

**Note:** Oracle 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 io(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 non-key column (i.e., any column after b in the stored column order).

---

The example presented earlier can be modified to create an index-organized table where the TOKEN_OFFSETS column value is always stored in the overflow area:

```
CREATE TABLE docindex(
        token CHAR(20),
        doc_id NUMBER,
        token_frequency NUMBER,
        token_offsets VARCHAR2(512),
        CONSTRAINT pk_docindex PRIMARY KEY (token, doc_id))
```

```
    ORGANIZATION INDEX TABLESPACE ind_tbs
        PCTTHRESHOLD 20
        INCLUDING token_frequency
        OVERFLOW TABLESPACE ovf_tbs;
```

Here, only non-key columns up to TOKEN_FREQUENCY (in this case a single column only) are stored with the key column values in the index leaf block.

### 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 per 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 iot(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 iot(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 iot(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 A MOVE NOCOMPRESS;
```

> **See Also:** For more details about key compression, see *Oracle8i Concepts* and the *Oracle8i SQL Reference.*

## Maintaining Index-Organized Tables

Index-organized tables differ from regular tables only in physical organization; logically, they are manipulated in the same manner. You can use an index-organized table in place of a regular table in INSERT, SELECT, DELETE, and UPDATE statements.

### Altering Index-Organized Tables

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 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 DOCINDEX table as follows:

```
ALTER TABLE 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, if the DOCINDEX table did not have an overflow segment, then you can add an overflow segment as follows:

```
ALTER TABLE docindex ADD OVERFLOW TABLESPACE ovf_tbs;
```

### Moving (Rebuilding) Index-Organized Tables

Because index-organized tables are primarily stored in a B*-tree index, you may 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 DOCINDEX after setting its INITRANS to 10:

```
ALTER TABLE docindex MOVE INITRANS 10;
```

You can move index-organized tables with no overflow data segment online using the ONLINE option. For example, if the DOCINDEX table does not have an overflow data segment, then you can perform the move online as follows:

```
ALTER TABLE docindex MOVE ONLINE INITRANS 10;
```

The following statement rebuilds the index-organized table DOCINDEX along with its overflow data segment:

```
ALTER TABLE docindex MOVE TABLESPACE ix_tbs OVERFLOW TABLESPACE ov_tbs;
```

And in this last statement, index-organized table IOT is moved while the LOB index and data segment for C2 are rebuilt:

```
ALTER TABLE iot MOVE LOB (C2) STORE AS (TABLESPACE lob_ts);
```

### Scenario: Updating the Key Column

A key column update is logically equivalent to deleting the row with the old key value and inserting the row with the new key value at the appropriate place to maintain the primary key order.

Logically, in the following example, the employee row for `dept_id=20` and `e_id=10` are deleted and the employee row for `dept_id=23` and `e_id=10` are inserted:

```
UPDATE employees
    SET dept_id=23
    WHERE dept_id=20 and e_id=10;
```

## Analyzing Index-Organized Tables

Just like conventional tables, index-organized tables are analyzed using the ANALYZE statement:

```
ANALYZE TABLE docindex COMPUTE STATISTICS;
```

The ANALYZE statement 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's physical statistics for the table `docindex` as follows:

  ```
  SELECT * FROM DBA_INDEXES WHERE INDEX_NAME= 'PK_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 DOCINDEX table as follows:

  ```
  SELECT * FROM DBA_TABLES WHERE IOT_TYPE='IOT_OVERFLOW'
            and IOT_NAME= 'DOCINDEX';
  ```

## 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.

For example, you create the following table:

```
CREATE TABLE employees (dept_id INTEGER, e_id INTEGER, e_name
   VARCHAR2, PRIMARY KEY (dept_id, e_id)) ORGANIZATION INDEX;
```

The following queries avoid sorting overhead because the data is already sorted on the primary key:

```
SELECT * FROM employees ORDER BY (dept_id, e_id);
SELECT * FROM employees ORDER BY (dept_id);
```

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 employees ORDER BY (e_id);
SELECT * FROM employees ORDER BY (e_name);
```

## Converting Index-Organized Tables to Regular Tables

You can convert index-organized tables to regular tables using the Oracle IMPORT/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:** For more details about using IMPORT/EXPORT, see *Oracle8i Utilities.*

# 14

# Managing Indexes

This chapter describes various aspects of index management, and includes the following topics:

- Guidelines for Managing Indexes
- Creating Indexes
- Altering Indexes
- Monitoring Space Use of Indexes
- Dropping Indexes

Before attempting tasks described in this chapter, familiarize yourself with the concepts in Chapter 12, "Guidelines for Managing Schema Objects".

# Guidelines for Managing Indexes

This section describes guidelines to follow when managing indexes, and includes the following topics:



An *index* is an optional structure associated with tables and clusters, which you can create explicitly to speed SQL statement execution on a table. Just as the index in this manual helps you locate information faster than if there were no index, an Oracle index provides a faster access path to table data.

Oracle provides several indexing schemes, which provide complementary performance functionality: B*-tree indexes (currently the most common), B*-tree cluster indexes, hash cluster indexes, reverse key indexes, and bitmap indexes. Oracle also provides support for function-based indexes and domain indexes specific to an application or cartridge.

The absence or presence of an index does not require a change in the wording of any SQL statement. An index merely offers a fast access path to the data; it affects only the speed of execution. Given a data value that has been indexed, the index points directly to the location of the rows containing that value.

Indexes are logically and physically independent of the data in the associated table. You can create or drop an index any time without affecting the base tables or other indexes. If you drop an index, all applications continue to work; however, access to previously indexed data might be slower. Indexes, being independent structures, require storage space.

Oracle automatically maintains and uses indexes after they are created. Oracle automatically reflects changes to data, such as adding new rows, updating rows, or deleting rows, in all relevant indexes with no additional action by users.

**See Also:**

- For conceptual information about indexes and indexing, including descriptions of the various indexing schemes offered by Oracle, see *Oracle8i Concepts.*
- For information about performance implications of index creation, and specific information about using bitmap indexes (including size estimates), see *Oracle8i Designing and Tuning for Performance.*
- For information about defining domain-specific operators and indexing schemes and integrating them into the Oracle database server, see the *Oracle8i Data Cartridge Developer's Guide.*

## Create Indexes After Inserting Table Data

You should create an index for a table after inserting or loading data (via SQL*Loader or Import) into the table. It is more efficient to insert rows of data into a table that has no indexes and then create the indexes for subsequent access. If you create indexes before table data is loaded, every index must be updated every time a row is inserted into the table. You must also create the index for a cluster before inserting any data into the cluster.

When an index is created on a table that already has data, Oracle must use sort space. Oracle uses the sort space in memory allocated for the creator of the index (the amount per user is determined by the initialization parameter SORT_AREA_SIZE), but must also swap sort information to and from temporary segments allocated on behalf of the index creation.

If the index is extremely large, you may want to perform the following tasks.

**To Manage a Large Index:**

1. Create a new temporary segment tablespace.
2. Alter the index creator's temporary segment tablespace.
3. Create the index.

4. Remove the temporary segment tablespace and re-specify the creator's temporary segment tablespace, if desired.

> **See Also:** Under certain conditions, data can be loaded into a table with SQL*Loader's direct path load and an index can be created as data is loaded; see *Oracle8i Utilities* for more information.

## Limit the Number of Indexes per 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 may be preferable.

## Specify Transaction Entry Parameters

By specifying the INITRANS and MAXTRANS parameters during the creation of each index, you can affect how much space is initially and can ever be allocated for transaction entries in the data blocks of an index's segment. You should also leave room for updates and later identify long-term (for example, the life of the index) values for these settings.

> **See Also:** For more information about setting these parameters, see "Transaction Entry Settings (INITRANS and MAXTRANS)" on page 12-7.

## Specify Index Block Space Use

When an index is created for a table, data blocks of the index are filled with the existing values in the table up to PCTFREE. The space reserved by PCTFREE for an index block is only used when a new row is inserted into the table and the corresponding index entry must be placed in the correct index block (that is, between preceding and following index entries). If no more space is available in the appropriate index block, the indexed value is placed where it belongs (based on the lexical set ordering). Therefore, if you plan on inserting many rows into an indexed table, PCTFREE should be high to accommodate the new index values. If the table is

relatively static without many inserts, PCTFREE for an associated index can be low so that fewer blocks are required to hold the index data.

> **See Also:** PCTUSED cannot be specified for indexes. See "Managing Space in Data Blocks" on page 12-2 for information about the PCTFREE parameter.

## Estimate Index Size and Set Storage Parameters

Estimating the size of an index before creating one is useful for the following reasons:

- You can use the combined estimated size of indexes, along with estimates for tables, rollback segments, 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 index to better manage the disk space that the index will use. 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 a index before creating it. If you then set the storage parameters when you create the index, fewer extents will be allocated for the table's data segment, and all of the index's data will be 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. As with tables, you can explicitly set storage parameters when creating an index.

> **See Also:** For specific information about storage parameters, see "Setting Storage Parameters" on page 12-8.

## 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, then database maintenance may be more convenient (such as tablespace or file backup and application availability or update) and all the related data will always be 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, due to reduced disk contention.

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.

## Parallelize Index Creation

You can parallelize index creation. Because multiple processes work together to create the index, Oracle 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:** For more information on parallel index creation, see *Oracle8i Designing and Tuning for Performance.*

## 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 LOGGING are not archived, you should 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 affect 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

When you encounter index fragmentation (due to improper sizing or increased growth), you can rebuild or coalesce the index. Before you perform either task, though, weigh the costs and benefits of each option and choose the one that works best for your situation. Table 14–1 is a comparison of the costs and benefits associated with rebuilding and coalescing indexes.

***Table 14–1 To Rebuild or Coalesce...That Is the Question***

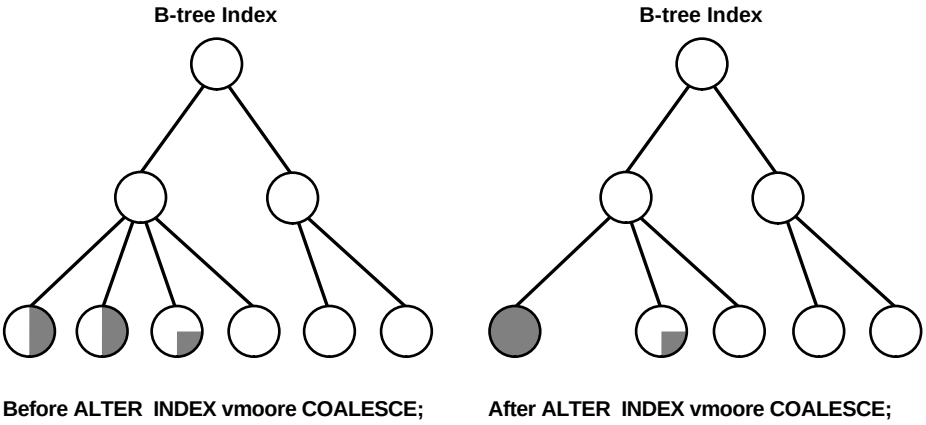
| REBUILD | COALESCE |
|---|---|
| Quickly moves index to another tablespace. | Cannot move index to another tablespace. |
| Higher costs. Requires more disk space. | Lower costs. Does not require more disk space. |
| Creates new tree, shrinks height if applicable. | Coalesces leaf blocks within same 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 14–1 illustrates the effect of an ALTER INDEX COALESCE on the index VMOORE. Before performing the operation, the first two leaf blocks are 50% full, which means you have an opportunity to reduce fragmentation and completely fill the first block while freeing up the second (in this example, assume that PCTFREE=0).

*Figure 14–1 Coalescing Indexes*




## 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 may save time by leaving the constraint enabled rather than dropping and re-creating the large index.

# Creating Indexes

This section describes how to create an index, and includes the following topics:

- Creating an Index Explicitly
- Creating an Index Associated with a Constraint
- Creating an Index Online
- Creating a Function-Based Index
- Rebuilding an Existing Index
- Creating a Key-Compressed Index

To create an index in your own schema, one of the following conditions must be true:

- The table or cluster to be indexed must be in your own schema.

- You must have INDEX privilege on the table to be indexed.
- You must have CREATE ANY INDEX system privilege.

To create an index in another schema, you must have CREATE ANY INDEX system privilege. Also, the owner of the schema to contain the index must have either space quota on the tablespaces to contain the index or index partitions, or UNLIMITED TABLESPACE system privilege.

> **See Also:** For syntax and restrictions on the use of the CREATE INDEX, ALTER INDEX, and DROP INDEX statements, see the *Oracle8i SQL Reference*.

## 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)
      PCTFREE 0;
```

Notice that several storage settings 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 host tablespace are automatically used.

LOBS, LONG and LONG RAW columns cannot be indexed.

## Creating an Index Associated with a Constraint

Oracle enforces a UNIQUE key or PRIMARY KEY integrity constraint by creating a unique index on the unique key or primary key. This index is automatically created by Oracle when the constraint is enabled; no action is required by the issuer of the CREATE TABLE or ALTER TABLE statement to create the index. This includes both when a constraint is defined and enabled, and when a defined but disabled constraint is enabled.

To enable a UNIQUE key or PRIMARY KEY (which creates an associated index), the owner of the table needs a quota for the tablespace intended to contain the index, or the UNLIMITED TABLESPACE system privilege.

You can set the storage options for the indexes associated with UNIQUE key and PRIMARY KEY constraints using the ENABLE clause with the USING INDEX option. The following statement defines a PRIMARY KEY constraint and specifies the associated index's storage option:

```
CREATE TABLE emp (
     empno NUMBER(5) PRIMARY KEY, age INTEGER)
     ENABLE PRIMARY KEY USING INDEX
     TABLESPACE users
     PCTFREE 0;
```

Oracle recommends that you do not explicitly define UNIQUE indexes on tables (CREATE UNIQUE INDEX). In general, it is better to create constraints to enforce uniqueness than it is to use the CREATE UNIQUE INDEX syntax. A constraint's associated index always assumes the name of the constraint; you cannot specify a specific name for a constraint index.

## Creating an Index Online

Previously, when creating an index on a table there has always been a DML S-lock on that table during the index build operation, which meant you could not perform DML operations on the base table during the build.

Now, with the ever-increasing size of tables and necessity for continuous operations, you can create and rebuild indexes online—meaning you can update base tables at the same time you are building or rebuilding indexes on that table. Note, though, that there are still DML SS-locks, which means you cannot perform other DDL operations during an online index build.

The following statements perform online index build operations:

```
ALTER INDEX emp_name REBUILD ONLINE;

CREATE INDEX emp_name ON emp (mgr, emp1, emp2, emp3) ONLINE;
```

**Note:** While you can perform DML operations during an online index build, Oracle recommends that you do not perform major/large DML operations during this procedure. For example, if you wish to load rows that total up to 30% of the size of an existing table, you should perform this load before the online index build.

## 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 pre-computed and stored in the index. Specific features of function-based indexing include:

- You can create indexes where the search key is an expression.
- They provide an efficient mechanism for evaluating predicates involving functions.
- They provide support for linguistic sorts based on linguistic sort keys (collation). The linguistic sort index can be used for efficient linguistic collation in SQL statements.
- You can perform case-insensitive sorts.
- You can create true descending order indexes. They are treated as a special case of function-based indexes.

To illustrate a function based index, lets 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 r
WHERE      Area(geo) >5000;
```

Table owners should have EXECUTE privileges on the functions used in function-based indexes. Also, because a function-based index depends upon any function it is using, it can be invalidated when a function changes. You can use an ALTER INDEX...ENABLE statement to enable a function-based index that has been disabled if the function is valid. The ALTER INDEX...DISABLE statement allows you to disable the use of a function-based index. You might want to do this if you are working on the body of the function.

For the creation of a function-based index in your own schema, you must be granted the CREATE INDEX and QUERY REWRITE system privileges. To create the index in another schema or on another schema's tables, you must have the CREATE ANY INDEX and GLOBAL QUERY REWRITE privileges.

You must have the following initialization parameters defined to create a function-based index:

- QUERY_REWRITE_INTEGRITY must be set to TRUSTED
- QUERY_REWRITE_ENABLED must be set to TRUE
- COMPATIBLE must set to 8.1.0.0.0 or a greater value

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 will be marked invalid. You must use the ANALYZE VALIDATE INDEX statement to validate this index.

---

Some examples of using function based indexes follow.

**See Also:** Other sources of information about function-based indexes include:

- *Oracle8i Concepts*
- *Oracle8i Data Warehousing Guide*
- *Oracle8i Application Developer's Guide - Fundamentals*

### Example 1

The following statement creates function-based index IDX on table EMP based on an uppercase evaluation of the ENAME column:

```
CREATE INDEX idx ON emp (UPPER(emp_name));
```

Now the SELECT statement uses the function-based index on UPPER(EMP_NAME) to retrieve all employees with names that start with JOH:

```
SELECT * FROM emp WHERE UPPER(emp_name) LIKE 'JOH%';
```

This example also illustrates a case-insensitive search.

### Example 2

This statement creates a function-based index on an expression:

```
CREATE INDEX idx ON t (a + b * (c - 1), a, b);
```

SELECT statements can use either an index range scan (in the following SELECT statement the expression is a prefix of the index) or index full scan (preferable when the index specifies a high degree of parallelism).

```
SELECT a FROM t WHERE a + b * (c - 1) < 100;
```

### Example 3

You can also use function-based indexes to support NLS sort index as well. NLSSORT is a function that returns a sort key that has been given a string. Thus, if you want to build an index on NAME using NLSSORT, issue the following statement:

```
CREATE INDEX nls_index ON t_table (NLSSORT(name, 'NLS_SORT = German'));
```

This statement creates index NLS_INDEX on table T_TABLE with the collation sequence German.

Now, to select from T_TABLE using the NLS_SORT index:

```
SELECT * FROM t_table ORDER BY name;
```

Rows will be ordered using the collation sequence in German.

### Example 4

This example combines a case-insensitive sort and a language sort.

```
CREATE INDEX empi ON emp
   UPPER ((ename), NLSSORT(ename));
```

Here, an NLS_SORT specification does not appear in the NLSSORT argument because NLSSORT looks at the session setting for the language of the linguistic sort key. Example 3 illustrated a case where NLS_SORT was specified.

## Rebuilding an Existing Index

Before rebuilding or re-creating an existing index, compare the costs and benefits associated with rebuilding to those associated with coalescing indexes as described in Table 14–1 on page 14-7.

You can create an index using an existing index as the data source. Creating an index in this manner allows you to change storage characteristics or move to a new tablespace. Rebuilding an index based on an existing data source also removes intra-block fragmentation. In fact, compared to dropping the index and using the CREATE INDEX statement, re-creating an existing index offers better performance.

Issue the following statement to rebuild an existing index:

```
ALTER INDEX index_name REBUILD;
```

The REBUILD clause must immediately follow the index name, and precede any other options. Also, the REBUILD clause cannot be used in conjunction with the DEALLOCATE UNUSED clause.

## 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 per 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 will be stored as a prefix entry on the index block without the ROWID. The remaining rows will be suffix entries consisting of only the ROWID
- You have a unique multi-column index.

You can enable key compression using the COMPRESS clause.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. For example, the following statement will compress away duplicate occurrences of a key in the index leaf block.

```
CREATE INDEX  emp_ename (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;
```

## Altering Indexes

To alter an index, your schema must contain the index or you must have the ALTER ANY INDEX system privilege. You can rebuild or coalesce an index, alter its real and default storage characteristics and some other physical properties, but you cannot change its column structure.

Alter the storage parameters of any index, including those created by Oracle to enforce primary and unique key integrity constraints, using the SQL statement ALTER INDEX. For example, the following statement alters the EMP_ENAME index:

```
ALTER INDEX emp_ename
      INITRANS 5
      MAXTRANS 10
      STORAGE (PCTINCREASE 50);
```

When you alter the transaction entry settings (INITRANS, MAXTRANS) of an index, a new setting for INITRANS applies only to data blocks subsequently allocated, while a new setting for MAXTRANS applies to all blocks (currently and subsequently allocated blocks) of an index.

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 also adjust storage parameters by issuing an ALTER TABLE statement that includes the ENABLE clause with the USING INDEX option. For example, the following statement changes the storage options of the index defined in the previous section:

```
ALTER TABLE emp
     ENABLE PRIMARY KEY USING INDEX
     PCTFREE 5;
```

# Monitoring Space Use of Indexes

If key values in an index are inserted, updated, and deleted frequently, the index may or may not use its acquired space efficiently over time. Monitor an index's efficiency of space usage at regular intervals by first analyzing the index's structure and then querying the INDEX_STATS view:

```
SELECT pct_used FROM sys.index_stats WHERE name = 'indexname';
```

The percentage of an index's space usage will vary according to how often index keys are inserted, updated, or deleted. Develop a history of an index's average efficiency of space usage by performing the following sequence of operations several times:

- Analyzing statistics
- Validating the index
- Checking PCT_USED
- Dropping and re-creating (or coalescing) the index

When you find that an index's space usage drops below its average, you can condense the index's space by dropping the index and rebuilding it, or coalescing it. For information about analyzing an index's structure, see "Analyzing Tables, Indexes, and Clusters" on page 19-3.

# Dropping Indexes

To drop an index, the index must be contained in your schema, or you must have the DROP ANY INDEX system privilege.

You might want to drop an index for any of the following reasons:

- 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's 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 constraint's associated index, you must disable or drop the constraint itself. For more information about dropping a constraint's associated index, see "Managing Integrity Constraints" on page 19-14.

---

**Note:** If a table is dropped, all associated indexes are dropped automatically.

---

# 15

# Managing Partitioned Tables and Indexes

This chapter describes various aspects of managing partitioned tables and indexes, and includes the following sections:

# What Are Partitioned Tables and Indexes?

Today's enterprises frequently run mission critical databases containing upwards of several hundred gigabytes and, in many cases, several terabytes of data. These enterprises are challenged by the support and maintenance requirements of very large databases (VLDB), and must devise methods to meet those challenges.

One way to meet VLDB demands is to create and use *partitioned tables and indexes*. Partitioned tables allow your data to be broken down into smaller, more manageable pieces called *partitions*, or even *subpartitions*. Indexes, may be partitioned in similar fashion. 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.

If you are using parallel execution, partitions provide another means of parallelization. Operations on partitioned tables and indexes are performed in parallel by assigning different parallel execution servers to different partitions of the table or index.

Partitions and subpartitions of a table or index all share the same logical attributes. For example, all partitions (or subpartitions) in a table share the same column and constraint definitions, and all partitions (or subpartitions) of an index share the same index options. They can, however, have different physical attributes (such as TABLESPACE).

Although you are not required to keep each table or index partition (or subpartition) in a separate tablespace, it is to your advantage to do so. Storing partitions in separate tablespaces enables you to:

- Reduce the possibility of data corruption in multiple partitions
- Back up and recover each partition independently
- Control the mapping of partitions to disk drives (important for balancing I/O load)
- Improve manageability, availability and performance

Partitioning is transparent to existing applications and standard DML statements run against partitioned tables. However, an application can be programmed to take advantage of partitioning by using partition-extended table or index names in DML.

**See Also:** Detailed information on the concepts of partitioning is contained in *Oracle8i Concepts*. Before attempting to create a partitioned table or index, or perform maintenance operations on any partitioned table, it is recommended that you review that information.

You can find information on parallel execution in *Oracle8i Concepts* and *Oracle8i Designing and Tuning for Performance*.

# Partitioning Methods

There are three partitioning methods offered by Oracle:

- Range Partitioning
- Hash Partitioning
- Composite Partitioning

Indexes, as well as tables, can be partitioned. A global index can only be partitioned by range, but it may be defined on any type of partitioned, or nonpartitioned, table. It usually requires more maintenance than a local index.

A local index is constructed so that it reflects the structure of the underlying table. It is equipartitioned with the underlying table, meaning that it is partitioned on the same columns as the underlying table, creates the same number of partitions or subpartitions, and gives them the same partition bounds as corresponding partitions of the underlying table. For local indexes, index partitioning is maintained automatically when partitions are affected by maintenance activity. This ensures that the index remains equipartitioned with the underlying table.

Oracle's partitioning methods are introduced in the following sections:

- Using the Range Partitioning Method
- Using the Hash Partitioning Method
- Using the Composite Partitioning Method

## Using the Range Partitioning Method

Use range partitioning to map rows to partitions based on ranges of column values. This type of partitioning is useful when dealing with data that has logical ranges into which it can be distributed; for example months of the year. Performance is best when the data evenly distributes across the range. If partitioning by range

causes partitions to vary dramatically in size because of unequal distribution, you may want to consider one of the other methods of partitioning.

When creating range partitions, you must specify:

- Partitioning method: range
- Partitioning column(s)
- Partition descriptions identifying partition bounds

The example below creates a table of four partitions, one for each quarter's sales. The columns SALE_YEAR, SALE_MONTH, and SALE_DAY are the *partitioning columns*, while their values constitute a specific row's *partitioning key*. The VALUES LESS THAN clause determines the *partition bound*: rows with partitioning key values that compare less than the ordered list of values specified by the clause will be stored in the partition. Each partition is given a name (SALES_Q1, SALES_q2,...), and each partition is contained in a separate tablespace (TSA, TSB,...).

```
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 sales_q1 VALUES LESS THAN (1999, 04, 01)
        TABLESPACE tsa,
      PARTITION sales_q2 VALUES LESS THAN (1999, 07, 01)
        TABLESPACE tsb,
      PARTITION sales_q3 VALUES LESS THAN (1999, 10, 01)
        TABLESPACE tsc,
      PARTITION sales_q4 VALUES LESS THAN (2000, 01, 01)
        TABLESPACE tsd );
```

A row with SALE_YEAR=1999, SALE_MONTH=8, and SALE_DAY=1 has a partitioning key of (1999, 8, 1) and would be stored in partition SALES_Q3.

Each partition of a range-partitioned table is stored in a separate segment.

More specific information on creating range-partitioned tables is contained in the section "Creating Range Partitions" on page 15-8.

After you have created a range-partitioned table, you can use the ALTER TABLE statement to add additional partitions, merge partitions, load data (exchange partition), or perform other maintenance operations. These maintenance operations are listed in Table 15–1 on page 15-12. The section "Maintaining Partitions" on page 15-12 describes and presents examples of these operations.

You can create nonpartitioned global indexes, range-partitioned global indexes, and local indexes on range-partitioned tables, and perform maintenance on them as specified in Table 15–2 on page 15-13. See "Creating Partitions" on page 15-7 and "Maintaining Partitions" on page 15-12 for specific information on creating and maintaining partitioned indexes.

---

**Note:** If your enterprise has or will have databases using different character sets, use caution when partitioning on character columns, because the sort sequence of characters is not identical in all character sets. For more information, see *Oracle8i National Language Support Guide*.

---

## Using the Hash Partitioning Method

Use hash partitioning if your data does not easily lend itself to range partitioning, but you would like to partition for performance reasons. Hash partitioning provides a method of evenly distributing data across a specified number of partitions. Rows are mapped into partitions based on a hash value of the partitioning key. Creating and using hash partitions gives you a highly tunable method of data placement, because you can influence availability and performance by spreading these evenly sized partitions across I/O devices (striping).

To create hash partitions you specify the following:

- Partitioning method: hash
- Partitioning columns(s)
- Number of partitions or individual partition descriptions

The following example creates a hash-partitioned table. The partitioning column is ID, four partitions are created and assigned system generated names, and they are placed in four named tablespaces (GEAR1, GEAR2,...).

```
CREATE TABLE scubagear
     (id NUMBER,
      name VARCHAR2 (60))
   PARTITION BY HASH (id)
   PARTITIONS 4
   STORE IN (gear1, gear2, gear3, gear4);
```

Each partition of a hash-partitioned table is stored in a separate segment.

More detailed information on creating hash-partitioned tables is contained in the section "Creating Hash Partitions" on page 15-10.

The ALTER TABLE statement can be used to perform maintenance operations on hash-partitioned tables. Most range partition maintenance operations are supported for hash partitions, except for the following:

- SPLIT PARTITION
- DROP PARTITION
- MERGE PARTITIONS

Additionally, there are two maintenance operations specifically for partitions created using the hash partitioning method.

- COALESCE PARTITION: drops a hash partition by redistributing its contents into one or more remaining partitions as determined by the hash function. See "Coalescing Partitions" on page 15-16.
- ADD PARTITION: different syntax than the add range partition clause. See "Adding a Partition to a Hash-Partitioned Table" on page 15-14.

Maintenance operations for hash-partitioned tables are listed in Table 15–1 on page 15-12 and discussed in "Maintaining Partitions" on page 15-12.

You can create nonpartitioned global indexes, range-partitioned global indexes, and local indexes on hash-partitioned tables. For more information about indexing see "Creating Partitions" on page 15-7 and "Maintaining Partitions" on page 15-12.

## Using the Composite Partitioning Method

Composite partitioning partitions data using the range method, and within each partition, subpartitions it using the hash method. Composite partitions are ideal for both historical data and striping, and provide improved manageability of range partitioning and data placement, as well as the parallelism advantages of hash partitioning.

When creating composite partitions, you specify the following:

- Partitioning method: range
- Partitioning column(s)
- Partition descriptions identifying partition bounds
- Subpartitioning method: hash
- Subpartitioning column(s)

- Number of subpartitions per partition or descriptions of subpartitions

The following statement creates a composite-partitioned table. In this example, three range partitions are created, each containing 8 subpartitions. The subpartitions are not named so system generated names are assigned, but the STORE IN clause distributes them across the 4 specified tablespaces (TS1,...,TS4).

```
CREATE TABLE scubagear (equipno NUMBER, equipname VARCHAR(32), price NUMBER)
  PARTITION BY RANGE (equipno) SUBPARTITION BY HASH(equipname)
    SUBPARTITIONS 8 STORE IN (ts1, ts3, ts5, ts7)
      (PARTITION p1 VALUES LESS THAN (1000),
       PARTITION p2 VALUES LESS THAN (2000),
       PARTITION p3 VALUES LESS THAN (MAXVALUE));
```

Each subpartition of a composite-partitioned table is stored its own segment. The partitions of a composite-partitioned table are logical structures only as their data is stored in the segments of their subpartitions. As with partitions, these subpartitions share the same logical attributes. Unlike range partitions in a range partitioned table, the subpartitions cannot have different physical attributes from the owning partition, although they are not required to reside in the same tablespace.

More specific information on creating composite-partitioned tables is contained in the section "Creating Composite Partitions and Subpartitions" on page 15-11.

The ALTER TABLE statement can be used to perform maintenance operations on composite-partitioned tables. You can perform all range partition maintenance operations on a composite partition of a table. You can perform the same maintenance operations on the hash subpartitions as on the hash partitions of a hash-partitioned table. Maintenance operations for composite-partitioned tables are listed in Table 15–1 on page 15-12 and discussed in "Maintaining Partitions" on page 15-12.

You can create nonpartitioned global indexes, range-partitioned global indexes, and local indexes on composite-partitioned tables. For more information about indexing see "Creating Partitions" below and "Maintaining Partitions" on page 15-12.

## Creating Partitions

This section presents details and examples of creating partitions for the different types of partitioned tables and indexes. Creating a partitioned table or index is very similar to creating a regular table or index, but you include a partitioning clause. The partitioning clause, and subclauses, that you include depend upon the type of partitioning you are trying to achieve.

When you create (or alter) a partitioned table, a row movement clause, either ENABLE ROW MOVEMENT or DISABLE ROW MOVEMENT can be specified. This clause either enables or disables the migration of a row to a new partition if its key is updated. The default is disable.

> **See Also:** Information on the exact syntax of the partitioning clauses for creating and altering partitioned tables and indexes, any restrictions on their use, and specific privileges required for creating and altering tables is contained in the *Oracle8i SQL Reference.*
>
> You can partition tables containing columns with LOBs, objects, varrays, and nested tables. For more information about creating such tables, refer to the following books:
>
> - *Oracle8i Application Developer's Guide - Large Objects (LOBs)*
> - *Oracle8i Application Developer's Guide - Fundamentals*

## Creating Range Partitions

The PARTITION BY RANGE clause of the CREATE TABLE statement identifies that the table is to be range-partitioned. The PARTITION clauses identify the individual partition ranges, and optional subclauses of a PARTITION clause can specify physical and other attributes specific to a partition's segment. If not overridden at the partition level, partitions will inherit the attributes of their underlying table.

In this example, the example presented earlier for a range-partitioned table is made more complex. Storage parameters and a LOGGING attribute are specified at the table level. These will replace the corresponding defaults inherited from the tablespace level for the table itself, and will be inherited by the range partitions. However, since there was little business in the first quarter, the storage attributes for partition SALES_Q1 are made smaller. The ENABLE ROW MOVEMENT clause is specified to allow the migration of a row to a new partition if an update to a key value is made that would place the row in a different partition.

```
CREATE TABLE sales
     ( invoice_no NUMBER,
       sale_year  INT NOT NULL,
       sale_month INT NOT NULL,
       sale_day   INT NOT NULL )
   STORAGE (INITIAL 100K NEXT 50K) LOGGING
   PARTITION BY RANGE ( sale_year, sale_month, sale_day)
     ( PARTITION sales_q1 VALUES LESS THAN ( 1999, 04, 01 )
```

```
        TABLESPACE tsa STORAGE (INITIAL 20K, NEXT 10K),
       PARTITION sales_q2 VALUES LESS THAN ( 1999, 07, 01 )
        TABLESPACE tsb,
       PARTITION sales_q3 VALUES LESS THAN ( 1999, 10, 01 )
        TABLESPACE tsc,
       PARTITION sales q4 VALUES LESS THAN ( 2000, 01, 01 )
        TABLESPACE tsd)
   ENABLE ROW MOVEMENT;
```

The rules for creating range-partitioned global indexes are similar to those for creating range-partitioned tables. The following is an example of creating a range-partitioned global index by SALES_MONTH on the above table. Each index partition is named but is stored in the default tablespace for the index.

```
CREATE INDEX month_ix ON sales(sales_month)
   GLOBAL PARTITION BY RANGE(sales_month)
      (PARTITION pm1_ix VALUES LESS THAN (2)
       PARTITION pm2_ix VALUES LESS THAN (3)
       PARTITION pm3_ix VALUES LESS THAN (4)
       PARTITION pm4_ix VALUES LESS THAN (5)
       PARTITION pm5_ix VALUES LESS THAN (6)
       PARTITION pm6_ix VALUES LESS THAN (7)
       PARTITION pm7_ix VALUES LESS THAN (8)
       PARTITION pm8_ix VALUES LESS THAN (9)
       PARTITION pm9_ix VALUES LESS THAN (10)
       PARTITION pm10_ix VALUES LESS THAN (11)
       PARTITION pm11_ix VALUES LESS THAN (12)
       PARTITION pm12_ix VALUES LESS THAN (MAXVALUE));
```

You can partition index-organized tables, and their secondary indexes, but only by the range method. In the following example, a range-partitioned index-organized table SALES is created. The INCLUDING clause specifies all columns after WEEK_NO are stored in an overflow segment; there is one overflow segment for each partition, all stored in the same tablespace (OVERFLOW_HERE). Optionally, OVERFLOW TABLESPACE could be specified at the individual partition level, in which case some or all of the overflow segments could have separate TABLESPACE attributes.

```
CREATE TABLE sales(acct_no NUMBER(5),
                   acct_name CHAR(30),
                   amount_of_sale NUMBER(6),
                   week_no INTEGER,
                   sale_details VARCHAR2(1000),
             PRIMARY KEY (acct_no, acct_name, week_no))
     ORGANIZATION INDEX INCLUDING week_no
```

```
        OVERFLOW TABLESPACE overflow_here
PARTITION BY RANGE (week_no)
       (PARTITION VALUES LESS THAN (5) TABLESPACE ts1,
        PARTITION VALUES LESS THAN (9) TABLESPACE ts2,
        ...
        PARTITION VALUES LESS THAN (MAXVALUE) TABLESPACE ts13);
```

## Creating Hash Partitions

The PARTITION BY HASH clause of the CREATE TABLE statement identifies that the table is to be hash-partitioned. The PARTITIONS clause can then be used to specify the number of partitions to create, and optionally, the tablespaces to store them in. Alternatively, you can use PARTITION clauses to name the individual partitions and their tablespaces.

The only attribute you can specify for hash partitions is TABLESPACE. All of the hash partitions of a table must share the same segment attributes (except TABLESPACE), which are inherited from the table level.

The following examples illustrate two methods of creating a hash-partitioned table named DEPT. In the first example the number of partitions is specified, but system generated names are assigned to them and they are stored in the default tablespace of the table.

```
CREATE TABLE dept (deptno NUMBER, deptname VARCHAR(32))
     PARTITION BY HASH(deptno) PARTITIONS 16;
```

In this second example, names of individual partitions, and tablespaces in which they will reside, are specified. The initial extent size for each hash partition (segment) is also explicitly stated at the table level, and all partitions will inherit this attribute.

```
CREATE TABLE dept (deptno NUMBER, deptname VARCHAR(32))
     STORAGE (INITIAL 10K)
     PARTITION BY HASH(deptno)
       (PARTITION p1 TABLESPACE ts1, PARTITION p2 TABLESPACE ts2,
        PARTITION p3 TABLESPACE ts1, PARTITION p4 TABLESPACE ts3);
```

If you create a local index for the above table, Oracle will construct the index so that it is equipartitioned with the underlying table and ensure that it is maintained automatically when maintenance operations are performed on the underlying table. The following is an example of creating a local index on the table DEPT.

```
CREATE INDEX locd_dept_ix ON dept(deptno) LOCAL
```

You can optionally name the hash partitions and tablespaces into which the local index partitions will be stored, but if you do not do so, Oracle will use the name of the corresponding base partition as the index partition name, and store the index partition in the same tablespace as the table partition.

## Creating Composite Partitions and Subpartitions

To create a composite-partitioned table, you start by using the PARTITION BY RANGE clause of a CREATE TABLE statement. Next, you specify a SUBPARTITION BY HASH clause that follows similar syntax and rules as the PARTITION BY HASH statement. The individual PARTITION and SUBPARTITION or SUBPARTITIONS clauses follow.

Attributes specified for a (range) partition apply to all subpartitions of that partition. You can specify different attributes for each (range) partition, and a STORE IN clause can be specified at the partition level if the list of tablespaces across which that partition's subpartitions should be spread is different from those of other partitions. All of this is illustrated in the following example.

```
CREATE TABLE emp (deptno NUMBER, empname VARCHAR(32), grade NUMBER)
     PARTITION BY RANGE(deptno) SUBPARTITION BY HASH(empname)
        SUBPARTITIONS 8 STORE IN (ts1, ts3, ts5, ts7)
    (PARTITION p1 VALUES LESS THAN (1000) PCTFREE 40,
     PARTITION p2 VALUES LESS THAN (2000)
        STORE IN (ts2, ts4, ts6, ts8),
     PARTITION p3 VALUES LESS THAN (MAXVALUE)
       (SUBPARTITION p3_s1 TABLESPACE ts4,
        SUBPARTITION p3_s2 TABLESPACE ts5));
```

The following statement creates a local index on the EMP table where the index segments will be spread across tablespaces TS7, TS8, and TS9.

```
CREATE INDEX emp_ix ON emp(deptno)
     LOCAL STORE IN (ts7, ts8, ts9);
```

This local index will be equipartitioned with the base table as follows:

- It will consist of as many partitions as the base table.
- Each index partition will consist of as many subpartitions as the corresponding base table partition.
- Index entries for rows in a given subpartition of the base table will be stored in the corresponding subpartition of the index.

# Maintaining Partitions

This section describes how to perform partition and subpartition maintenance operations for both tables and indexes.

Table Table 15–1 lists the maintenance operations that can be performed on table partitions (or subpartitions) and, for each type of partitioning, lists the specific clause of the ALTER TABLE statement that is used to perform that maintenance operation.

***Table 15–1 ALTER TABLE Maintenance Operations for Table Partitions***

| Maintenance Operation | Range | Hash | Composite |
|---|---|---|---|
| Adding Partitions | ADD PARTITION | ADD PARTITION | ADD PARTITION<br>MODIFY PARTITION...ADD SUBPARTITION |
| Coalescing Partitions | n/a | COALESCE PARTITION | MODIFY PARTITION...COALESCE SUBPARTITION |
| Dropping Partitions | DROP PARTITION | n/a | DROP PARTITION |
| Exchanging Partitions | EXCHANGE PARTITION | EXCHANGE PARTITION | EXCHANGE PARTITION<br>EXCHANGE SUBPARTITION |
| Merging Partitions | MERGE PARTITIONS | n/a | MERGE PARTITIONS |
| Modifying Partition Default Attributes | MODIFY DEFAULT ATTRIBUTES | MODIFY DEFAULT ATTRIBUTES | MODIFY DEFAULT ATTRIBUTES<br>MODIFY DEFAULT ATTRIBUTES FOR PARTITION |
| Modifying Real Attributes of Partitions | MODIFY PARTITION | MODIFY PARTITION | MODIFY PARTITION<br>MODIFY SUBPARTITION |
| Moving Partitions | MOVE PARTITION | MOVE PARTITION | MOVE SUBPARTITION |
| Renaming Partitions | RENAME PARTITION | RENAME PARTITION | RENAME PARTITION<br>RENAME SUBPARTITION |
| Splitting Partitions | SPLIT PARTITION | n/a | SPLIT PARTITION |
| Truncating Partitions | TRUNCATE PARTITION | TRUNCATE PARTITION | TRUNCATE PARTITION<br>TRUNCATE SUBPARTITION |

Table 15–2 lists the maintenance operations that can be performed on index partitions, and indicates on which type of index (global or local) they can be performed. Global indexes do not reflect the structure of the underlying table, and if partitioned, they can only be partitioned by range. Range-partitioned indexes share

some, but not all, of the partition maintenance operations that can be performed on range-partitioned tables.

Because local index partitioning is maintained automatically when table partitions and subpartitions are affected by maintenance activity, partition maintenance on local indexes is less necessary and there are fewer options.

***Table 15–2 ALTER INDEX Maintenance Operations for Index Partitions***

| Maintenance Operation | Type of Index | Type of Index Partitioning | | |
|---|---|---|---|---|
| | | **Range** | **Hash** | **Composite** |
| Dropping Index Partitions | Global | DROP PARTITION | | |
| | Local | n/a | n/a | n/a |
| Modifying Default Attributes of Index Partitions | Global | MODIFY DEFAULT ATTRIBUTES | | |
| | Local | MODIFY DEFAULT ATTRIBUTES | MODIFY DEFAULT ATTRIBUTES | MODIFY DEFAULT ATTRIBUTES<br>MODIFY DEFAULT ATTRIBUTES FOR PARTITION |
| Modifying Real Attributes of Index Partitions | Global | MODIFY PARTITION | | |
| | Local | MODIFY PARTITION | MODIFY PARTITION | MODIFY PARTITION<br>MODIFY SUBPARTITION |
| Rebuilding Index Partitions | Global | REBUILD PARTITION | | |
| | Local | REBUILD PARTITION | REBUILD PARTITION | REBUILD SUBPARTITION |
| Renaming Index Partitions | Global | RENAME PARTITION | | |
| | Local | RENAME PARTITION | RENAME PARTITION | RENAME PARTITION<br>RENAME SUBPARTITION |
| Splitting Index Partitions | Global | SPLIT PARTITION | | |
| | Local | n/a | n/a | n/a |

Additionally, you can use the SQL*Loader, IMPORT, and EXPORT Utilities to load or unload data stored in partitioned tables. These utilities are all partition and subpartition aware.

> **See also:** The SQL*Loader, Import, and Export Utilities are described in *Oracle8i Utilities.*

## Adding Partitions

This section describes how to add new partitions to a partitioned table and explains why partitions cannot be specifically added to global partitioned or local indexes.

### Adding a Partition to a Range-Partitioned Table

You can use the ALTER TABLE...ADD PARTITION statement to add a new partition to the "high" end (the point after the last existing partition). If you want to add a partition at the beginning or in the middle of a table, use the SPLIT PARTITION clause.

For example, a DBA has a table, SALES, which contains data for the current month in addition to the previous 12 months. On January 1, 1999, the DBA adds a partition for January, which is stored in tablespace TSX.

```
ALTER TABLE sales
      ADD PARTITION jan96 VALUES LESS THAN ( '01-FEB-1999' )
      TABLESPACE tsx;
```

### Adding a Partition to a Hash-Partitioned Table

When you add a partition to a hash-partitioned table, Oracle populates the new partition with rows rehashed from other partitions of the table as determined by the hash function.

The following statements show two ways of adding a hash partition to table SCUBAGEAR. Choosing the first statement would add a new hash partition whose partition name will be system generated, and it will be placed in the table's default tablespace. The second statement also adds a new hash partition, but that partition is explicitly named P_NAMED, and is created in tablespace GEAR5.

```
ALTER TABLE scubagear ADD PARTITION;

ALTER TABLE scubagear
      ADD PARTITION p_named TABLESPACE gear5;
```

If the table has a local index, all local index partitions are marked UNUSABLE and must be rebuilt. Any global index, or all partitions of a partitioned global index will also be marked UNUSABLE.

### Adding Partitions to a Composite-Partitioned Table

Partitions may be added at both the range partition level and the hash subpartition level.

**Adding a Partition** You add a new range partition in similar fashion as described previously in "Adding a Partition to a Range-Partitioned Table", but you can specify a SUBPARTITIONS clause that allows you to add a specified number of subpartitions, or a SUBPARTITION clause for naming specific subpartitions. If no SUBPARTITIONS or SUBPARTITION clause is specified, the partition inherits table level defaults for subpartitions.

This example adds a range partition Q1_2000 to table SALES, which will be populated with data for the first quarter of the year 2000. There will be eight subpartitions stored in tablespace TBS5.

```
ALTER TABLE sales ADD PARTITION q1_2000
      VALUES LESS THAN (2000, 04, 01)
      SUBPARTITIONS 8 STORE IN tbs5;
```

**Adding a Subpartition** You use the MODIFY PARTITION...ADD SUBPARTITION clause of the ALTER TABLE statement to add a hash subpartition to a composite-partitioned table. The newly added subpartition is populated with rows rehashed from other subpartitions of the same partition as determined by the hash function. Any global index, and local index subpartitions corresponding to the added and rehashed subpartitions must be rebuilt.

In the following example, a new hash subpartition US_LOC5, stored in tablespace US1, is added to range partition LOCATIONS_US in table DIVING.

```
ALTER TABLE diving MODIFY PARTITION locations_us
      ADD SUBPARTITION us_locs5 TABLESPACE us1;
```

### Adding Index Partitions

You cannot explicitly add a partition to a local index. Instead, a new partition is added to a local index only when you add a partition to the underlying table. Specifically, when there is a local index defined on a table and you issue the ALTER TABLE statement to add a partition, a matching partition is also added to the local index. Since Oracle assigns names and default physical storage attributes to the new index partitions, you may want to rename or alter them after the ADD operation is complete.

You cannot add a partition to a global index because the highest partition always has a partition bound of MAXVALUE. If you want to add a new highest partition, use the ALTER INDEX...SPLIT PARTITION statement.

## Coalescing Partitions

Coalescing partitions is a way of reducing the number of partitions in a hash-partitioned table, or the number of subpartitions in a composite-partitioned table. When a hash partition is coalesced, its contents are redistributed into one or more remaining partitions determined by the hash function. The specific partition that is coalesced is selected by the RDBMS, and is dropped after its contents have been redistributed.

Any local index partition corresponding to the selected partition is also dropped. Local index partitions corresponding to the one or more absorbing partitions are marked UNUSABLE, and must be rebuilt. Any global index is marked unusable.

### Coalescing a Partition in a Hash-Partitioned Table

The ALTER TABLE...COALESCE PARTITION statement is used to coalesce a partition in a hash-partitioned table. The following statement reduces by one the number of partitions in a table by coalescing a partition.

```
ALTER TABLE ouu1
     COALESCE PARTITION;
```

### Coalescing a Subpartition in a Composite-Partitioned Table

The following statement distributes the contents of a subpartition of partition US_LOCATIONS into one or more remaining subpartitions (determined by the hash function) of the same partition. Basically, this operation is the inverse of the MODIFY PARTITION...ADD SUBPARTITION clause discussed earlier.

```
ALTER TABLE diving MODIFY PARTITION us_locations
     COALESCE SUBPARTITION;
```

## Dropping Partitions

You may drop partitions from range or composite-partitioned tables. For hash-partitioned tables, or hash subpartitions of composite-partitioned tables, you must perform a coalesce operation instead.

### Dropping a Table Partition

You use the ALTER TABLE...DROP PARTITION statement to drop a table partition from either a range or composite partitioned table. If you want to preserve the data in the partition, you should merge the data into an adjacent partition instead.

If there are local indexes defined for the table, this statement also drops the matching partition or subpartitions from the local index. Any global nonpartitioned indexes on the table will be marked UNUSABLE, and all partitions of any global partitioned indexes will be marked UNUSABLE, unless the partition being dropped or its subpartitions are empty.

> **Note:** You cannot drop the only partition in a table. Instead, you must drop the table.

The following sections contain some scenarios for dropping table partitions.

**Dropping a Partition from a Table Containing Data and Global Indexes** If the partition contains data and one or more global indexes are defined on the table, use either of the following methods to drop the table partition.

1. Leave the global indexes in place during the ALTER TABLE...DROP PARTITION statement. Afterward, you must rebuild any global indexes (whether partitioned or not) because the index (or index partitions) will have been marked as unusable. The following statements provide and example of dropping partition DEC98 from the SALES table, then rebuilding its global nonpartitioned index.

   ```
   ALTER TABLE sales DROP PARTITION dec98;
   ALTER INDEX sales_area_ix REBUILD;
   ```

   If index SALES_AREA_IX were a range-partitioned global index, then all partitions of the index would need rebuilding. Further, it is not possible to rebuild all partitions of an index in one statement; you must write a separate REBUILD statement for each partition in the index. The following statements rebuild the index partitions JAN99_IX, FEB99_IX, MAR99_IX, ..., DEC99_IX.

   ```
   ALTER INDEX sales_area_ix REBUILD PARTITION jan99_ix;
   ALTER INDEX sales_area_ix REBUILD PARTITION feb99_ix;
   ALTER INDEX sales_area_ix REBUILD PARTITION mar99_ix;
   ...
   ALTER INDEX sales_area_ix REBUILD PARTITION nov99_ix;
   ```

   This method is most appropriate for large tables where the partition being dropped contains a significant percentage of the total data in the table.

2. Issue the DELETE statement to delete all rows from the partition before you issue the ALTER TABLE...DROP PARTITION statement. The DELETE

statement updates the global indexes, and also fires triggers and generates redo and undo logs.

For example, if you want to drop the first partition, which has a partition bound of 10000 you can issue the following statements:

```
DELETE FROM sales WHERE TRANSID < 10000;
ALTER TABLE sales DROP PARTITION dec98;
```

This method is most appropriate for small tables, or for large tables when the partition being dropped contains a small percentage of the total data in the table.

**Dropping a Partition Containing Data and Referential Integrity Constraints** If a partition contains data and the table has referential integrity constraints, choose either of the following methods to drop the table partition. This table has a local index only, so it is not necessary to rebuild any indexes.

1. Disable the integrity constraints, issue the ALTER TABLE...DROP PARTITION statement, then enable the integrity constraints:

   ```
   ALTER TABLE sales
      DISABLE CONSTRAINT dname_sales1;
   ALTER TABLE sales DROP PARTITTION dec98;
   ALTER TABLE sales
      ENABLE CONSTRAINT dname_sales1;
   ```

   This method is most appropriate for large tables where the partition being dropped contains a significant percentage of the total data in the table.

2. Issue the DELETE statement to delete all rows from the partition before you issue the ALTER TABLE...DROP PARTITION statement. The DELETE statement enforces referential integrity constraints, and also fires triggers and generates redo and undo log.

   ```
   DELETE FROM sales WHERE TRANSID < 10000;
   ALTER TABLE sales DROP PARTITION dec94;
   ```

   This method is most appropriate for small tables or for large tables when the partition being dropped contains a small percentage of the total data in the table.

## Dropping Index Partitions

You cannot explicitly drop a partition of a local index. Instead, local index partitions are dropped only when you drop a partition from the underlying table.

If a global index partition is empty, you can explicitly drop it by issuing the ALTER INDEX...DROP PARTITION statement. But, if a global index partition contains data, dropping the partition causes the next highest partition to be marked UNUSABLE. For example, you would like to drop the index partition P1 and P2 is the next highest partition. You must issue the following statements:

```
ALTER INDEX npr DROP PARTITION P1;
ALTER INDEX npr REBUILD PARTITION P2;
```

**Note:** You cannot drop the highest partition in a global index.

## Exchanging Partitions

You can convert a partition (or subpartition) into a nonpartitioned table, and a nonpartitioned table into a partition (or subpartition) of a partitioned table by exchanging their data segments. You can also convert a hash-partitioned table into a partition of a composite-partitioned table, or convert the partition of the composite partitioned table into a hash-partitioned table.

Exchanging table partitions is most useful when you have an application using nonpartitioned tables which you want to convert to partitions of a partitioned table. For example, you may already have partition views that you want to migrate into partitioned tables. A scenario for converting a partitioned view is presented in "Converting a Partition View into a Partitioned Table" on page 15-34.

Exchanging partitions also facilitates high-speed data loading when used with transportable tablespaces. This topic is discussed in "Using Transportable Tablespaces" on page 9-35.

When you exchange partitions, logging attributes are preserved, but you can optionally specify if local indexes are also to be exchanged, and if rows are to be validated for proper mapping.

### Exchanging a Hash or Range Partition

To exchange a partition of a range or hash-partitioned table with a nonpartitioned table, or the reverse, you use the ALTER TABLE...EXCHANGE PARTITION statement. An example of converting a partition into a nonpartitioned table follows. In this example, table STOCKS could be either range or hash partitioned.

```
ALTER TABLE stocks
    EXCHANGE PARTITION p3 WITH stock_table_3;
```

### Exchanging a Hash-Partitioned Table with a Composite Partition

For this operation, you again use the ALTER TABLE...EXCHANGE PARTITION statement, but this time you are exchanging a whole hash-partitioned table, with all of its partitions, with a composite-partitioned table's range partition and all of its hash subpartitions. This is illustrated in the following example.

First, create a hash-partitioned table:

```
CREATE TABLE t1 (i NUMBER, j NUMBER)
     PARTITION BY HASH(i)
       (PARTITION p1, PARTITION p2);
```

Populate the table, then create a composite partitioned table as shown:

```
CREATE TABLE t2 (i NUMBER, j NUMBER)
     PARTITION BY RANGE(j)
     SUBPARTITION BY HASH(i)
        (PARTITION p1 VALUES LESS THAN (10)
            SUBPARTITION t2_pls1
            SUBPARTITION t2_pls2,
         PARTITION p2 VALUES LESS THAN (20)
            SUBPARTITION t2_p2s1
            SUBPARTITION t2_p2s2));
```

It is important that the partitioning key in table T1 is the same as the subpartitioning key in table T2.

To migrate the data in T1 to T2, and validate the rows, use the following statement:

```
ALTER TABLE t1 EXCHANGE PARTITION p1 WITH TABLE t2
     WITH VALIDATION;
```

### Exchanging a Subpartition of a Composite-Partitioned Table

Use the ALTER TABLE...EXCHANGE SUBPARTITION statement to convert a hash subpartition of a composite-partitioned table into a nonpartitioned table, or the reverse. The following example converts the subpartition Q3_1999_S1 of table SALES into the nonpartitioned table Q3_1999. Local indexes partitions are exchanged with corresponding indexes on Q3_1999.

```
ALTER TABLE sales EXCHANGE SUBPARTITIONS q3_1999_s1
      WITH TABLE q3_1999 INCLUDING INDEXES;
```

## Merging Partitions

You can use the ALTER TABLE...MERGE PARTITIONS statement to merge the contents of two adjacent range partitions into one partition. The resulting partition inherits the higher upper bound of the two merged partitions. The two original partitions are dropped, as are any corresponding local indexes. Any global nonpartitioned indexes on the table will be marked UNUSABLE, and all partitions of any global partitioned indexes will be marked UNUSABLE, if the partitions being merged are not empty. Also, unless the involved partitions or subpartitions are empty, Oracle marks UNUSABLE all resulting corresponding local index partitions or subpartitions.

You cannot use this statement for a hash-partitioned table or for hash subpartitions of a composite-partitioned table.

You might want to merge partitions so as to keep historical data online in larger partitions. For example, you can have daily partitions, with the oldest partition rolled up into weekly partitions, which can then be rolled up into monthly partitions, and so on.

### Merging Range Partitions

The following scripts create an example of merging range partitions.

First, create a partitioned table and create local indexes.

```
-- Create a Table with four partitions each on its own tablespace
-- Partitioned by range on the data column.
--
CREATE TABLE four_seasons
(
        one DATE,
        two VARCHAR2(60),
        three NUMBER
)
PARTITION  BY RANGE ( one)
(
PARTITION quarter_one
   VALUES LESS THAN ( TO_DATE('01-aug-1998','dd-mon-yyyy'))
   TABLESPACE quarter_one,
PARTITION quarter_two
   VALUES LESS THAN ( TO_DATE('01-sep-1998','dd-mon-yyyy'))
   TABLESPACE quarter_two,
PARTITION quarter_three
   VALUES LESS THAN ( TO_DATE('01-oct-1998','dd-mon-yyyy'))
   TABLESPACE quarter_three,
```

```
PARTITION quarter_four
   VALUES LESS THAN ( TO_DATE('01-nov-1998','dd-mon-yyyy'))
   TABLESPACE quarter_four
)
/
--
-- Create local PREFIXED index on Four_Seasons
-- Prefixed because the leftmost columns of the index match the
-- Partition key
--
CREATE INDEX i_four_seasons_l ON four_seasons ( one,two )
LOCAL (
PARTITION i_quarter_one TABLESPACE i_quarter_one,
PARTITION i_quarter_two TABLESPACE i_quarter_two,
PARTITION i_quarter_three TABLESPACE i_quarter_three,
PARTITION i_quarter_four TABLESPACE i_quarter_four
)
/
```

Next, merge partitions.

```
--
-- Merge the first two partitions
--
ALTER TABLE four_seasons
MERGE PARTITIONS quarter_one, quarter_two INTO PARTITION quarter_two
/
```

Then, rebuild the local index for the affected partition.

```
-- Rebuild index for quarter_two, which has been marked unusable
-- because it has not had all of the data from Q1 added to it.
-- Rebuilding the index will correct this.
--
ALTER TABLE four_seasons MODIFY PARTITION
quarter_two REBUILD UNUSABLE LOCAL INDEXES
/
```

### Merging Range Composite Partitions

When you merge range composite partitions, the subpartitions will be rehashed into either the number of subpartitions specified in a SUBPARTITIONS or SUBPARTITION clause, or, if no such clause is included, table-level defaults will be used.

```
ALTER TABLE all_seasons
```

```
MERGE PARTITIONS quarter_1, quarter_2 INTO PARTITION quarter_2
SUBPARTITIONS 8;
```

## Modifying Partition Default Attributes

You can modify the default attributes of a partition or subpartition of a table or index. When you modify default attributes, the new attributes will affect only future partitions that are created. The default values can still be specifically overridden when creating a new partition.

### Modifying Default Attributes of Partitions

You modify the default attributes that will be inherited for range or hash partitions using the MODIFY DEFAULT ATTRIBUTES clause of ALTER TABLE. The following example changes the default value of PCTFREE in table EMP for any new partitions that are created.

```
ALTER TABLE emp
      MODIFY DEFAULT ATTRIBUTES PCTFREE 25;
```

For hash-partitioned tables, only the TABLESPACE attribute can be modified.

### Modifying Default Attributes of Subpartitions

To modify the default attributes used for creating the subpartitions of a range partition in a composite-partitioned table, use the ALTER TABLE...MODIFY DEFAULT ATTRIBUTES FOR PARTITION. This statement modifies the TABLESPACE in which future subpartitions of partition P1 in composite-partitioned table EMP will reside.

```
ALTER TABLE emp
     MODIFY DEFAULT ATTRIBUTES FOR PARTITION p1 TABLESPACE ts1;
```

Since all subpartitions must share the same attributes, except TABLESPACE, it is the only attribute that can be changed.

### Modifying Default Attributes of Index Partitions

In similar fashion to table partitions, you can alter the default attributes that will be inherited by partitions of a range-partitioned global index, or local index partitions for range, hash, or composite-partitioned tables. For this you use the ALTER INDEX...MODIFY DEFAULT ATTRIBUTES statement. Use the ALTER INDEX...MODIFY DEFAULT ATTRIBUTES FOR PARTITION statement if you are

altering default attributes to be inherited by subpartitions of a composite-partitioned table.

## Modifying Real Attributes of Partitions

It is possible to modify attributes of an existing partition of a table or index.

You cannot change the TABLESPACE attribute. Use ALTER TABLESPACE...MOVE PARTITION / SUBPARTITION to move a partition or subpartition to a new tablespace.

### Modifying Real Attributes for a Range Partition

Use the ALTER TABLE...MODIFY PARTITION statement to modify existing attributes of a range partition. You can modify segment attributes (except TABLESPACE), or you can allocate and deallocate extents, mark local index partitions UNUSABLE, or rebuild local indexes that have been marked UNUSABLE.

If this is a range partition of a composite-partitioned table, note the following:

- If you allocate or deallocate an extent, this action will be performed for every subpartition of the specified partition.
- Likewise, changing any other attributes will result in corresponding changes to those attributes of all the subpartitions for that partition. The partition level default attributes will be changed as well. To avoid changing attributes of existing subpartitions, use the FOR PARTITION clause of the MODIFY DEFAULT ATTRIBUTES statement.

The following are some examples of modifying the real attributes of a partition.

This example modifies the MAXEXTENTS storage attribute for the range partition SALES_Q1 of table SALES:

```
ALTER TABLE sales MODIFY PARTITION sales_Q1
     STORAGE (MAXEXTENTS 10);
```

All of the local index subpartitions of partition TS1 in composite-partitioned table SCUBAGEAR are marked UNUSABLE in this example:

```
ALTER TABLE scubagear MPDIFY PARTITION ts1 UNUSABLE LOCAL INDEXES;
```

### Modifying Real Attributes for a Hash Partition

You also use the ALTER TABLE...MODIFY PARTITION statement to modify attributes of a hash partition. However, since the physical attributes of individual hash partitions must all be the same (except for TABLESPACE), you are restricted to:

- Allocating a new extent
- Deallocating an unused extent
- Marking a local index subpartition UNUSABLE
- Rebuilding local index subpartitions that are marked UNUSABLE

The following example rebuilds any unusable local index partitions associated with hash partition P1 of table DEPT:

```
ALTER TABLE dept MODIFY PARTITION p1
     REBUILD UNUSABLE LOCAL INDEXES;
```

### Modifying Real Attributes of a Subpartition

With the MODIFY SUBPARTITION clause of ALTER TABLE you can perform the same actions as listed previously for hash partitions, but at the specific composite-partitioned table subpartition level. For example:

```
ALTER TABLE emp MODIFY SUBPARTITION p3_s1
     REBUILD UNUSABLE LOCAL INDEXES
```

### Modifying Real Attributes of Index Partitions

The MODIFY PARTITION clause of ALTER INDEX allows you to modify the real attributes of an index partition or its subpartitions. The rules are very similar to those for table partitions, but unlike the MODIFY PARTITION clause for ALTER TABLE, there is no subclause to rebuild an unusable index partition, but there is a subclause to coalesce an index partition or its subpartitions. In this context, coalesce means to merge index blocks where possible to free them for reuse.

You can also allocate or deallocate storage for a subpartition of a local index, or mark it UNUSABLE, using the MODIFY SUBPARTITION clause.

## Moving Partitions

You can use the MOVE PARTITION clause of the ALTER TABLE statement to:

- re-cluster data and reduce fragmentation

- move a partition to another tablespace
- modify create-time attributes

Typically, you can change the physical storage attributes of a partition in a single step via a ALTER TABLE/INDEX...MODIFY PARTITION statement. However, there are some physical attributes, such as TABLESPACE, that you cannot modify via MODIFY PARTITION. In these cases you can use the MOVE PARTITION clause.

When the partition you are moving contains data, MOVE PARTITION marks the matching partition in each local index, and all global index partitions as unusable. You must rebuild these index partitions after issuing MOVE PARTITION. Global indexes must also be rebuilt.

### Moving Table Partitions

Use the MOVE PARTITION clause to move a partition. For example, a DBA wants to move the most active partition to a tablespace that resides on its own disk (in order to balance I/O) and he wishes to LOG the action. The DBA can issue the following statement:

```
ALTER TABLE parts MOVE PARTITION depot2
     TABLESPACE ts094 NOLOGGING;
```

This statement always drops the partition's old segment and creates a new segment, even if you don't specify a new tablespace.

### Moving Subpartitions

The following statement shows how to move data in a subpartition of a table. In this example, a PARALLEL clause has also been specified.

```
ALTER TABLE scuba_gear MOVE SUBPARTITION bcd_types
     TABLESPACE tbs23 PARALLEL (DEGREE 2);
```

### Moving Index Partitions

Some clauses, such as MOVE PARTITION and DROP PARTITION, mark all partitions of a global index unusable. You can rebuild the entire index by rebuilding each partition individually using the ALTER INDEX...REBUILD PARTITION statement. You can perform these rebuilds concurrently.

You can also simply drop the index and re-create it.

## Rebuilding Index Partitions

You might rebuild index partitions for any of the following reasons:

- To recover space and improve performance
- To repair a damaged index partition caused by media failure
- To rebuild a local index partition after loading the underlying table partition with IMPORT or SQL*Loader
- To rebuild index partitions that have been marked UNUSABLE

The following sections discuss your options for rebuilding index partitions and subpartitions.

### Rebuilding Global Index Partitions

You can rebuild global index partitions in two ways:

1. Rebuild each partition by issuing the ALTER INDEX...REBUILD PARTITION statement (you can run the rebuilds concurrently).
2. Drop the index and re-create it.

> **Note:** This second method is more efficient because the table is scanned only once.

### Rebuilding Local Index Partitions

You can rebuild local indexes using either ALTER INDEX or ALTER TABLE:

- ALTER INDEX...REBUILD PARTITION / SUBPARTITION--this statement rebuilds an index partition or subpartition unconditionally.
- ALTER TABLE...MODIFY PARTITION / SUBPARTITION...REBUILD UNUSABLE LOCAL INDEXES--this statement finds all of the unusable indexes for the given table partition or subpartition and rebuilds them. It only rebuilds an index partition if it has been marked UNUSABLE.

**Using Alter Index to Rebuild a Partition** The ALTER INDEX...REBUILD PARTITION statement rebuilds one partition of an index. It cannot be used on a composite-partitioned table. At the same time as you recreate the index, you can move the partition to a new tablespace or change attributes.

For composite-partitioned tables, use ALTER INDEX...REBUILD SUBPARTITION to rebuild a subpartition of an index. You can move the subpartition to another tablespace or specify a parallel clause. The following statement rebuilds a

subpartition of a local index on a table and moves the index subpartition is another tablespace.

```
ALTER INDEX scuba
   REBUILD SUBPARTITION bcd_types
   TABLESPACE tbs23 PARALLEL (DEGREE 2);
```

**Using Alter Table to Rebuild an Index Partition** The REBUILD UNUSABLE LOCAL INDEXES clause of the ALTER TABLE...MODIFY PARTITION does not allow you to specify any new attributes for the rebuilt index partition. The following example finds and rebuilds any unusable local index partitions for table SCUBAGEAR, partition P1.

```
ALTER TABLE scubagear
   MODIFY PARTITION p1 REBUILD UNUSABLE LOCAL INDEXES;
```

There is a corresponding ALTER TABLE...MODIFY SUBPARTITION clause for rebuilding unusable local index subpartitions.

## Renaming Partitions

It is possible to rename partitions and subpartitions of both tables and indexes. One reason for renaming a partition might be to assign a meaningful name, as opposed to a default system name that was assigned to the partition in another maintenance operation.

### Renaming a Table Partition

You can rename a range or hash partition, using the ALTER TABLE...RENAME PARTITION statement. An example is:

```
ALTER TABLE scubagear RENAME PARTITION sys_p636 TO tanks
```

### Renaming a Table Subpartition

Likewise, you can assign new names to subpartitions of a table. In this case you would use the ALTER TABLE...RENAME SUBPARTITION syntax.

### Renaming Index Partitions

Index partitions and subpartitions can be renamed in similar fashion, but the ALTER INDEX syntax is used.

**Renaming a Index Partition** Use the ALTER INDEX...RENAME PARTITION statement to rename an index partition.

**Renaming an Index Subpartition** This next statement simply shows how to rename a subpartition that has a system generated name that was a consequence of adding a partition to an underlying table:

```
ALTER INDEX scuba RENAME SUBPARTITION sys_subp3254 TO bcd_types;
```

## Splitting Partitions

The SPLIT PARTITION clause or the ALTER TABLE or ALTER INDEX statement is used to redistribute the contents of a partition into two new partitions. You may want to do this when a partition becomes too large and causes backup, recovery, or maintenance operations to take a long time to complete. You can also use the SPLIT PARTITION clause to redistribute the I/O load.

If the partition you are splitting contains data, the ALTER TABLE...SPLIT PARTITION statement marks UNUSABLE the new partitions (there are two) in each local index, all global index partitions, and any global nonpartitioned index. You must rebuild such affected indexes or index partitions.

This clause cannot be used for hash partitions or subpartitions.

### Splitting a Range Table Partition

You can split a table partition by issuing the ALTER TABLE...SPLIT PARTITION statement. You may optionally specify new attributes for the two partitions resulting from the split. If there are local indexes defined on the table, this statement also splits the matching partition in each local index.

In the following example FEE_KATY is a partition in the table VET_CATS, which has a local index, JAF1. There is also a global index, VET on the table. VET contains two partitions, VET_PARTA, and VET_PARTB.

To split the partition FEE_KATY, and rebuild the index partitions, the DBA issues the following statements:

```
ALTER TABLE vet_cats SPLIT PARTITION
      fee_katy at (100) INTO ( PARTITION
      fee_katy1 ..., PARTITION fee_katy2 ...);
ALTER INDEX JAF1 REBUILD PARTITION fee_katy1;
ALTER INDEX JAF1 REBUILD PARTITION fee_katy2;
ALTER INDEX VET REBUILD PARTITION vet_parta;
ALTER INDEX VET REBUILD PARTITION vet_partb;
```

**Note:** If you do not specify new partition names, Oracle assigns names of the form SYS_Pn. You can examine the data dictionary to locate the names assigned to the new local index partitions. You may want to rename them. Any attributes you do not specify, are inherited from the original partition.

### Splitting a Range Composite Partition

This is the opposite of merging range composite partitions. When you split range composite partitions, the new subpartitions will be rehashed into either the number of subpartitions specified in a SUBPARTITIONS or SUBPARTITION clause, or, if no such clause is included, table-level defaults will be used.

```
ALTER TABLE all_seasons SPLIT PARTITION quarter_1
     AT (TO_DATE('16-dec-1997','dd-mon-yyyy'))
     INTO (PARTITION q1_1997_1 SUBPARTITIONS 4 STORE IN (ts1,ts3),
           PARTITION q1_1997_2);
```

### Splitting Index Partitions

You cannot explicitly split a partition in a local index. A local index partition is split only when you split a partition in the underlying table.

The following statement splits the global index partition, QUON1:

```
ALTER INDEX quon1 SPLIT
    PARTITION canada AT VALUES LESS THAN ( 100 ) INTO
    PARTITION canada1 ..., PARTITION canada2 ...);
ALTER INDEX quon1 REBUILD PARTITION canada1;
ALTER INDEX quon1 REBUILD PARTITION canada2;
```

The index being split can contain index data, and you only need to rebuild if that partition was previously marked UNUSABLE.

## Truncating Partitions

Use the ALTER TABLE...TRUNCATE PARTITION statement when you want to remove all rows from a table partition. Truncating a partition is similar to dropping a partition, except that the partition is emptied of its data, but not physically dropped.

You cannot truncate an index partition; however, the ALTER TABLE TRUNCATE PARTITION statement truncates the matching partition in each local index. If there

is a global index (partitioned or nonpartitioned) on the table, it is marked UNUSABLE and must be rebuilt.

### Truncating a Table Partition

You can use the ALTER TABLE...TRUNCATE PARTITION statement to remove all rows from a table partition with or without reclaiming space. If there are local indexes defined for this table, ALTER TABLE...TRUNCATE PARTITION also truncates the matching partition from each local index.

**Truncating Table Partitions Containing Data and Global Indexes** If the partition contains data and global indexes, use either of the following methods to truncate the table partition:

1. Leave the global indexes in place during the ALTER TABLE TRUNCATE PARTITION statement. In this example, table SALES has a global index SALES_AREA_IX, which is rebuilt.

   ```
   ALTER TABLE sales TRUNCATE PARTITION dec94;
   ALTER INDEX sales_area_ix REBUILD;
   ```

   This method is most appropriate for large tables where the partition being truncated contains a significant percentage of the total data in the table.

2. Issue the DELETE statement to delete all rows from the partition before you issue the ALTER TABLE...TRUNCATE PARTITION statement. The DELETE statement updates the global indexes, and also fires triggers and generates redo and undo log.

   This method is most appropriate for small tables, or for large tables when the partition being truncated contains a small percentage of the total data in the table.

**Truncating a Partition Containing Data and Referential Integrity Constraints** If a partition contains data and has referential integrity constraints, choose either of the following methods to truncate the table partition:

1. Disable the integrity constraints, issue the ALTER TABLE...TRUNCATE PARTITION statement, then re-enable the integrity constraints:

   ```
   ALTER TABLE sales
       DISABLE CONSTRAINT dname_sales1;
   ALTER TABLE sales TRUNCATE PARTITTION dec94;
   ALTER TABLE sales
       ENABLE CONSTRAINT dname_sales1;
   ```

This method is most appropriate for large tables where the partition being truncated contains a significant percentage of the total data in the table.

2. Issue the DELETE statement to delete all rows from the partition before you issue the ALTER TABLE...TRUNCATE PARTITION statement. The DELETE statement enforces referential integrity constraints, and also fires triggers and generates redo and undo log.

   **Note:** You can substantially reduce the amount of logging by setting the NOLOGGING attribute (using ALTER TABLE...MODIFY PARTITION...NOLOGGING) for the partition before deleting all of its rows.

```
DELETE FROM sales WHERE TRANSID < 10000;
ALTER TABLE sales TRUNCATE PARTITION dec94;
```

   This method is most appropriate for small tables, or for large tables when the partition being truncated contains a small percentage of the total data in the table.

### Truncating a Subpartition

You use the ALTER TABLE...TRUNCATE SUBPARTITION statement to remove all rows from a subpartition of a composite-partitioned table. Corresponding local index subpartitions are also truncated.

The following statement shows how to truncate data in a subpartition of a table. In this example, the space occupied by the deleted rows is made available for use by other schema objects in the tablespace .:

```
ALTER TABLE diving
   TRUNCATE SUBPARTITION us_locations
      DROP STORAGE;
```

## Partitioned Tables and Indexes Examples

This section presents some examples for working with partitioned tables and indexes.

## Moving the Time Window in a Historical Table

A *historical* table describes the business transactions of an enterprise over intervals of time. Historical tables can be *base* tables, which contain base information; for example, sales, checks, orders. Historical tables can also be *rollup* tables, which contain summary information derived from the base information via operations such as GROUP BY, AVERAGE, or COUNT.

The time interval in a historical table is often a rolling window; DBAs periodically delete sets of rows that describe the oldest transaction, and in turn allocate space for sets of rows that describe the most recent transaction. For example, at the close of business on April 30, 1995 the DBA deletes the rows (and supporting index entries) that describe transactions from April 1994, and allocates space for the April 1995 transactions.

Now consider a specific example.

You have a table, ORDER, which contains 13 months of transactions: a year of historical data in addition to orders for the current month. There is one partition for each month; the partitions are named ORDER_yymm, as are the tablespaces in which they reside.

The ORDER table contains two local indexes, ORDER_IX_ONUM, which is a local, prefixed, unique index on the order number, and ORDER_IX_SUPP, which is a local, non-prefixed index on the supplier number. The local index partitions are named with suffixes that match the underlying table. There is also a global unique index, ORDER_IX_CUST, for the customer name. ORDER_IX_CUST contains three partitions, one for each third of the alphabet. So on October 31, 1994, change the time window on ORDER as follows:

1. Back up the data for the oldest time interval.

```
ALTER TABLESPACE order_9310 BEGIN BACKUP;
...
ALTER TABLESPACE order_9310 END BACKUP;
```

2. Drop the partition for the oldest time interval.

```
ALTER TABLE order DROP PARTITION order_9310;
```

3. Add the partition to the most recent time interval.

```
ALTER TABLE order ADD PARTITION order_9411;
```

4. Recreate the global index partitions.

```
ALTER INDEX order_ix_cust REBUILD PARTITION order_ix_cust_AH;
```

```
ALTER INDEX order_ix_cust REBUILD PARTITION order_ix_cust_IP;
ALTER INDEX order_ix_cust REBUILD PARTITION order_ix_cust_QZ;
```

Ordinarily, Oracle acquires sufficient locks to ensure that no operation (DML, DDL, or utility) interferes with an individual DDL statement, such as ALTER TABLE...DROP PARTITION. However, if the partition maintenance operation requires several steps, it is the DBA's responsibility to ensure that applications (or other maintenance operations) do not interfere with the multi-step operation in progress.

A couple of methods for doing this are:

- Bring down all user-level applications during a well-defined batch window.
- You can ensure that no one is able to access table ORDER by revoking access privileges from a role that is used in all applications.

## Converting a Partition View into a Partitioned Table

This scenario describes how to convert a partition view (also called "manual partition") into a partitioned table. The partition view is defined as follows:

```
CREATE VIEW accounts
      SELECT * FROM accounts_jan98
      UNION ALL
      SELECT * FROM accounts_feb98
      UNION ALL
      ...
      SELECT * FROM accounts_dec98;
```

To incrementally migrate the partition view to a partitioned table, follow these steps:

1. Initially, only the two most recent partitions, ACCOUNTS_NOV98 and ACCOUNTS_DEC98, will be migrated from the view to the table by creating the partitioned table. Each partition gets a segment of two blocks (as a placeholder).

```
CREATE TABLE accounts_new (...)
    TABLESPACE ts_temp STORAGE (INITIAL 2)
    PARTITION BY RANGE (opening_date)
         (PARTITION jan98 VALUES LESS THAN ('01-FEB-1998'),
          ...
         PARTITION dec98 VALUES LESS THAN ('01-FEB-1998'));
```

2. Use the EXCHANGE PARTITION statement to migrate the tables to the corresponding partitions.

```
ALTER TABLE accounts_new
    EXCHANGE PARTITION nov98 WITH TABLE
        accounts_nov98 WITH VALIDATION;

ALTER TABLE accounts_new
    EXCHANGE PARTITION dec98 WITH TABLE
        accounts_dec98 WITH VALIDATION;
```

   So now the placeholder data segments associated with the NOV98 and DEC98 partitions have been exchanged with the data segments associated with the ACCOUNTS_NOV98 and ACCOUNTS_DEC98 tables.

3. Redefine the ACCOUNTS view.

```
CREATE OR REPLACE VIEW accounts
    SELECT * FROM accounts_jan98
    UNION ALL
    SELECT * FROM accounts_feb_98
    UNION ALL
    ...
    UNION ALL
    SELECT * FROM accounts_new PARTITION (nov98)
    UNION ALL
    SELECT * FROM accounts_new PARTITION (dec98);
```

4. Drop the ACCOUNTS_NOV98 and ACCOUNTS_DEC98 tables, which own the placeholder segments that were originally attached to the NOV98 and DEC98 partitions.

5. After all the tables in the UNION ALL view are converted into partitions, drop the view and rename the partitioned to the name of the view being dropped.

```
DROP VIEW accounts;
RENAME accounts_new TO accounts;
```

# 16

# Managing Clusters

This chapter describes aspects of managing clusters. It includes the following topics relating to the management of indexed clusters, clustered tables, and cluster indexes:

- Guidelines for Managing Clusters
- Creating Clusters
- Altering Clusters
- Dropping Clusters

Another type of cluster, a hash cluster, is described in Chapter 17, "Managing Hash Clusters".

Before attempting tasks described in this chapter, familiarize yourself with the concepts in Chapter 12, "Guidelines for Managing Schema Objects".

# Guidelines for Managing 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, which 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 16–1), Oracle physically stores all rows for each department from both the EMP and DEPT tables in the same data blocks. You should not use clusters for tables that are frequently accessed individually.

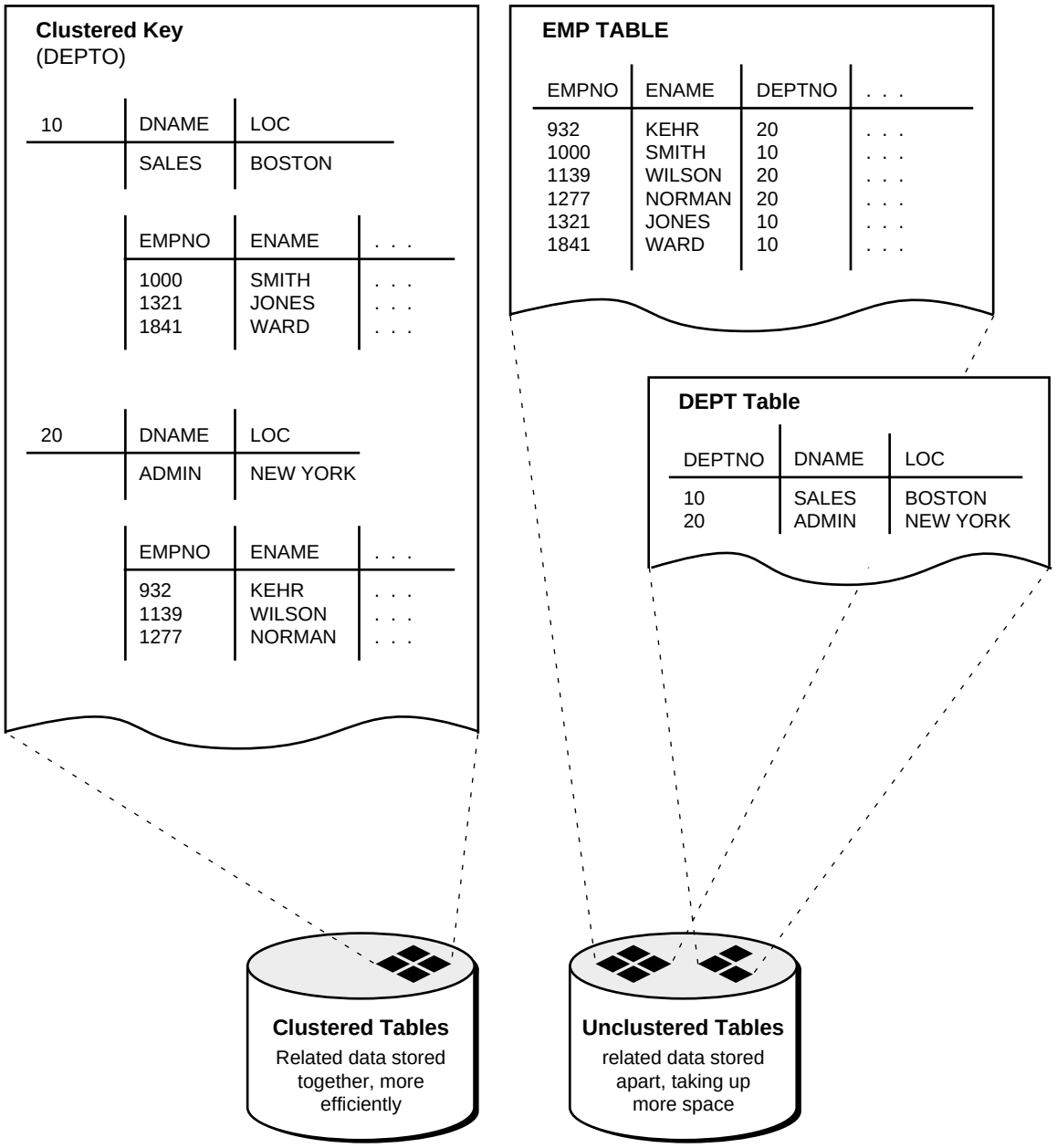
Because clusters store related rows of different tables together in the same data blocks, properly used clusters offer two primary benefits:

- 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, 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.

***Figure 16–1 Clustered Table Data***



The following sections describe guidelines to consider when managing clusters, and includes the following topics:

- Choose Appropriate Tables for the Cluster
- Choose Appropriate Columns for the Cluster Key
- Specify Data Block Space Use
- 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:** For more information about clusters, see *Oracle8i Concepts*.
>
> For guidelines on when you should use clusters, see *Oracle8i Designing and Tuning for Performance.*

## Choose Appropriate Tables for the Cluster

Use clusters to store one or more tables that are primarily queried (not predominantly inserted into or updated) and for which the queries often join data of multiple tables in the cluster or retrieve related data from a single table.

## 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 14-2.

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 per 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).

Too many rows per 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 Data Block Space Use

By specifying the PCTFREE and PCTUSED parameters during the creation of a cluster, you can affect the space utilization and amount of space reserved for updates to the current rows in the data blocks of a cluster's data segment. Note that PCTFREE and PCTUSED parameters set for tables created in a cluster are ignored; clustered tables automatically use the settings set for the cluster. The setting PCTFREE and PCTUSED, is discussed in "Managing Space in Data Blocks" on page 12-2.

## Specify the Space Required by an Average Cluster Key and Its Associated Rows

The CREATE CLUSTER statement has an optional argument, SIZE, which is the estimated number of bytes required by an average cluster key and its associated rows. Oracle 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, Oracle stores only one cluster key and its associated rows in each data block of the cluster's data segment. Although block size can vary from one operating system to the next, the rule of one key per 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 option 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

Following are benefits of estimating a cluster's size before creating it:

- You can use the combined estimated size of clusters, along with estimates for indexes, rollback segments, 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 non-clustered 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. See Chapter 23, "Managing User Privileges and Roles"for more information about

system privileges, and Chapter 22, "Managing Users and Resources"for information about tablespace quotas.

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))
   PCTUSED 80
   PCTFREE 5
   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 17, "Managing Hash Clusters".

> **See Also:** For a more complete description of syntax, restrictions, and authorizations required for the SQL statements presented in this chapter, see *Oracle8i SQL Reference*.

## 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 SQL CREATE TABLE statement with the CLUSTER option. The EMP and DEPT tables can be created in the EMP_DEPT cluster using the following statements:

```
CREATE TABLE dept (
   deptno NUMBER(3) PRIMARY KEY, . . . )
   CLUSTER emp_dept (deptno);

CREATE TABLE emp (
   empno NUMBER(5) PRIMARY KEY,
   ename VARCHAR2(15) NOT NULL,
   . . .
```

```
deptno NUMBER(3) REFERENCES dept)
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.

## Creating Cluster Indexes

To create a cluster index, one of the following conditions must be true:

- Your schema contains the cluster and you have the CREATE INDEX system privilege.
- 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
   INITRANS 2
   MAXTRANS 5
   TABLESPACE users
   STORAGE (INITIAL 50K
      NEXT 50K
      MINEXTENTS 2
      MAXEXTENTS 10
      PCTINCREASE 33)
   PCTFREE 5;
```

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.

## 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 (PCTFREE, PCTUSED, INITRANS, MAXTRANS, 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. Oracle 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 the Oracle Parallel Server, 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 data block space usage parameters (PCTFREE and PCTUSED) or 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 settings (INITRANS, MAXTRANS) of a cluster, a new setting for INITRANS applies only to data blocks subsequently allocated for the cluster, while a new setting for MAXTRANS applies to all blocks (already and subsequently allocated blocks) of a 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. The following statement alters the EMP_DEPT cluster:

```
ALTER CLUSTER emp_dept
   PCTFREE 30
   PCTUSED 60;
```

**See Also:** For additional information about the CLUSTER parameter in the ALTER CLUSTER statement, see *Oracle8i Parallel Server Administration, Deployment, and Performance.*

### Altering Cluster Tables and Cluster Indexes

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"). Oracle 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 13-11.

You alter cluster indexes exactly as you do other indexes. See "Altering Indexes" on page 14-15.

---

**Note:** When estimating the size of cluster indexes, remember that the index is on each cluster key, not the actual rows; therefore, each key will only appear once in the index.

---

## Dropping Clusters

A cluster can be dropped if the tables within the cluster are no longer necessary. When a cluster is dropped, so are the tables within the cluster and the corresponding cluster index. All extents belonging to both the cluster's 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 option of the DROP CLUSTER statement, as follows:

```
DROP CLUSTER emp_dept INCLUDING TABLES;
```

If the INCLUDING TABLES option 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 option of the DROP CLUSTER statement, as shown in the following example:

```
DROP CLUSTER emp_dept INCLUDING TABLES CASCADE CONSTRAINTS;
```

Oracle returns an error if you do not use the CASCADE CONSTRAINTS option and constraints exist.

## 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 table's cluster, other clustered tables, or the cluster index. A clustered table is dropped just as a non-clustered table is dropped—with the DROP TABLE statement. See "Dropping Tables" on page 13-15.

---

**Note:** When you drop a single table from a cluster, Oracle 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 option. 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 14-16.

# 17

# Managing Hash Clusters

This chapter describes how to manage hash clusters, and includes the following topics:

- Should You Use Hash Clusters?
- Creating Hash Clusters
- Altering Hash Clusters
- Dropping Hash Clusters

> **See Also:** Before attempting tasks described in this chapter, familiarize yourself with the concepts in Chapter 12, "Guidelines for Managing Schema Objects".

# Should You Use 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 locates the rows in a table using key values that Oracle stores in a separate index. To use hashing, you create a hash cluster and load tables into it. Oracle physically stores the rows of a table in a hash cluster and retrieves them according to the results of a *hash function*.

Oracle 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, Oracle applies the hash function to the row's cluster key value; the resulting hash value corresponds to a data block in the cluster, which Oracle 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, Oracle 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.

This section presents the advantages and disadvantages of hashing to help you decide if it is appropriate for your situation.

> **See Also:** For more information about hash clusters, see *Oracle8i Concepts*.

## Advantages of Hashing

If you opt to use indexing rather than hashing, consider whether to store a table individually or as part of a cluster.

Hashing is most advantageous 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.

## Disadvantages of Hashing

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 like 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 and 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 pre-allocate the space that the hash cluster will eventually need.

> **See Also:** Even if you decide to use hashing, a table can still have separate indexes on any columns, including the cluster key. See the *Oracle8i Application Developer's Guide - Fundamentals* for additional recommendations.

# 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))
    PCTUSED 80
    PCTFREE 5
    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. Oracle rounds the number specified to the nearest prime number.

If no HASH IS clause is specified, Oracle 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 above 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 16, "Managing Clusters". The following sections explain and provide guidelines for setting the parameters of the CREATE CLUSTER statement specific to hash clusters:

- Creating Single-Table Hash Clusters
- Controlling Space Use Within a Hash Cluster

- How to Estimate Size Required by Hash Clusters and Set Storage Parameters

**See Also:** For detailed information about hash functions and specifying user-defined hash functions, see *Oracle8i Concepts.*

For a more complete description of syntax, restrictions, and authorizations required for the SQL statements CREATE CLUSTER and CREATE TABLE, see *Oracle8i SQL Reference.*

## 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;
```

Oracle rounds the HASHKEY value up to the nearest prime number, so this cluster has a maximum of 503 hash key values, each of size 512 bytes.

**Note:** The SINGLE TABLE option is valid only for hash clusters. HASHKEYS must also be specified.

## 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 Oracle's internal hash function.

### 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 the above conditions apply, you can distribute rows in the cluster so that each unique cluster key value hashes, with no collisions, to a unique hash value. If these conditions do not apply, omit this option 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 per 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.
- If the hash cluster does not use the internal hash function (if you specified HASH IS) and you expect little or no collisions, you can set SIZE as estimated; 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 increase SIZE as shown in the following chart.

| Available Space per Block/Calculated SIZE | Setting for SIZE |
|---|---|
| 1 | Calculated SIZE |
| 2 | Calculated SIZE + 15% |
| 3 | Calculated SIZE + 12% |
| 4 | Calculated SIZE + 8% |
| >4 | Calculated 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 above adjustments and use the estimated value for SIZE.

### Setting HASHKEYS

For maximum distribution of rows in a hash cluster, Oracle rounds the HASHKEYS value up to the nearest prime number.

### Controlling Space in Hash Clusters: Examples

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).

**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. Since 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 per data block. HASHKEYS can be set to the number of rows in the table, 10000, rounded up to the next highest prime number, 10007.

```
CREATE CLUSTER emp_cluster (empno
NUMBER)
. . .
SIZE 55
HASH IS empno HASHKEYS 10007;
```

**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 per department. Note that 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 pre-estimated SIZE (the average amount of space required to hold all rows per department) is 55 bytes * 10, or 550 bytes. Using this value for SIZE, only three hash keys can be assigned per 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 (see previous section about setting SIZE for clarification), only three hash keys are assigned per data block, leaving more space for rows from expected collisions.

HASHKEYS can be set to the number of unique department numbers, 1000, rounded up to the next highest prime number, 1009.

```
CREATE CLUSTER emp_cluster (deptno NUMBER)
. . .
SIZE 620
HASH IS deptno HASHKEYS 1009;
```

## How to Estimate Size Required by Hash Clusters and Set Storage Parameters

As with index clusters, it is important to estimate the storage required for the data in a hash cluster.

Oracle 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 per 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 per 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. However, note that the SIZE, HASHKEYS, and HASH IS parameters cannot be specified in an ALTER CLUSTER statement. You must re-create the cluster to change these parameters and then copy the data from the original cluster.

> **See Also:** For more information about altering an index cluster, see "Altering Clusters" on page 16-9.

## 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 for index clusters.

> **See Also:** For more information about dropping clusters, see "Dropping Clusters" on page 16-10.

# 18

# Managing Views, Sequences and Synonyms

This chapter describes aspects of view management, and includes the following topics:

- Managing Views
- Managing Sequences
- Managing Synonyms

Before attempting tasks described in this chapter, familiarize yourself with the concepts in Chapter 12, "Guidelines for Managing Schema Objects".

# Managing Views

A view is a tailored presentation of the data contained in one or more tables (or other views), and takes the output of a query and treats it as a table. You can think of a view as a "stored query" or a "virtual table." You can use views in most places where a table can be used.

This section describes aspects of managing views, and includes the following topics:

- Creating Views
- Updating a Join View
- Altering Views
- Dropping Views
- Replacing Views

## Creating Views

To create a view, you must fulfill the requirements listed below.

- 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 may acquire these privileges explicitly or via 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 is dependent on the privileges of the view's owner. For example, if the owner of the view has only the INSERT privilege for Scott's EMP table, the view can only be used to insert new rows into the EMP table, not to SELECT, UPDATE, or DELETE rows from it.
- 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, snapshots, 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 is rolled back and 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 optionally 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.

---

**Note:** The restrictions for creating views are included in the description of the CREATE VIEW statement in the *Oracle8i SQL Reference*. Please refer to that book for specifics.

---

**See Also:** For detailed syntax, restriction, and authorization information relating to creating or replacing, updating, altering, and dropping views, see *Oracle8i SQL Reference*.

### 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 18-5 for further discussion.

### Expansion of Defining Queries at View Creation Time

In accordance with the ANSI/ISO standard, Oracle expands any wildcard in a top-level view query into a column list when a view is created and stores the resulting query 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;
```

Oracle 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, Oracle can create the view even if the defining query of the view cannot be executed; 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 option of the CREATE VIEW statement.

```
CREATE FORCE VIEW AS ....;
```

By default, views with errors are not created as VALID. When you try to create such a view, Oracle returns a message indicating the view was created with errors. The status of a view created with errors is INVALID. 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 19-23.

## 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.

---

**Note:** There are some restrictions and conditions which may affect whether a join view is updatable. These are listed in the description of the CREATE VIEW statement in the *Oracle8i SQL Reference*. Please refer to that book for specifics.

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 reverencing views, see *Oracle8i Concepts* and *Oracle8i Designing and Tuning for Performance*.

There are data dictionary views which indicate whether the columns in a join view are updatable. See Table 18–1, "UPDATABLE_COLUMNS Views" on page 18-10 for descriptions of these views.

---

The rules for updatable join views are as follows:

| Rule | Description |
|---|---|
| General Rule | Any INSERT, UPDATE, or DELETE operation on a join view can modify only one underlying base table at a time. |
| UPDATE Rule | All updatable columns of a join view must map to columns of a *key-preserved table*. If the view is defined with the WITH CHECK OPTION clause, then all join columns and all columns of repeated tables are non-updatable. |
| DELETE Rule | Rows from a join view can be deleted as long as there is exactly one *key-preserved table* in the join. 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. |

Examples illustrating these rules, and a discussion of key-preserved tables, are presented in succeeding sections.

The examples given work only if you explicitly define the primary and foreign keys in the tables, or define unique indexes. Following are 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 above, 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 key(s) 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, INSERT, or DELETE statement on a join view can modify only one underlying base table. The following examples will 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 ORA-01779 error (''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 of repeated tables 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.

**DELETE Statements** You can delete from a join view provided there is *one and only one* key-preserved table in the join.

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.

If you were to create the following view, a DELETE operation could not be performed on the view because both E1 and E2 are key-preserved tables:

```
CREATE VIEW emp_emp AS
     SELECT e1.ename, e2.empno, 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, then 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;
```

No deletion can be performed on this view because the view involves a self-join of the table that is key preserved.

**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 like 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.

```
INSERT INTO emp_dept (ename, empno, deptno)
   VALUES ('KURODA', 9010, 77);
```

The following INSERT statement would fail with an ORA-01776 error (''cannot modify more than one base table through a 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.

### Using the UPDATABLE_ COLUMNS Views

The views described in Table 18–1 can assist you when modifying join views.

*Table 18–1 UPDATABLE_COLUMNS Views*

| View Name | Description |
|---|---|
| USER_UPDATABLE_COLUMNS | Shows all columns in all tables and views in the user's schema that are modifiable. |
| DBA_UPDATABLE_COLUMNS | Shows all columns in all tables and views in the DBA schema that are modifiable. |
| ALL_UPDATABLE_VIEWS | Shows all columns in all tables and views 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.
```

## 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 18-11.

The ALTER VIEW statement allows you to locate recompilation errors before run time. You may want to explicitly recompile a view after altering one of its base tables to ensure that the alteration does not affect the view or other objects that depend on it.

To use the ALTER VIEW statement, the view must be in your schema, or you must have the ALTER ANY TABLE system privilege.

## 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;
```

## Replacing Views

To replace a view, you must have all the privileges required to drop and create a view. If the definition of a view must change, the view must be replaced; you cannot change the definition of a view. You can replace views in the following ways:

- You can drop and re-create the view.

  **WARNING: 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 re-granted.**

- You can redefine the view with a CREATE VIEW statement that contains the OR REPLACE option. The OR REPLACE option 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's 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 and PL/SQL program units dependent on a replaced view become invalid (not usable). See "Managing Object Dependencies" on page 19-23for more information on how Oracle manages such dependencies.

# Managing Sequences

Sequences are database objects from which multiple users may generate unique integers. You can use sequences to automatically generate primary key values. This section describes various aspects of managing sequences, and includes the following topics:

- Creating Sequences
- Altering Sequences
- Dropping Sequences

> **See Also:** For more information about sequences, see *Oracle8i Concepts*. For statement syntax, refer to *Oracle8i SQL Reference*.

## 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;
```

The CACHE option pre-allocates 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, Oracle reads another set of numbers into the cache.

Oracle 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. Oracle might also skip cached sequence numbers after an export and import; see *Oracle8i Utilities* for details.

> **See Also:** For information about how the Oracle Parallel Server affects cached sequence numbers, see *Oracle8i Parallel Server Administration, Deployment, and Performance.*
>
> For performance information on caching sequence numbers, see *Oracle8i Designing and Tuning for Performance.*

## 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's starting number. To change the starting point of a sequence, drop the sequence and then re-create it. When you perform DDL on sequence numbers you will lose the cache values.

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;
```

## 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.

# Managing 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 the user's grantees.

This section includes the following synonym management information:

- Creating Synonyms
- Dropping Synonyms

> **See Also:** For more information about synonyms, see *Oracle8i Concepts*. For statement syntax, refer to *Oracle8i SQL Reference*.

## 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. 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;
```

## 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" on page 19-23

# 19

# General Management of 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
- Renaming Schema Objects
- Analyzing Tables, Indexes, and Clusters
- Truncating Tables and Clusters
- Enabling and Disabling Triggers
- Managing Integrity Constraints
- Managing Object Dependencies
- Managing Object Name Resolution
- Changing Storage Parameters for the Data Dictionary
- Displaying Information About Schema Objects

> **See Also:** For more information about syntax, authorizations, and restrictions for the SQL statements discussed in this chapter, see the *Oracle8i SQL Reference.*

# 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 and 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 CREATE TABLE, CREATE VIEW, and GRANT statements. You must have the privileges necessary to issue the included statements.

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 extensions to the ANSI CREATE TABLE and CREATE VIEW statements; this includes the STORAGE clause.

## Renaming Schema Objects

To rename an object, you must own it. 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 re-granted 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 rename 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.

For more information about how Oracle manages object dependencies, see "Managing Object Dependencies" on page 19-23.

## Analyzing Tables, Indexes, and Clusters

You can analyze a table, index, or cluster to gather data about it, or to verify the validity of its storage format.

These schema objects can also be analyzed to collect or update statistics about specific objects. When a DML statement is issued, the statistics for the referenced objects are used to determine the most efficient execution plan for the statement. This optimization is called "cost-based optimization." The statistics are stored in the data dictionary.

A table, index, or cluster can be analyzed to *validate* the structure of the object. 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 a schema object is corrupt, you can drop and re-create it.

A table or cluster can be analyzed to collect information about chained rows of the table or cluster. These results are useful in determining whether you have enough room for updates to rows. For example, this information can show whether PCTFREE is set appropriately for the table or cluster.

To analyze a table, cluster, or index, you must own the table, cluster, or index or have the ANALYZE ANY system privilege.

The following topics are discussed in this section:

- Using Statistics for Tables, Indexes, and Clusters
- Validating Tables, Indexes, and Clusters
- Listing Chained Rows of Tables and Clusters

For information specific to analyzing index-organized tables, see "Analyzing Index-Organized Tables" on page 13-24.

> **See Also:** For more information about analyzing tables, indexes, and clusters for performance statistics and the optimizer, see *Oracle8i Designing and Tuning for Performance.*

## Using Statistics for Tables, Indexes, and Clusters

Statistics about the physical storage characteristics of a table, index, or cluster can be gathered and stored in the data dictionary using the ANALYZE statement. Oracle can use these statistics when cost-based optimization is employed to choose the most efficient execution plan for SQL statements accessing analyzed objects. You can also use statistics generated by this statement to write efficient SQL statements that access analyzed objects.

You can choose either of the following clauses of the ANALYZE statement for gathering statistics:

- COMPUTE STATISTICS

  When computing statistics, an entire object is scanned to gather data about the object. This data is used by Oracle to compute exact statistics about the object. Slight variances throughout the object are accounted for in these computed statistics. Because an entire object is scanned to gather information for

computed statistics, the larger the size of an object, the more work that is required to gather the necessary information.

- ESTIMATE STATISTICS

  When estimating statistics, Oracle gathers representative information from portions of an object. This subset of information provides reasonable, estimated statistics about the object. The accuracy of estimated statistics depends upon how representative the sampling used by Oracle is. Only parts of an object are scanned to gather information for estimated statistics, so an object can be analyzed quickly. You can optionally specify the number or percentage of rows that Oracle should use in making the estimate.

> **Note:** When calculating statistics for tables or clusters, the amount of temporary space required to perform the calculation is related to the number of rows specified. For COMPUTE STATISTICS, enough temporary space to hold and sort the entire table plus a small overhead for each row is required. For ESTIMATE STATISTICS, enough temporary space to hold and sort the requested sample of rows plus a small overhead for each row is required. For indexes, no temporary space is required for analyzing.

### Computing Statistics Using the ANALYZE Statement

The following statement computes statistics for the EMP table:

```
ANALYZE TABLE emp COMPUTE STATISTICS;
```

The following query estimates statistics on the EMP table, using the default statistical sample of 1064 rows:

```
ANALYZE TABLE emp ESTIMATE STATISTICS;
```

To specify the statistical sample that Oracle should use, include the SAMPLE option with the ESTIMATE STATISTICS option. You can specify an integer that indicates either a number of rows or index values, or a percentage of the rows or index values in the table. The following statements show examples of each option:

```
ANALYZE TABLE emp
   ESTIMATE STATISTICS
      SAMPLE 2000 ROWS;

ANALYZE TABLE emp
   ESTIMATE STATISTICS
```

```
SAMPLE 33 PERCENT;
```

In either case, if you specify a percentage greater than 50, or a number of rows or index values that is greater than 50% of those in the object, Oracle computes the exact statistics, rather than estimating.

If the data dictionary currently contains statistics for the specified object when an ANALYZE statement is issued, the new statistics replace the old statistics in the data dictionary.

## What Statistics Are Gathered?

This section lists the statistics that are gathered for tables, indexes, and clusters.

> **Note:** The * symbol indicates that the numbers will always be an exact value when computing statistics.

### Table Statistics

- Number of rows
- Number of blocks that have been used *
- Number of blocks never used
- Average available free space
- Number of chained rows
- Average row length
- Number of distinct values in a column
- The low value in a column *
- The high value in a column *

> **Note:** Statistics for all indexes associated with a table are automatically gathered when the table is analyzed.

### Index Statistics

- Index level *
- Number of leaf blocks

- Number of distinct keys
- Average number of leaf blocks/key
- Average number of data blocks/key
- Clustering factor

> **Note:** You will receive an error if you use the ANALYZE statement on an index that has been marked unusable. When you analyze a table, Oracle also collect statistics for each of the table's indexes, so if any index has been marked unusable, you will receive an error. You must drop and recreate the index that has been marked unusable for the ANALYZE statement to succeed, or you can specify a for clause which causes analyze to skip collection of index statistics.

#### Cluster Statistics

The only statistic that can be gathered for a cluster is the average cluster key chain length; this statistic can be estimated or computed. Statistics for tables in a cluster and all indexes associated with the cluster's tables (including the cluster key index) are automatically gathered when the cluster is analyzed for statistics.

### Viewing Object Statistics

Whether statistics for an object are computed or estimated, the statistics are stored in the data dictionary. The statistics can be queried using the following data dictionary views:

| View | Description |
|---|---|
| USER_INDEXES<br>ALL_INDEXES<br>DBA_INDEXES | This view contains descriptions of indexes in the database, including the index statistics gathered by ANALYZE. The type of view (USER, ALL, DBA) determines which index entries are displayed. |
| USER_TABLES<br>ALL_TABLES<br>DBA_TABLES | This view contains descriptions of relational tables in the database, including the table statistics gathered by ANALYZE. |
| USER_TAB_COLUMNS<br>ALL_TAB_COLUMNS<br>DBA_TAB_COLUMNS | This view contains descriptions of columns for tables, views, and clusters in the database, including statistics gathered by ANALYZE. |

**Note:** Rows in these views contain entries in the statistics columns only for indexes, tables, and clusters for which you have gathered statistics. The entries are updated for an object each time you ANALYZE the object.

**See Also:** For more information about the data dictionary views containing statistics, see the *Oracle8i Reference.*

### Removing Statistics for a Schema Object

You can remove statistics for a table, index, or cluster from the data dictionary using the ANALYZE statement with the DELETE STATISTICS option. For example, you might want to delete statistics for an object if you do not want cost-based optimization to be used for statements regarding the object. The following statement deletes statistics for the EMP table from the data dictionary:

```
ANALYZE TABLE emp DELETE STATISTICS;
```

### Shared SQL and Analyzing Statistics

Analyzing a table, cluster, or index can affect current shared SQL statements, which are statements currently in the shared pool. Whenever an object is analyzed to update or delete statistics, all shared SQL statements that reference the analyzed object are flushed from memory so that the next execution of the statement can take advantage of the new statistics.

### Some Optional Means of Computing Statistics

There are some PL/SQL packages that allow you to effectively execute an ANALYZE statement. These are briefly discussed here.

**DBMS_STATS** This is a powerful package that 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 backed up.

For information about using the DBMS_STATS package, see *Oracle8i Designing and Tuning for Performance.* For a description of procedures, syntax and exceptions, see *Oracle8i Supplied PL/SQL Packages Reference.*

**DBMS_UTILITY** This package contains the ANALYZE_SCHEMA procedure that takes two arguments: the name of a schema and an analysis method ('COMPUTE', 'ESTIMATE', or 'DELETE'). It gathers statistics on all of the objects in the schema.

For information on the DBMS_UTILITY package, see *Oracle8i Supplied PL/SQL Packages Reference.*

**DBMS_DDL** This package contains the ANALYZE_OBJECT procedure that takes four arguments: the type of object ('CLUSTER', 'TABLE', or 'INDEX'), the schema of the object, the name of the object, and an analysis method ('COMPUTE', 'ESTIMATE', or 'DELETE'). It gathers statistics on the object.

For information on the DBMS_DDL package, see *Oracle8i Supplied PL/SQL Packages Reference.*

## Validating Tables, Indexes, and Clusters

To verify the integrity of the structure of a table, index, cluster, or snapshot, 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. If a table, index, or cluster is corrupt, you should drop it and re-create it. If a snapshot is corrupt, perform a complete refresh and ensure that you have remedied the problem; if not, drop and re-create the snapshot.

The following statement analyzes the EMP table:

```
ANALYZE TABLE emp VALIDATE STRUCTURE;
```

You can validate an object and all related objects by including the CASCADE option. The following statement validates the EMP table and all associated indexes:

```
ANALYZE TABLE emp VALIDATE STRUCTURE CASCADE;
```

## 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 option. The results of this statement are stored in a specified table created explicitly to accept the information returned by the LIST CHAINED ROWS option.

To create an appropriate table to accept data returned by an ANALYZE...LIST CHAINED ROWS statement, use the UTLCHAIN.SQL script provided with Oracle. The UTLCHAIN.SQL script creates a table named CHAINED_ROWS in the schema of the user submitting the script.

After a CHAINED_ROWS table is created, you can specify it when using 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:** The name and location of the UTLCHAIN.SQL script are operating system-dependent; see your operating system-specific Oracle documentation.
>
> For more information about reducing the number of chained and migrated rows in a table or cluster, see *Oracle8i Designing and Tuning for Performance.*

## 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, you may have 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 three options:

1. Using the DELETE statement

   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;
   ```

2. Using the DROP and CREATE statements

   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 ( . . . );
   ```

3. Using TRUNCATE

   You can delete all rows of the table using the SQL statement TRUNCATE. For example, the following statement truncates the EMP table:

   ```
   TRUNCATE TABLE emp;
   ```

### Using DELETE

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 rollback 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 wipe out the entire object.

### Using DROP and CREATE

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

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 rollback 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 the user's associated schema. Also, any user that 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 Chapter 24, "Auditing Database Use", for information about auditing.

A hash cluster cannot be truncated. Also, tables within a hash or index cluster cannot 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. Also note that the storage parameters for a truncated table, cluster, or associated indexes are not changed as a result of the truncation.

## 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 Oracle 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).

For a full list of statements and database events that will cause triggers to fire, see *Oracle8i SQL Reference.*

Triggers are created 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 will fire, 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.

Information on creating and using triggers is contained in *Oracle8i Application Developer's Guide - Fundamentals.*

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:** For a description of triggers, see *Oracle8i Concepts*.
>
> For syntax, restrictions, and specific authorization requirements for the SQL statements used to create and manage triggers, see *Oracle8i SQL Reference.*

## 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;
```

### Disabling Triggers

You may want to temporarily disable a trigger if one of the following conditions is true:

- An object that the trigger references is not available.
- You have to 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 following topics are included in this section:

- Integrity Constraint States
- Setting Integrity Constraints Upon Definition

- Modifying Existing Integrity Constraints
- Deferring Constraint Checks
- Managing Constraints That Have Associated Indexes
- Dropping Integrity Constraints
- Reporting Constraint Exceptions

> **See Also:** This book briefly discusses the concepts of constraints and identifies the SQL statements used to define and manage integrity constraints. For a more thorough discussion of integrity constraints, see *Oracle8i Concepts*. For detailed information and examples of using integrity constraints in applications, see *Oracle8i Application Developer's Guide - Fundamentals*.

## Integrity Constraint States

You may 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's rule 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 *Oracle8i SQL 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, you may wish to temporarily disable 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 bullets above.

### 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 19-21. All rows violating constraints will be put onto 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.

### Integrity Constraint States: Procedures and Benefits

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 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's definition, Oracle 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 of the table that violate the integrity constraint. The definition of the constraint is allowed because its rule is not enforced.

For information about constraint exceptions, see "Reporting Constraint Exceptions" on page 19-21.

### 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 may fail because rows of the table may violate the integrity constraint. In this case, the statement is rolled back and the constraint definition is not stored and not enabled.

To enable a UNIQUE key or PRIMARY KEY, which creates an associated index, the owner of the table also needs a quota for the tablespace intended to contain the index, or the UNLIMITED TABLESPACE system privilege.

## Modifying Existing Integrity Constraints

You can use the ALTER TABLE statement to enable, disable or modify a constraint.

### Disabling Enabled Constraints

The following statements disable integrity constraints:

```
ALTER TABLE dept
    DISABLE CONSTRAINT dname_ukey;

ALTER TABLE dept
    DISABLE PRIMARY KEY,
    DISABLE UNIQUE (dname, loc);
```

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;
```

## Deferring Constraint Checks

When Oracle 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.

---

**Note:** You cannot issue a SET CONSTRAINT statement inside a trigger.

---

### 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 will fail and the constraint causing the error will be identified. If you commit while constraints are violated, the transaction will be rolled back and you will receive an error message.

## Managing Constraints That Have Associated Indexes

When you create a UNIQUE or PRIMARY key, Oracle checks to see if an existing index can be used to enforce uniqueness for the constraint. If there is no such index, Oracle creates one.

When Oracle is using a unique index to enforce a constraint, and constraints associated with the unique index are dropped or disabled, the index is dropped.

While enabled foreign keys reference a PRIMARY or UNIQUE key, you cannot disable or drop the PRIMARY or UNIQUE key constraint or the index.

**Note:** Deferrable UNIQUE and PRIMARY keys all must use non-unique indexes.

## Dropping Integrity 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 the DROP clause. The following two statements drop integrity constraints:

```
ALTER TABLE dept
    DROP UNIQUE (dname, loc);

ALTER TABLE emp
```

```
DROP PRIMARY KEY,
DROP CONSTRAINT dept_fkey;
```

Dropping UNIQUE key and PRIMARY KEY constraints drops the associated unique indexes. Also, 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.

## 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.

You cannot use the CREATE TABLE statement to determine which rows are in violation. 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.

---

**Note:** 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 submitting the script UTLEXCPT.SQL, which creates a table named EXCEPTIONS. You can create additional exceptions tables with different names by modifying and resubmitting the script.

The exact name and location of the UTLEXCPT.SQL script is operating system specific. For more information, see your operating system-specific Oracle documentation.

---

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, the following rows might be placed in the table EXCEPTIONS by the previous statement:

```
SELECT * FROM exceptions;

ROWID                  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 example:

```
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 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, other users may issue statements creating new exceptions. You can avoid this by enable novalidating the constraint before you start eliminating exceptions.

---

**See Also:** For details about the EXCEPTIONS table, see *Oracle8i Reference.*

## Managing Object Dependencies

This section describes the various object dependencies, and includes the following topics:

- Manually Recompiling Views
- Manually Recompiling Procedures and Functions
- Manually Recompiling Packages

First, review Table 19–1, which shows how objects are affected by changes in other objects on which they depend.

***Table 19–1 Operations that Affect Object Status*** **(Page 1 of 2)**

| Operation | Resulting Status of Object | Resulting Status of Dependent Objects |
|---|---|---|
| CREATE table, sequence, synonym | VALID if there are no errors | No change[1] |
| ALTER table (ADD column MODIFY column)<br>RENAME table, sequence, synonym, view | VALID if there no errors | INVALID |
| DROP table, sequence, synonym, view, procedure, function, package | None; the object is dropped | INVALID |
| CREATE view, procedure[2] | VALID if there are no errors; INVALID if there are syntax or authorization errors | No change[1] |
| CREATE OR REPLACE view or procedure[2] | VALID if there are no error; INVALID if there are syntax or authorization errors | INVALID |

*Table 19–1 Operations that Affect Object Status* **(Page 2 of 2)**

| Operation | Resulting Status of Object | Resulting Status of Dependent Objects |
|---|---|---|
| REVOKE object privilege[3] ON objectTO / FROM user | No change | All objects of user that depend on object are INVALID[3] |
| REVOKE object privilege[3] ON object TO / FROM PUBLIC | No change | All objects in the database that depend on object are INVALID[3] |
| REVOKE system privilege[4] TO / FROM user | No change | All objects of user are INVALID[4] |
| REVOKE system privilege[4] TO / FROM PUBLIC | No change | All objects in the database are INVALID[4] |

[1] **May cause dependent objects to be made INVALID, if object did not exist earlier.**
[2] **Stand-alone procedures and functions, packages, and triggers.**
[3] **Only DML object privileges, including SELECT, INSERT, UPDATE, DELETE, and EXECUTE; revalidation does not require recompiling.**
[4] **Only DML system privileges, including SELECT, INSERT, UPDATE, DELETE ANY TABLE, and EXECUTE ANY PROCEDURE; revalidation does not require recompiling.**

Oracle automatically recompiles an invalid view or PL / SQL program unit the next time it is used. In addition, a user can force Oracle to recompile a view or program unit using the appropriate SQL statement with the COMPILE clause. Forced compilations are most often used to test for errors when a dependent view or program unit is invalid, but is not currently being used. In these cases, automatic recompilation would not otherwise occur until the view or program unit was executed. To identify invalid dependent objects, query the views USER_ / ALL_ / DBA_OBJECTS.

## Manually Recompiling Views

To recompile a view manually, you must have the ALTER ANY TABLE system privilege or the view must be contained in your schema. Use the ALTER VIEW statement with the COMPILE clause to recompile a view. The following statement recompiles the view EMP_DEPT contained in your schema:

```
ALTER VIEW emp_dept COMPILE;
```

### Manually Recompiling Procedures and Functions

To recompile a stand-alone procedure manually, you must have the ALTER ANY PROCEDURE system privilege or the procedure must be contained in your schema. Use the ALTER PROCEDURE/FUNCTION statement with the COMPILE clause to recompile a stand-alone procedure or function. The following statement recompiles the stored procedure UPDATE_SALARY contained in your schema:

```
ALTER PROCEDURE update_salary COMPILE;
```

### Manually Recompiling Packages

To recompile a package manually, you must have the ALTER ANY PROCEDURE system privilege or the package must be contained in your schema. Use the ALTER PACKAGE statement with the COMPILE clause to recompile either a package body or both a package specification and body. The following statements recompile just the body, and the body and specification of the package ACCT_MGMT, respectively:

```
ALTER PACKAGE acct_mgmt COMPILE BODY;
ALTER PACKAGE acct_mgmt COMPILE PACKAGE;
```

## Managing Object Name Resolution

This section describes how Oracle resolves an object name.

1. First, Oracle 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, Oracle 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. If no schema object is found in the current schema, Oracle 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. If no public synonym is found, Oracle 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 a object in the previously qualified schema or there is not a second piece, Oracle returns an error.

If no schema is found in Step c, the object cannot be qualified and Oracle 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 Oracle resolves the reference locally. For example, it resolves a synonym to a remote table's global object name. The partially resolved statement is shipped to the remote database, and the remote Oracle completes the resolution of the object as described here.

## Changing Storage Parameters for the Data Dictionary

This section describes aspects of changing data dictionary storage parameters, and includes the following topics:

- Structures in the Data Dictionary
- Errors that Require Changing Data Dictionary Storage

If your database is very large or contains an unusually large number of objects, columns in tables, constraint definitions, users, or other definitions, the tables that make up the data dictionary might at some point be unable to acquire additional extents. For example, a data dictionary table may need an additional extent, but there is not enough contiguous space in the SYSTEM tablespace. If this happens, you cannot create new objects, even though the tablespace intended to hold the objects seems to have sufficient space. To remedy this situation, you can change the storage parameters of the underlying data dictionary tables to allow them to be allocated more extents, in the same way that you can change the storage settings for user-created segments. For example, you can adjust the values of NEXT or PCTINCREASE for the data dictionary table.

**WARNING: Exercise caution when changing the storage settings for the data dictionary objects. If you choose inappropriate settings, you could damage the structure of the data dictionary and be forced to re-create your entire database. For example, if you set PCTINCREASE for the data dictionary table USER$ to 0 and NEXT to 2K, that table will quickly reach the maximum number of extents for a segment, and you will not be able to create any more users or roles without exporting, re-creating, and importing the entire database.**

## Structures in the Data Dictionary

The following tables and clusters contain the definitions of all the user-created objects in the database:

| | |
|---|---|
| SEG$ | Segments defined in the database (including temporary segments) |
| OBJ$ | User-defined objects in the database (including clustered tables); indexed by I_OBJ1 and I_OBJ2 |
| UNDO$ | Rollback segments defined in the database; indexed by I_UNDO1 |
| FET$ | Available free extents not allocated to any segment |
| UET$ | Extents allocated to segments |
| TS$ | Tablespaces defined in the database |
| FILE$ | Files that make up the database; indexed by I_FILE1 |
| FILEXT$ | Datafiles with the AUTOEXTEND option set on |
| TAB$ | Tables defined in the database (includes clustered tables); indexed by I_TAB1 |
| CLU$ | Clusters defined in the database |
| IND$ | Indexes defined in the database; indexed by I_IND1 |
| ICOL$ | Columns that have indexes defined on them (includes individual entries for each column in a composite index); indexed by I_ICOL1 |
| COL$ | Columns defined in tables in the database; indexed by I_COL1 and I_COL2 |

| | |
|---|---|
| CON$ | Constraints defined in the database (includes information on constraint owner); indexed by I_CON1 and I_CON2 |
| CDEF$ | Definitions of constraints in CON$; indexed by I_CDEF1, I_CDEF2, and I_CDEF3 |
| CCOL$ | Columns that have constraints defined on them (includes individual entries for each column in a composite key); indexed by I_CCOL1 |
| USER$ | Users and roles defined in the database; indexed by I_USER1 |
| TSQ$ | Tablespace quotas for users (contains one entry for each tablespace quota defined for each user) |
| C_OBJ# | Cluster containing TAB$, CLU$, ICOL$, IND$, and COL$: indexed by I_OBJ# |
| C_TS# | Cluster containing FET$, TS$, and FILE$; indexed by I_TS# |
| C_USER# | Cluster containing USER and TSQ$$; indexed by I_USER# |
| C_COBJ# | Cluster containing CDEF$ and CCOL$; indexed by I_COBJ# |

Of all of the data dictionary segments, the following are the most likely to require change:

| | |
|---|---|
| C_TS# | If the free space in your database is very fragmented |
| C_OBJ# | If you have many indexes or many columns in your tables |
| CON$, C_COBJ# | If you use integrity constraints heavily |
| C_USER# | If you have a large number of users defined in your database |

For the clustered tables, you must change the storage settings for the cluster, not for the table.

## Errors that Require Changing Data Dictionary Storage

Oracle returns an error if a user tries to create a new object that requires Oracle to allocate an additional extent to the data dictionary when it is unable to allocate an extent. The error message ORA-1653, "failed to allocate extent of size *num* in tablespace '*name*'" indicates this kind of problem.

If you receive this error message and the segment you were trying to change (such as a table or rollback segment) has not reached the limits specified for it in its definition, check the storage settings for the object that contains its definition.

For example, if you received an ORA-1547 while trying to define a new PRIMARY KEY constraint on a table and there is sufficient space for the index that Oracle must create for the key, check if CON$ or C_COBJ# cannot be allocated another extent; to do this, query DBA_SEGMENTS and consider changing the storage parameters for CON$ or C_COBJ#.

For more information, see "Example 7: Displaying Segments that Cannot Allocate Additional Extents" on page 19-33.

## Displaying Information About Schema Objects

The data dictionary provides many views about the schema objects described in this book. The following list summarizes the views associated with schema objects:

- ALL_OBJECTS, USER_OBJECTS, DBA_OBJECTS
- ALL_CATALOG, USER_CATALOG, DBA_CATALOG
- ALL_TABLES, USER_TABLES, DBA_TABLES
- ALL_TAB_COLUMNS, USER_TAB_COLUMNS, DBA_TAB_COLUMNS
- ALL_TAB_COMMENTS, USER_TAB_COMMENTS
- ALL_COL_COMMENTS, USER_COL_COMMENTS, DBA_COL_COMMENTS
- ALL_VIEWS, USER_VIEWS, DBA_VIEWS
- ALL_INDEXES, USER_INDEXES, DBA_INDEXES
- ALL_IND_COLUMNS, USER_IND_COLUMNS, DBA_IND_COLUMNS
- USER_CLUSTERS, DBA_CLUSTERS
- USER_CLU_COLUMNS, DBA_CLU_COLUMNS
- ALL_SEQUENCES, USER_SEQUENCES, DBA_SEQUENCES
- ALL_SYNONYMS, USER_SYNONYMS, DBA_SYNONYMS
- ALL_DEPENDENCIES, USER_DEPENDENCIES, DBA_DEPENDENCIES

The following data dictionary views contain information about the segments of a database:

- USER_SEGMENTS

- DBA_SEGMENTS

The following data dictionary views contain information about a database's extents:

- USER_EXTENTS
- DBA_EXTENTS
- USER_FREE_SPACE
- DBA_FREE_SPACE

Additionally, the following Oracle supplied PL/SQL packages provide information about space usage and free blocks in objects:

| Package and Procedure | 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 blocks in an object (table, index, or cluster). |

The following examples demonstrate ways to display miscellaneous schema objects.

> **See Also:** For a complete description of data dictionary views, see *Oracle8i Reference.*
>
> For a description of PL/SQL packages, see *Oracle8i Supplied PL/SQL Packages Reference.*

## 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;

OBJECT_NAME                    OBJECT_TYPE
-------------------------  -------------------
EMP_DEPT                       CLUSTER
EMP                            TABLE
DEPT                           TABLE
EMP_DEPT_INDEX                 INDEX
PUBLIC_EMP                     SYNONYM
EMP_MGR                        VIEW
```

## Example 2: 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_default
    FROM user_tab_columns
    WHERE table_name = 'DEPT' OR table_name = 'EMP';

TABLE_NAME   COLUMN_NAME   DATA_DEFAULT
----------   ------------- --------------------
DEPT         DEPTNO
DEPT         DNAME
DEPT         LOC           'NEW YORK'
EMP          EMPNO
EMP          ENAME
EMP          JOB
EMP          MGR
EMP          HIREDATE       SYSDATE
EMP          SAL
EMP          COMM
EMP          DEPTNO
```

Notice that not all columns have user-specified defaults. These columns automatically have NULL as the default.

## Example 3: 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/USER/DBA_DEPENDENCIES data dictionary views can be used to reveal the dependencies for a view and the ALL/USER/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 the user JWARD:

```
SELECT table_owner, table_name, synonym_name
    FROM sys.dba_synonyms
    WHERE owner = 'JWARD';


TABLE_OWNER            TABLE_NAME   SYNONYM_NAME
---------------------  -----------  -----------------
SCOTT                  DEPT         DEPT
```

```
SCOTT                    EMP          EMP
```

## Example 4: Displaying General Segment Information

The following query returns the name of each rollback segment, the tablespace that contains each, and the size of each rollback segment:

```
SELECT segment_name, tablespace_name, bytes, blocks, extents
    FROM sys.dba_segments
    WHERE segment_type = 'ROLLBACK';

SEGMENT_NAME  TABLESPACE_NAME   BYTES       BLOCKS     EXTENTS
------------  ---------------   ---------   -------    ---------
RS1           SYSTEM              20480        10           2
RS2           TS1                 40960        20           3
SYSTEM        SYSTEM             184320        90           3
```

## Example 5: Displaying General Extent Information

General 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 associated with rollback segments and the size of each of those extents:

```
SELECT segment_name, bytes, blocks
    FROM sys.dba_extents
    WHERE segment_type = 'ROLLBACK';

SEGMENT_NAME      BYTES          BLOCKS
---------------   ---------      --------
RS1                   10240            5
RS1                   10240            5
SYSTEM                51200           25
SYSTEM                51200           25
SYSTEM                51200           25
```

Notice that the RS1 rollback segment is comprised of two extents, both 10K, while the SYSTEM rollback segment is comprised of three equally sized extents of 50K.

## Example 6: Displaying the Free Space (Extents) of a Database

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 via free extents in each tablespace:

```
SELECT tablespace_name, file_id, bytes, blocks
    FROM sys.dba_free_space;

TABLESPACE_NAME        FILE_ID     BYTES       BLOCKS
------------------     ---------   --------    ----------
SYSTEM                       1    8120320          3965
SYSTEM                       1      10240             5
TS1                          2   10432512          5094
```

## Example 7: Displaying Segments that Cannot Allocate Additional Extents

You can also use DBA_FREE_SPACE, in combination with the views DBA_SEGMENTS, DBA_TABLES, DBA_CLUSTERS, DBA_INDEXES, and DBA_ROLLBACK_SEGS, to determine if any other segment is unable to allocate additional extents for data dictionary objects only.

A segment may not 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, as recorded in the data dictionary (in SEG.MAX_EXTENTS).
- The segment has the maximum number of extents allowed by the data block size, which is operating system specific.

> **Note:** While the STORAGE clause value for MAXEXTENTS can be UNLIMITED, data dictionary tables cannot have MAXEXTENTS greater than the allowed block maximum. Thus, data dictionary tables cannot be converted to unlimited format.

The following query returns the names, owners, and tablespaces of all segments that fit any of the above criteria:

```
SELECT seg.owner, seg.segment_name,
       seg.segment_type, seg.tablespace_name,
       DECODE(seg.segment_type,
        'TABLE', t.next_extent,
        'CLUSTER', c.next_extent,
        'INDEX', i.next_extent,
```

```
    'ROLLBACK', r.next_extent)
FROM sys.dba_segments seg,
     sys.dba_tables t,
     sys.dba_clusters c,
     sys.dba_indexes i,
     sys.dba_rollback_segs r
WHERE ((seg.segment_type = 'TABLE'
     AND seg.segment_name = t.table_name
     AND seg.owner = t.owner
     AND NOT EXISTS (SELECT tablespace_name
         FROM dba_free_space free
         WHERE free.tablespace_name = t.tablespace_name
         AND free.bytes >= t.next_extent))
OR (seg.segment_type = 'CLUSTER'
     AND seg.segment_name = c.cluster_name
     AND seg.owner = c.owner
     AND NOT EXISTS (SELECT tablespace_name
         FROM dba_free_space free
         WHERE free.tablespace_name = c.tablespace_name
         AND free.bytes >= c.next_extent))
OR (seg.segment_type = 'INDEX'
     AND seg.segment_name = i.index_name
     AND seg.owner = i.owner
     AND NOT EXISTS (SELECT tablespace_name
         FROM dba_free_space free
         WHERE free.tablespace_name = i.tablespace_name
         AND free.bytes >= i.next_extent))
OR (seg.segment_type = 'ROLLBACK'
     AND seg.segment_name = r.segment_name
     AND seg.owner = r.owner
     AND NOT EXISTS (SELECT tablespace_name
         FROM dba_free_space free
         WHERE free.tablespace_name = r.tablespace_name
     AND free.bytes >= r.next_extent)))
OR seg.extents = seg.max_extents
OR seg.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 datafiles to the tablespace.
- If the segment has too many extents, and you cannot increase MAXEXTENTS for the segment, perform the following steps: first, export the data in the segment; second, drop and re-create the segment, giving it a larger INITIAL setting so that it does not need to allocate so many extents; and third, import the data back into the segment.

# 20

# Addressing Data Block Corruption

This chapter explains using the DBMS_REPAIR PL/SQL package to repair data block corruption in database schema objects. It includes 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, it is recommended that you work with an Oracle Worldwide Support analyst when performing any of the repair procedures included in this package.

# Options for Repairing Data Block Corruption

Oracle 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, another option is to rebuild the table by selecting all data except for the corrupt rows.

Yet 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. Using this approach, you can address corruptions where possible, and also 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. Hence, DBMS_REPAIR is not a magic wand—you must still determine whether the repair approach provided by this package is the appropriate tool for each specific corruption problem. Depending on the nature of the repair, you might lose data and logical inconsistencies can be introduced; therefore you need to weigh the gains and losses associated with using DBMS_REPAIR.

---

# About the DBMS_REPAIR Package

This section describes the DBMS_REPAIR procedures contained in the package and notes some limitations and restrictions on their use.

**See Also:** For a complete description of the DBMS_REPAIR Package and its procedures, see the *Oracle8i Supplied PL/SQL Packages Reference.*

## DBMS_REPAIR Procedures

Below are the procedures that make up the DBMS_REPAIR package.

| Procedure Name | Description |
|---|---|
| CHECK_OBJECT | Detects and reports corruptions in a table or index. |
| FIX_CORRUPT_BLOCKS | Marks blocks (that were previously identified by the CHECK_OBJECT procedure) as corrupt. |

| Procedure Name | Description |
|---|---|
| DUMP_ORPHAN_KEYS | Reports index entries that point to rows in corrupt data blocks. |
| REBUILD_FREELISTS | Rebuilds an object's free lists. |
| 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. |
| ADMIN_TABLES | Provides administrative functions (create, drop, purge) for DBMS_REPAIR repair and orphan key tables.<br>**Note:** These tables are always created in the SYS schema. |

These procedures are further described, with examples of their use, in "DBMS_ REPAIR Examples" on page 20-8.

## Limitations and Restrictions

DBMS_REPAIR procedures have the following limitations:

- Tables with LOBs, 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, at most, 3,950 bytes long.

# Using the DBMS_REPAIR Package

The following staged approach is recommended when considering DBMS_REPAIR for addressing data block corruption:

Stage 1: Detect and Report Corruptions

Stage 2: Evaluate the Costs and Benefits of Using DBMS_REPAIR

Stage 3: Make Objects Usable

Stage 4: Repair Corruptions and Rebuild Lost Data

These stages are discussed in succeeding sections.

## Stage 1: Detect and Report Corruptions

Your first task, before using DBMS_REPAIR, should be the detection and reporting of corruptions. Reporting not only indicates what is wrong with a block, but also identifies the associated repair directive. You have several options, in addition to DBMS_REPAIR, for detecting corruptions. Table 20–1 describes the different detection methodologies.

***Table 20–1 Comparison of Corruption Detection Methods***

| Detection Method | Description |
|---|---|
| DBMS_REPAIR | Performs block checking for a specified table, partition or index. Populates a repair table with results. |
| DB_VERIFY | External command-line utility that performs block checking on an offline database. |
| ANALYZE | Used with the VALIDATE STRUCTURE option, verifies the integrity of the structure of an index, table or cluster; checks or verifies that your tables and indexes are in sync. |
| DB_BLOCK_CHECKING | Performed when the initialization parameter DB_BLOCK_CHECKING=TRUE. Identifies corrupt blocks before they actually 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 respectively.

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 problems reported.

### DB_VERIFY: Performing an Offline Database Check

Typically, you use DB_VERIFY as an offline diagnostic utility when you encounter data corruption problems.

> **See Also:** For more information about DB_VERIFY, see *Oracle8i Utilities.*

### ANALYZE: Corruption Reporting

The ANALYZE TABLE...VALIDATE STRUCTURE statement validates the structure of the analyzed object. If Oracle successfully validates the structure, a message confirming its validation is returned to you. If Oracle encounters corruption in the structure of the object, an error message is returned to you. In this case, you would drop and re-create the object.

> **See Also:** For more information about the ANALYZE statement, see the *Oracle8i SQL Reference.*

### DB_BLOCK_CHECKING (Block Checking Initialization Parameter)

You can set block checking for instances via the DB_BLOCK_CHECKING initialization parameter (the default value is FALSE); this checks data and index blocks 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:** For more information about the DB_BLOCK_CHECKING initialization parameter, see the *Oracle8i Reference.*

## Stage 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.

A first step is to answer the following questions:

1. 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.

2. What other options are available for addressing block corruptions?

Assuming the data is available from another source, drop, re-create and re-populate the object. Another option is to issue the CREATE TABLE...AS SELECT statement from the corrupt table to create a new one.

You can ignore the corruption by excluding corrupt rows from select statements.

You can perform media recovery.

3. What logical corruptions or side effects will be introduced when you use DBMS_REPAIR to make an object usable? Can these be addressed? What is the effort required to do so?

   You may not have access to rows in blocks marked corrupt. However, a block may be marked corrupt even though there are still rows that you can validly access.

   Referential integrity constraints may be broken when blocks are marked corrupt. If this occurs, disable and re-enable the constraint; any inconsistencies will be reported. After fixing all issues, you should be able to successfully re-enable the constraint.

   Logical corruption may occur when there are triggers defined on the table. For example, if rows are re-inserted, should insert triggers be fired or not? You can address these issues only if you understand triggers and their use in your installation.

   Free list blocks may be inaccessible. If a corrupt block is at the head or tail of a free list, space management reinitializes the free list. There then may be blocks that should be on a free list, that aren't. You can address this by running the REBUILD_FREELISTS procedure.

   Indexes and tables may be out of sync. You can address this by first executing 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 get the table and its indexes back in sync.

4. 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. Of course, retrieving data in this manner depends on the amount of redundancy between the indexes and the table.

## Stage 3: Make Objects Usable

In this stage 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 make a corrupt object usable by establishing an environment that skips corruptions that remain outside the scope of DBMS_REPAIR's 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 will skip blocks marked corrupt for the object. When skip 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 out of sync, then a SET TRANSACTION READ ONLY transaction may be inconsistent in situations where one query probes only the index, and then a subsequent query probes both the index and the table. If the table block is marked corrupt, then the two queries will return different results, thereby breaking the rules of a read-only transaction. One way to approach this is to not skip corruptions when in a SET TRANSACTION READ ONLY transaction.

A similar issue occurs when selecting rows that are chained. Essentially, a query of the same row may or may not access the corruption—thereby giving different results.

## Stage 4: Repair Corruptions and Rebuild Lost Data

After making an object usable, you can 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.

### Repair Free Lists Using the REBUILD_FREELISTS Procedure

When a block marked "corrupt" is found at the head or tail of a free list, the free list is reinitialized and an error is returned. Although this takes the offending block off the free list, it causes you to lose free list access to all blocks that followed the corrupt block.

You can use the REBUILD_FREELISTS procedure to reinitialize the free lists. The object is scanned, and if it is appropriate for a block to be on the free list, it is added to the master free list. Free list groups are handled by meting out the blocks in an equitable fashion, a block at a time. Any blocks marked "corrupt" in the object are ignored during the rebuild.

## DBMS_REPAIR Examples

In this section, examples are presented reflecting the use of the DBMS_REPAIR procedures.

- Using ADMIN_TABLES to Build a Repair Table or Orphan Key Table
- Using the CHECK_OBJECT Procedure to Detect Corruption
- Fixing Corrupt Blocks with the FIX_CORRUPT_BLOCKS Procedure
- Finding Index Entries Pointing into Corrupt Data Blocks: DUMP_ORPHAN_KEYS
- Rebuilding Free Lists Using the REBUILD_FREELISTS Procedure
- Enabling or Disabling the Skipping of Corrupt Blocks: SKIP_CORRUPT_BLOCKS

> **See Also:** For more information on the syntax, restrictions, and exceptions for the DBMS_REPAIR procedures, see *Oracle8i Supplied PL/SQL Packages Reference.*

### Using ADMIN_TABLES to Build a Repair Table or Orphan Key Table

A repair table provides the interface to users as to what corruptions 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.

The ADMIN_TABLE procedure is used to create, purge, or drop a repair table or an orphan key table.

### Creating a Repair Table

The following example creates a repair table.

```
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, but is prefixed by DBA_ (for example DBA_REPAIR_TABLE or DBA_ORPHAN_KEY_TABLE).

The following query describes the repair table created in the previous example.

```
SQL> 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
```

### Creating an Orphan Key Table

This example illustrates the creation of an orphan key table.

```
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:

```
SQL> 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
```

## Using the CHECK_OBJECT Procedure to Detect Corruption

The CHECK_OBJECT procedure checks the specified objects, 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 would like 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 will be skipped.

Here is an example of executing the CHECK_OBJECT procedure.

```
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 will produce 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
```

At this point, 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.

## Fixing Corrupt Blocks with the FIX_CORRUPT_BLOCKS Procedure

Use the FIX_CORRUPT_BLOCKS procedure to fix the corrupt blocks in specified objects based on information in the repair table that was previously generated by the CHECK_OBJECT procedure. Prior to effecting any change to a block, the block is checked to ensure 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 fix 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
```

To 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
```

## Finding Index Entries Pointing into Corrupt Data Blocks: DUMP_ORPHAN_KEYS

The DUMP_ORPHAN_KEYS procedure reports on index entries that point to rows in corrupt data blocks. For each such index entry encountered, a row is inserted into the specified orphan key table. The orphan key table must have been previously created.

If the repair table is specified, then any corrupt blocks associated with the base table are handled in addition to all data blocks that are marked software corrupt. Otherwise, only blocks that are marked corrupt are handled.

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 line is output, indicating there are three orphan keys:

```
orphan key count: 3
```

Index entries in the orphan key table implies that the index should be rebuilt to guarantee the a table probe and an index probe return the same result set.

## Rebuilding Free Lists Using the REBUILD_FREELISTS Procedure

The REBUILD_FREELISTS procedure rebuilds the free lists for the specified object. All free blocks are placed on the master free list. All other free lists are zeroed. If the object has multiple free list groups, then the free blocks are distributed among all free lists, allocating to the different groups in round-robin fashion.

This example rebuilds the free lists for the table SCOTT.DEPT.

```
BEGIN
DBMS_REPAIR.REBUILD_FREELISTS (
     SCHEMA_NAME => 'SCOTT',
     OBJECT_NAME => 'DEPT',
     OBJECT_TYPE => dbms_repair.table_object);
END;
/
```

## Enabling or Disabling the Skipping of Corrupt Blocks: SKIP_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, skip 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 V

# Database Security

Part V addresses issues of user and privilege management affecting the security of the database. It includes the following chapters:

- Chapter 21, "Establishing Security Policies"
- Chapter 22, "Managing Users and Resources"
- Chapter 23, "Managing User Privileges and Roles"
- Chapter 24, "Auditing Database Use"

# 21

# Establishing Security Policies

This chapter provides guidelines for developing security policies for database operation, and includes the following topics:

- System Security Policy
- Data Security Policy
- User Security Policy
- Password Management Policy
- Auditing Policy

# System Security Policy

This section describes aspects of system security policy, and includes the following topics:

- Database User Management
- User Authentication
- Operating System Security

Each database has one or more administrators who are responsible for maintaining all aspects of the security policy: the security administrators. If the database system is small, the database administrator may have the responsibilities of the security administrator. However, if the database system is large, a special person or group of people may have responsibilities limited to those of a security administrator.

After deciding who will manage the security of the system, a security policy must be developed for every database. A database's security policy should include several sub-policies, as explained in the following sections.

## Database User Management

Database users are the access paths to the information in an Oracle database. Therefore, tight security should be maintained for the management of database users. Depending on the size of a database system and the amount of work required to manage database users, the security administrator may be the only user with the privileges required to create, alter, or drop database users. On the other hand, there may be a number of administrators with privileges to manage database users. Regardless, only trusted individuals should have the powerful privileges to administer database users.

## User Authentication

Database users can be *authenticated* (verified as the correct person) by Oracle using database passwords, the host operating system, network services, or by Secure Sockets Layer (SSL).

---

**Note:** To be authenticated using network authentication services or SSL, requires that you have installed Oracle Advanced Security. Refer to the *Oracle Advanced Security Administrator's Guide* for information about these types of authentication.

---

For more information about user authentication and how it is specified, see "User Authentication" on page 22-7.

## Operating System Security

If applicable, the following security issues must also be considered for the operating system environment executing Oracle and any database applications:

- Database administrators must have the operating system privileges to create and delete files.
- Typical database users should not have the operating system privileges to create or delete files related to the database.
- If the operating system identifies database roles for users, the security administrators must have the operating system privileges to modify the security domain of operating system accounts.

> **See Also:** For more information about operating system security issues for Oracle databases, see your operating system-specific Oracle documentation.

# Data Security Policy

*Data security* includes the mechanisms that control the access to and use of the database at the object level. Your data security policy determines which users have access to a specific schema object, and the specific types of actions allowed for each user on the object. For example, user SCOTT can issue SELECT and INSERT statements but not DELETE statements using the EMP table. Your data security policy should also define the actions, if any, that are audited for each schema object.

Your data security policy will be determined primarily by the level of security you wish to establish for the data in your database. For example, it may be acceptable to have little data security in a database when you wish to allow any user to create any schema object, or grant access privileges for their objects to any other user of the system. Alternatively, it might be necessary for data security to be very controlled when you wish to make a database or security administrator the only person with the privileges to create objects and grant access privileges for objects to roles and users.

Overall data security should be based on the sensitivity of data. If information is not sensitive, then the data security policy can be more lax. However, if data is sensitive, a security policy should be developed to maintain tight control over access to objects.

Some means of implementing data security include system and object privileges, and through roles. A role is a set of privileges grouped together that can be granted to users. Privileges and roles are discussed in Chapter 23, "Managing User Privileges and Roles".

Views can also implement data security because their definition can restrict access to table data. They can exclude columns containing sensitive data. Views are discussed in Chapter 18, "Managing Views, Sequences and Synonyms".

Another means of implementing data security is through fine-grained access control and use of an associated application context. Fine-grained access control is a feature of Oracle that allows you to implement security policies with functions, and to associate those security policies with tables or views. In effect, the security policy function generates a WHERE condition that is appended to a SQL statement, thereby restricting the users access to rows of data in the table or view. An application context is a secure data cache for storing information used to make access control decisions.

> **See Also:** For information about implementing fine-grained access control and an application context, see *Oracle8i Application Developer's Guide - Fundamentals* and *Oracle8i Supplied PL/SQL Packages Reference*.

# User Security Policy

This section describes aspects of user security policy, and includes the following topics:

- General User Security
- End-User Security
- Administrator Security
- Application Developer Security
- Application Administrator Security

## General User Security

For all types of database users, consider the following general user security issues:

- Password Security
- Privilege Management

### Password Security

If user authentication is managed by the database, security administrators should develop a password security policy to maintain database access security. For example, database users should be required to change their passwords at regular intervals, and of course, when their passwords are revealed to others. By forcing a user to modify passwords in such situations, unauthorized database access can be reduced.

To better protect the confidentiality of your password, Oracle can be configured to use encrypted passwords for client/server and server/server connections.

> **Note:** It is *strongly* recommended that you configure Oracle to encrypt passwords in client/server and server/server connections. Otherwise, a malicious user "snooping" on the network can grab an unencrypted password, and use it to connect to the database as another user, thereby "impersonating" that user.

By setting the following values, you can require that the password used to verify a connection always be encrypted:

- Set the ORA_ENCRYPT_LOGIN environment variable to TRUE on the client machine.
- Set the DBLINK_ENCRYPT_LOGIN server initialization parameter to TRUE.

If enabled at both the client and server, passwords will not be sent across the network "in the clear", but will be encrypted using a modified DES (Data Encryption Standard) algorithm.

The DBLINK_ENCRYPT_LOGIN initialization parameter is used for connections between two Oracle servers (for example, when performing distributed queries). If you are connecting from a client, Oracle checks the ORA_ENCRYPT_LOGIN environment variable.

Whenever you attempt to connect to a server using a password, Oracle encrypts the password before sending it to the server. If the connection fails and auditing is enabled, the failure is noted in the audit log. Oracle then checks the appropriate DBLINK_ENCRYPT_LOGIN or ORA_ENCRYPT_LOGIN value. If it set to FALSE, Oracle attempts the connection again using an unencrypted version of the password. If the connection is successful, the connection replaces the previous failure in the audit log, and the connection proceeds. To prevent malicious users from forcing Oracle to re-attempt a connection with an unencrypted version of the password, you must set the appropriate values to TRUE.

### Privilege Management

Security administrators should consider issues related to privilege management for all types of users. For example, in a database with many usernames, it may be beneficial to use roles (which are named groups of related privileges that you grant to users or other roles) to manage the privileges available to users. Alternatively, in a database with a handful of usernames, it may be easier to grant privileges explicitly to users and avoid the use of roles.

Security administrators managing a database with many users, applications, or objects should take advantage of the benefits offered by roles. Roles greatly simplify the task of privilege management in complicated environments.

## End-User Security

Security administrators must also define a policy for end-user security. If a database is large with many users, the security administrator can decide what groups of users can be categorized, create user roles for these user groups, grant the necessary privileges or application roles to each user role, and assign the user roles to the users. To account for exceptions, the security administrator must also decide what privileges must be explicitly granted to individual users.

### Using Roles for End-User Privilege Management

Roles are the easiest way to grant and manage the common privileges needed by different groups of database users.

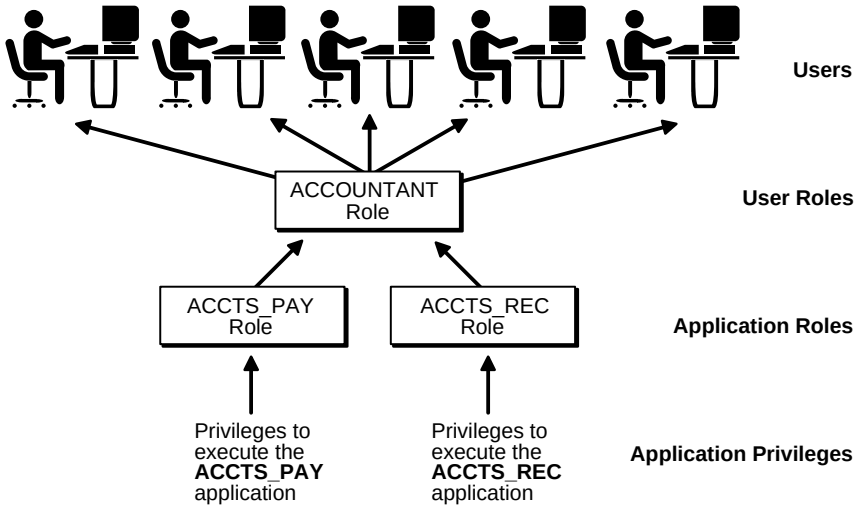
Consider a situation where every user in the accounting department of a company needs the privileges to run the ACCTS_RECEIVABLE and ACCTS_PAYABLE database applications. Roles are associated with both applications, and contain the object privileges necessary to execute those applications.

The following actions, performed by the database or security administrator, address this simple security situation:

1. Create a role named ACCOUNTANT.
2. Grant the roles for the ACCTS_RECEIVABLE and ACCTS_PAYABLE database applications to the ACCOUNTANT role.
3. Grant each user of the accounting department the ACCOUNTANT role.

This security model is illustrated in Figure 21–1.

***Figure 21–1 User Role***




This plan addresses the following potential situations:

- If accountants subsequently need a role for a new database application, that application's role can be granted to the ACCOUNTANT role, and all users in the accounting department will automatically receive the privileges associated with the new database application. The application's role does not need to be granted to individual users requiring use of the application.
- Similarly, if the accounting department no longer requires the need for a specific application, the application's role can be dropped from the ACCOUNTANT role.
- If the privileges required by the ACCTS_RECEIVABLE or ACCTS_PAYABLE applications change, the new privileges can be granted to, or revoked from, the application's role. The security domain of the ACCOUNTANT role, and all users granted the ACCOUNTANT role automatically reflect the privilege modification.

When possible, utilize roles in all possible situations to make end-user privilege management efficient and simple.

### Using a Directory Service for End-User Privilege Management

You can also manage users and their authorizations centrally, in a directory service, through the enterprise user and enterprise role features of Oracle Advanced

Security. See *Oracle Advanced Security Administrator's Guide* for information about this functionality.

## Administrator Security

Security administrators should have a policy addressing administrator security. For example, when the database is large and there are several types of database administrators, the security administrator may decide to group related administrative privileges into several administrative roles. The administrative roles can then be granted to appropriate administrator users. Alternatively, when the database is small and has only a few administrators, it may be more convenient to create one administrative role and grant it to all administrators.

### Protection for Connections as SYS and SYSTEM

After database creation, *immediately* change the passwords for the administrative SYS and SYSTEM usernames to prevent unauthorized access to the database. Connecting as SYS and SYSTEM gives a user the powerful privileges to modify a database in many ways. Connecting as SYS allows a user to alter data dictionary tables. Therefore, privileges for these usernames are extremely sensitive, and should only be available to select database administrators.

The passwords for these accounts can be modified using the procedures described in "Altering Users" on page 22-18.

### Protection for Administrator Connections

Only database administrators should have the capability to connect to a database with administrator privileges (for example, `connect as SYSDBA/SYSOPER`). Connecting as SYSOPER gives a user the ability to perform basic operational tasks (such as startup, shutdown, and recover); connecting as SYSDBA gives the user these abilities plus unrestricted privileges to do anything to a database or the objects within a database (such as create, drop, and delete). Connecting as SYSDBA places a user in the SYS schema, where they can alter data dictionary tables

### Using Roles for Administrator Privilege Management

Roles are the easiest way to restrict the powerful system privileges and roles required by personnel administrating of the database.

Consider a scenario where the database administrator responsibilities at a large installation are shared among several database administrators, each responsible for the following specific database management jobs:

- An administrator responsible for object creation and maintenance
- An administrator responsible for database tuning and performance
- A security administrator responsible for creating new users, granting roles and privileges to database users
- A database administrator responsible for routine database operation (for example, startup, shutdown, backup)
- An administrator responsible for emergency situations, such as database recovery
- New, inexperienced database administrators needing limited capabilities to experiment with database management

In this scenario, the security administrator should structure the security for administrative personnel as follows:

1. Six roles should be defined to contain the distinct privileges required to accomplish each type of job (for example, DBA_OBJECTS, DBA_TUNE, DBA_SECURITY, DBA_MAINTAIN, DBA_RECOV, DBA_NEW).
2. Each role is granted the appropriate privileges.
3. Each type of database administrator can be granted the corresponding role.

This plan diminishes the likelihood of future problems in the following ways:

- If a database administrator's job description changes to include more responsibilities, that database administrator can be granted other administrative roles corresponding to the new responsibilities.
- If a database administrator's job description changes to include fewer responsibilities, that database administrator can have the appropriate administrative roles revoked.
- The data dictionary always stores information about each role and each user, so information is available to disclose the task of each administrator.

## Application Developer Security

Security administrators must define a special security policy for the application developers using a database. A security administrator may grant the privileges to create necessary objects to application developers. Alternatively, the privileges to create objects may only be granted to a database administrator, who receives requests for object creation from developers.

### Application Developers and Their Privileges

Database application developers are unique database users who require special groups of privileges to accomplish their jobs. Unlike end users, developers need system privileges, such as CREATE TABLE, CREATE PROCEDURE, and so on. However, only specific system privileges should be granted to developers to restrict their overall capabilities in the database.

### The Application Developer's Environment: Test and Production Databases

In many cases, application development is restricted to test databases and not allowed on production databases. This restriction ensures that application developers do not compete with end users for database resources, and that they cannot detrimentally affect a production database.

After an application has been thoroughly developed and tested, it is permitted access to the production database and made available to the appropriate end users of the production database.

### Free Versus Controlled Application Development

The database administrator can define the following options when determining which privileges should be granted to application developers:

| | |
|---|---|
| Free Development | An application developer is allowed to create new schema objects, including tables, indexes, procedures, packages, and so on. This option allows the application developer to develop an application independent of other objects. |
| Controlled Development | An application developer is not allowed to create new schema objects. All required tables, indexes, procedures, and so on are created by a database administrator, as requested by an application developer. This option allows the database administrator to completely control a database's space usage and the access paths to information in the database. |

Although some database systems use only one of these options, other systems could mix them. For example, application developers can be allowed to create new stored procedures and packages, but not allowed to create tables or indexes. A security administrator's decision regarding this issue should be based on the following:

- The control desired over a database's space usage

- The control desired over the access paths to schema objects
- The database used to develop applications—if a test database is being used for application development, a more liberal development policy would be in order

### Roles and Privileges for Application Developers

Security administrators can create roles to manage the privileges required by the typical application developer. For example, a typical role named APPLICATION_DEVELOPER might include the CREATE TABLE, CREATE VIEW, and CREATE PROCEDURE system privileges. Consider the following when defining roles for application developers:

- CREATE system privileges are usually granted to application developers so that they can create their own objects. However, CREATE ANY system privileges, which allow a user to create an object in any user's schema, are not usually granted to developers. This restricts the creation of new objects only to the developer's user account.
- Object privileges are rarely granted to roles used by application developers. This is often impractical because granting object privileges via roles often restricts their usability in the creation of other objects (primarily views and stored procedures). It is more practical to allow application developers to create their own objects for development purposes.

### Space Restrictions Imposed on Application Developers

While application developers are typically given the privileges to create objects as part of the development process, security administrators must maintain limits on what and how much database space can be used by each application developer. For example, as the security administrator, you should specifically set or restrict the following limits for each application developer:

- The tablespaces in which the developer can create tables or indexes
- The quota for each tablespace accessible to the developer

Both limitations can be set by altering a developer's security domain. This is discussed in "Altering Users" on page 22-18.

## Application Administrator Security

In large database systems with many database applications (for example, precompiler and Forms applications), you might want to have application

administrators. An application administrator is responsible for the following types of tasks:

- Creating roles for an application and managing the privileges of each application role
- Creating and managing the objects used by a database application
- Maintaining and updating the application code and Oracle procedures and packages, as necessary

Often, an application administrator is also the application developer who designed the application. However, these jobs might not be the responsibility of the developer and can be assigned to another individual familiar with the database application.

# Password Management Policy

Database security systems depend on passwords being kept secret at all times. Still, passwords are vulnerable to theft, forgery, and misuse. To allow for greater control over database security, Oracle's password management policy is controlled by DBAs.

- Password Aging and Expiration
- Password History
- Password Complexity Verification

## Account Locking

When a particular user exceeds a designated number of failed login attempts, the server automatically locks that user's account. DBAs specify the permissible number of failed login attempts using the CREATE PROFILE statement. DBAs also specify the amount of time accounts remain locked.

In the following example, the maximum number of failed login attempts for the user ASHWINI is 4, and the amount of time the account will remain locked is 30 days; the account will unlock automatically after the passage of 30 days.

```
CREATE PROFILE prof LIMIT
    FAILED_LOGIN_ATTEMPTS 4
    PASSWORD_LOCK_TIME 30;
ALTER USER ashwini PROFILE prof;
```

If the DBA does not specify a time interval for unlocking the account, PASSWORD_LOCK_TIME assumes the value specified in a default profile (see "Creating Profiles" on page 22-22). If the DBA specifies PASSWORD_LOCK_TIME as UNLIMITED, then the system security officer must explicitly unlock the account.

After a user successfully logs into an account, that user's unsuccessful login attempt count, if there is one, is reset to 0.

The security officer can also explicitly lock user accounts. When this occurs, the account cannot be unlocked automatically; only the security officer should unlock the account.

> **See Also:** For more information about the CREATE PROFILE statement, see the *Oracle8i SQL Reference*.

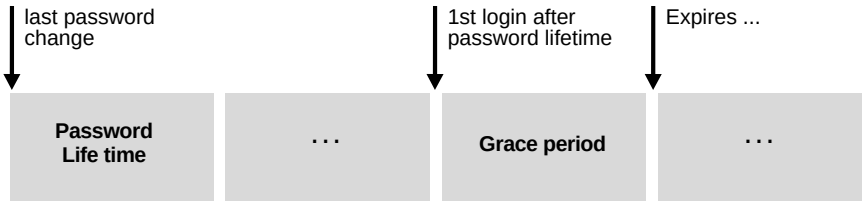
## Password Aging and Expiration

DBAs use the CREATE PROFILE statement to specify a maximum lifetime for passwords. When the specified amount of time passes and the password expires, the user or DBA must change the password. The following statement indicates that ASHWINI can use the same password for 90 days before it expires:

```
CREATE PROFILE prof LIMIT
   FAILED_LOGIN_ATTEMPTS 4
   PASSWORD_LOCK_TIME 30
   PASSWORD_LIFE_TIME 90;
ALTER USER ashwini PROFILE prof;
```

DBAs can also specify a grace period using the CREATE PROFILE statement. Users enter the grace period upon the first attempt to log in to a database account after their password has expired. During the grace period, a warning message appears each time users try to log in to their accounts, and continues to appear until the grace period expires. Users must change the password within the grace period. If the password is not changed within the grace period, the account expires and no further logins to that account are allowed until the password is changed. Figure 21–2 shows the chronology of the password lifetime and grace period.

***Figure 21–2 Chronology of Password Lifetime and Grace Period***




For example, the lifetime of a password is 60 days, and the grace period is 3 days. If the user tries to log in on *any* day after the 60th day (this could be the 70th day, 100th day, or another; the point here is that it is the first login attempt after the password lifetime), that user receives a warning message indicating that the password is about to expire in 3 days. If the user does not change the password within three days from the first day of the grace period, the user's account expires. The following statement indicates that the user must change the password within 3 days of its expiration:

```
CREATE PROFILE prof LIMIT
   FAILED_LOGIN_ATTEMPTS 4
   PASSWORD_LOCK_TIME 30
   PASSWORD_GRACE_TIME 3;
ALTER USER ashwini PROFILE prof;
```

The security officer can also explicitly expire the account. This is particularly useful for new accounts.

## Password History

DBAs use the CREATE PROFILE statement to specify a time interval during which users cannot reuse a password.

In the following statement, the DBA indicates that the user cannot reuse her password for 60 days.

```
CREATE PROFILE prof LIMIT
   PASSWORD_REUSE_TIME 60
   PASSWORD_REUSE_MAX UNLIMITED;
```

The next statement shows that the number of password changes the user must make before her current password can be used again is 3.

```
CREATE PROFILE prof LIMIT
   PASSWORD_REUSE_MAX 3
```

```
PASSWORD_REUSE_TIME UNLIMITED;
```

> **Note:** If you specify PASSWORD_REUSE_TIME or PASSWORD_REUSE_MAX, you must set the other to UNLIMITED or not specify it at all.

## Password Complexity Verification

Oracle's password complexity verification routine can be specified using a PL/SQL script (UTLPWDMG.SQL), which sets the default profile parameters.

The password complexity verification routine performs the following checks:

- The password has a minimum length of 4.
- The password is not the same as the userid.
- The password has at least one alpha, one numeric, and one punctuation mark.
- The password does not match simple words like welcome, account, database, or user.
- The password differs from the previous password by at least 3 letters.

> **Note:** Oracle recommends that you do not change passwords using the ALTER USER statement because it does not fully support the password verification function. Instead, you should use OCIPasswordChange() to change passwords.

### Password Verification Routine Formatting Guidelines

DBAs can enhance the existing password verification complexity routine or create their own password verification routines using PL/SQL or third-party tools.

The DBA-authored PL/SQL call must adhere to the following format:

```
routine_name (
userid_parameter IN VARCHAR(30),
password_parameter IN VARCHAR (30),
old_password_parameter IN VARCHAR (30)
)
RETURN BOOLEAN
```

After a new routine is created, it must be assigned as the password verification routine using the user's profile or the system default profile.

```
CREATE/ALTER PROFILE profile_name LIMIT
PASSWORD_VERIFY_FUNCTION routine_name
```

The password verify routine must be owned by SYS.

The following sample script sets default password resource limits and provides minimum checking of password complexity. You can use this sample script as a model when developing your own complexity checks for a new password.

This script sets the default password resource parameters, and must be run to enable the password features. However, you can change the default resource parameters if necessary.

The default password complexity function performs the following minimum complexity checks:

- The password satisfies minimum length requirements.
- The password is not the username. You can modify this function based on your requirements.

This function must be created in SYS schema, and you must `connect sys/<password> AS sysdba` before running the script.

```
CREATE OR REPLACE FUNCTION verify_function
(username varchar2,
   password varchar2,
   old_password varchar2)
   RETURN boolean IS
   n boolean;
   m integer;
   differ integer;
   isdigit boolean;
   ischar  boolean;
   ispunct boolean;
   digitarray varchar2(20);
   punctarray varchar2(25);
   chararray varchar2(52);

BEGIN
   digitarray:= '0123456789';
   chararray:= 'abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ';
   punctarray:='!"#$%&()''*+,-/:;<=>?_';
```

```
--Check if the password is same as the username
IF password = username THEN
   raise_application_error(-20001, 'Password same as user');
END IF;

--Check for the minimum length of the password
IF length(password) < 4 THEN
   raise_application_error(-20002, 'Password length less than 4');
END IF;

--Check if the password is too simple. A dictionary of words may be
--maintained and a check may be made so as not to allow the words
--that are too simple for the password.
IF NLS_LOWER(password) IN ('welcome', 'database', 'account', 'user',
   'password', 'oracle', 'computer', 'abcd')
   THEN raise_application_error(-20002, 'Password too simple');
END IF;

--Check if the password contains at least one letter,
--one digit and one punctuation mark.
--1. Check for the digit
--You may delete 1. and replace with 2. or 3.
isdigit:=FALSE;
m := length(password);
FOR i IN 1..10 LOOP
  FOR j IN 1..m LOOP
    IF substr(password,j,1) = substr(digitarray,i,1) THEN
      isdigit:=TRUE;
        GOTO findchar;
    END IF;
   END LOOP;
END LOOP;
IF isdigit = FALSE THEN
  raise_application_error(-20003, 'Password should contain at least one \
  digit, one character and one punctuation');
END IF;
--2. Check for the character

<<findchar>>
ischar:=FALSE;
FOR i IN 1..length(chararray) LOOP
  FOR j IN 1..m LOOP
    IF substr(password,j,1) = substr(chararray,i,1) THEN
       ischar:=TRUE;
         GOTO findpunct;
```

```
       END IF;
    END LOOP;
END LOOP;
IF ischar = FALSE THEN
  raise_application_error(-20003, 'Password should contain at least one digit,\
    one character and one punctuation');
END IF;
--3. Check for the punctuation

<<findpunct>>
ispunct:=FALSE;
FOR i IN 1..length(punctarray) LOOP
  FOR j IN 1..m LOOP
    IF substr(password,j,1) = substr(punctarray,i,1) THEN
       ispunct:=TRUE;
         GOTO endsearch;
       END IF;
   END LOOP;
END LOOP;
IF ispunct = FALSE THEN raise_application_error(-20003, 'Password should \
 contain at least one digit, one character and one punctuation');
END IF;

<<endsearch>>
--Check if the password differs from the previous password by at least 3 letters
IF old_password = '' THEN
  raise_application_error(-20004, 'Old password is null');
END IF;
--Everything is fine; return TRUE ;
differ := length(old_password) - length(password);
IF abs(differ) < 3 THEN
  IF length(password) < length(old_password) THEN
    m := length(password);
  ELSE
    m:= length(old_password);
  END IF;
  differ := abs(differ);
  FOR i IN 1..m LOOP
    IF substr(password,i,1) != substr(old_password,i,1) THEN
             differ := differ + 1;
    END IF;
  END LOOP;
  IF differ < 3 THEN
    raise_application_error(-20004, 'Password should differ by at \
      least 3 characters');
```

```
    END IF;
  END IF;
--Everything is fine; return TRUE ;
  RETURN(TRUE);
END;
```

## Auditing Policy

Security administrators should define a policy for the auditing procedures of each database. You may, for example, decide to have database auditing disabled unless questionable activities are suspected. When auditing is required, the security administrator must decide what level of detail to audit the database; usually, general system auditing is followed by more specific types of auditing after the origins of suspicious activity are determined. Auditing is discussed in Chapter 24, "Auditing Database Use".

# 22

# Managing Users and Resources

This chapter describes how to control access to an Oracle database, and includes the following topics:

- Session and User Licensing
- User Authentication
- Oracle Users
- Managing Resources with Profiles
- Listing Information About Database Users and Profiles
- Examples

For guidelines on establishing security policies for users and profiles, see Chapter 21, "Establishing Security Policies".

Privileges and roles control the access a user has to a database and the schema objects within the database. For information on privileges and roles, see Chapter 23, "Managing User Privileges and Roles".

# Session and User Licensing

Oracle helps you ensure that your site complies with its Oracle Server license agreement. If your site is licensed by concurrent usage, you can track and limit the number of sessions concurrently connected to a database. If your site is licensed by named users, you can limit the number of named users created in a database. In either case, you control the licensing facilities, and must enable the facilities and set the appropriate limits. You do this by setting the following initialization parameters in your initialization parameter file:

- LICENSE_MAX_SESSIONS
- LICENSE_SESSIONS_WARNING
- LICENSE_MAX_USERS

These initialization parameters are discussed in succeeding sections.

To use the licensing facility, you need to know which type of licensing agreement your site has, and what the maximum number of sessions or named users is. Your site may use either type of licensing (concurrent usage or named user), but not both.

---

**Note:** In a few cases, a site might have an unlimited license, rather than concurrent usage or named user licensing. In these cases only, leave the licensing mechanism disabled, and omit LICENSE_MAX_SESSIONS, LICENSE_SESSIONS_WARNING, and LICENSE_MAX_USERS from the initialization parameter file, or set the value of all three to 0.

---

This section describes aspects of session and user licensing, and includes the following topics:

- Concurrent Usage Licensing
- Named User Limits
- Viewing Licensing Limits and Current Values

**See Also:** For the description and syntax of the LICENSE_MAX_SESSIONS, LICENSE_SESSIONS_WARNING, and LICENSE_MAX_USERS initialization parameters, see the *Oracle8i Reference*.

## Concurrent Usage Licensing

Concurrent usage licensing limits the number of sessions that can be connected simultaneously to the database on the specified computer. You can set a limit on the number of concurrent sessions before you start an instance. In fact, you should have set this limit as part of the initial installation procedure as described in Chapter 2, "Creating an Oracle Database". You can also change the maximum number of concurrent sessions while the database is running.

### Connecting Privileges

After your instance's session limit is reached, only users with RESTRICTED SESSION privilege (usually DBAs) can connect to the database. When a user with RESTRICTED SESSION privileges connects, Oracle sends the user a message indicating that the maximum limit has been reached, and writes a message to the ALERT file. When the maximum is reached, you should connect only to terminate unneeded processes. For information about terminating sessions, see "Terminating Sessions" on page 4-20.

Do not raise the licensing limits unless you have upgraded your Oracle license agreement.

In addition to setting a maximum concurrent session limit, you can set a warning limit on the number of concurrent sessions. After this limit is reached, additional users can continue to connect (up to the maximum limit); however, Oracle writes an appropriate message to the ALERT file with each connection, and sends each connecting user who has the RESTRICTED SESSION privilege a warning indicating that the maximum is about to be reached.

If a user is connecting with administrator privileges, the limits still apply; however, Oracle enforces the limit after the first statement the user executes.

In addition to enforcing the concurrent usage limits, Oracle tracks the highest number of concurrent sessions for each instance. You can use this "high water mark"; it may help you determine if your Oracle license needs to be reviewed. For information about Oracle licensing limit upgrades, see "Viewing Licensing Limits and Current Values" on page 22-6.

For instances running with the Parallel Server, each instance can have its own concurrent usage limit and warning limit. However, the sum of the instances' limits must not exceed the site's concurrent usage license.

**WARNING: Sessions that connect to Oracle through multiplexing software or hardware (such as a TP monitor) each contribute individually to the concurrent usage limit. However, the Oracle licensing mechanism cannot distinguish the number of sessions connected this way. If your site uses multiplexing software or hardware, you must consider that and set the maximum concurrent usage limit lower to account for the multiplexed sessions.**

**See Also:** For more information about setting and changing limits in a parallel server environment, see *Oracle8i Parallel Server Administration, Deployment, and Performance.*

### Setting the Maximum Number of Sessions

To set the maximum number of concurrent sessions for an instance, set the LICENSE_MAX_SESSIONS initialization parameter. This example sets the maximum number of concurrent sessions to 80.

```
LICENSE_MAX_SESSIONS = 80
```

If you set this limit, you are not required to set a warning limit (LICENSE_SESSIONS_WARNING). However, using the warning limit makes the maximum limit easier to manage, because it gives you advance notice that your site is nearing maximum use.

### Setting the Session Warning Limit

To set the warning limit for an instance, set the LICENSE_SESSIONS_WARNING initialization parameter in the parameter file used to start the instance.

Set the session warning to a value lower than the concurrent usage maximum limit (LICENSE_MAX_SESSIONS).

### Changing Concurrent Usage Limits While the Database is Running

To change either the maximum concurrent usage limit or the warning limit while the database is running, use the ALTER SYSTEM statement with the appropriate option. The following statement changes the maximum limit to 100 concurrent sessions:

```
ALTER SYSTEM SET LICENSE_MAX_SESSIONS = 100;
```

The following statement changes both the warning limit and the maximum limit:

```
ALTER SYSTEM
   SET LICENSE_MAX_SESSIONS = 64
   LICENSE_SESSIONS_WARNING = 54;
```

If you change either limit to a value lower than the current number of sessions, the current sessions remain; however, the new limit is enforced for all future connections until the instance is shut down. To change the limit permanently, change the value of the appropriate parameter in the initialization parameter file.

To change the concurrent usage limits while the database is running, you must have the ALTER SYSTEM privilege. Also, to connect to an instance after the instance's maximum limit has been reached, you must have the RESTRICTED SESSION privilege.

**WARNING: Do not raise the concurrent usage limits unless you have appropriately upgraded your Oracle Server license. Contact your Oracle representative for more information.**

**See Also:** For more information about using the ALTER SYSTEM statement to change the value of initialization parameters see *Oracle8i SQL Reference.*

## Named User Limits

Named user licensing limits the number of individuals authorized to use Oracle on the specified computer. To enforce this license, you can set a limit on the number of users created in the database before you start an instance. You can also change the maximum number of users while the instance is running, or disable the limit altogether. You cannot create more users after reaching this limit. If you try to do so, Oracle returns an error indicating that the maximum number of users have been created, and writes a message to the ALERT file.

This mechanism operates on the assumption that each person accessing the database has a unique username, and that there are no shared usernames. Do not allow multiple users to connect using the same username.

### Setting User Limits

To limit the number of users created in a database, set the LICENSE_MAX_USERS parameter in the database's parameter file. The following example sets the maximum number of users to 200:

```
LICENSE_MAX_USERS = 200
```

If the database contains more than LICENSE_MAX_USERS when you start it, Oracle returns a warning and writes an appropriate message in the ALERT file. You cannot create additional users until the number of users drops below the limit or until you delete users or upgrade your Oracle license.

> **See Also:** For instances running with the Parallel Server, all instances connected to the same database should have the same named user limit. See *Oracle8i Parallel Server Administration, Deployment, and Performance.*

### Changing User Limits

To change the maximum named users limit, use the ALTER SYSTEM statement with the LICENSE_MAX_USERS option. The following statement changes the maximum number of defined users to 300:

```
ALTER SYSTEM SET LICENSE_MAX_USERS = 300;
```

If you try to change the limit to a value lower than the current number of users, Oracle returns an error and continues to use the old limit. If you successfully change the limit, the new limit remains in effect until you shut down the instance; to change the limit permanently, change the value of LICENSE_MAX_USERS in the parameter file.

To change the maximum named users limit, you must have the ALTER SYSTEM privilege.

> **WARNING: Do not raise the named user limit unless you have appropriately upgraded your Oracle license. Contact your Oracle representative for more information.**

## Viewing Licensing Limits and Current Values

You can see the current limits of all of the license settings, the current number of sessions, and the maximum number of concurrent sessions for the instance by querying the V$LICENSE data dictionary view. You can use this information to

determine if you need to upgrade your Oracle license to allow more concurrent sessions or named users:

```
SELECT sessions_max s_max,
   sessions_warning s_warning,
   sessions_current s_current,
   sessions_highwater s_high,
   users_max
   FROM v$license;

S_MAX    S_WARNING   S_CURRENT    S_HIGH    USERS_MAX
-------  ----------  -----------  --------  ----------
    100          80           65        82          50
```

In addition, Oracle writes the session high water mark to the database's ALERT file when the database shuts down, so you can check for it there.

To see the current number of named users defined in the database, use the following query:

```
SELECT COUNT(*) FROM dba_users;

COUNT(*)
----------
       174
```

> **See Also:** For a complete description of the V$LICENSE view, see the *Oracle8i Reference.*

## User Authentication

Depending on how you want user identities to be authenticated, there are several ways to define users before they are allowed to create a database session:

1. You can define users such that the database performs both identification and authentication of users. This is called *database authentication*.
2. You can define users such that authentication is performed by the operating system or network service. This is called *external authentication*.
3. You can define users such that they are authenticated by SSL (Secure Sockets Layer). These users are called *global users.* For global users, an enterprise directory can be used to authorize their access to the database through *global roles*.

4. You can specify users who are allowed to connect through a proxy server. This is called multi-tier authentication and authorization.

These types of authentication are discussed in the following sections:

- Database Authentication
- External Authentication
- Global Authentication and Authorization
- Multi-Tier Authentication and Authorization

Other attributes to consider when creating users for your database are discussed later in "Oracle Users" on page 22-14.

## Database Authentication

If you choose database authentication for a user, administration of the user account, password, and authentication of that user is performed entirely by Oracle. To have Oracle authenticate a user, specify a password for the user when you create or alter the user. Users can change their password at any time. Passwords are stored in an encrypted format. Each password must be made up of single-byte characters, even if your database uses a multi-byte character set.

To enhance security when using database authentication, Oracle recommends the use of password management, including account locking, password aging and expiration, password history, and password complexity verification. Oracle password management is discussed in Chapter 21, "Establishing Security Policies".

### Creating a User Who is Authenticated by the Database

The following statement creates a user who is identified and authenticated by Oracle. User SCOTT must specify the password TIGER whenever connecting to Oracle.

```
CREATE USER scott IDENTIFIED BY tiger;
```

> **See Also:** For more information about valid passwords, and how to specify the IDENTIFIED BY clause, in the CREATE USER and ALTER USER statements, see *Oracle8i SQL Reference*.

### Advantages of Database Authentication

Following are advantages of database authentication:

- User accounts and all authentication are controlled by the database. There is no reliance on anything outside of the database.
- Oracle provides strong password management features to enhance security when using database authentication.
- It is easier to administer when there are small user communities.

## External Authentication

When you choose external authentication for a user, the user account is maintained by Oracle, but password administration and user authentication is performed by an external service. This external service can be the operating system or a network service, such as Net8.

With external authentication, your database relies on the underlying operating system or network authentication service to restrict access to database accounts. A database password is not used for this type of login. If your operating system or network service permits, you can have it authenticate users. If you do so, set the initialization parameter OS_AUTHENT_PREFIX, and use this prefix in Oracle usernames. The OS_AUTHENT_PREFIX parameter defines a prefix that Oracle adds to the beginning of every user's operating system account name. Oracle compares the prefixed username with the Oracle usernames in the database when a user attempts to connect.

For example, assume that OS_AUTHENT_PREFIX is set as follows:

```
OS_AUTHENT_PREFIX=OPS$
```

If a user with an operating system account named TSMITH is to connect to an Oracle database and be authenticated by the operating system, Oracle checks that there is a corresponding database user OPS$TSMITH and, if so, allows the user to connect. All references to a user authenticated by the operating system must include the prefix, as seen in OPS$TSMITH.

The default value of this parameter is OPS$ for backward compatibility with previous versions of Oracle. However, you might prefer to set the prefix value to some other string or a null string (an empty set of double quotes: ""). Using a null string eliminates the addition of any prefix to operating system account names, so that Oracle usernames exactly match operating system usernames.

After you set OS_AUTHENT_PREFIX, it should remain the same for the life of a database. If you change the prefix, any database username that includes the old prefix cannot be used to establish a connection, unless you alter the username to have it use password authentication.

### Creating a User Who is Authenticated Externally

The following statement creates a user who is identified by Oracle and authenticated by the operating system or a network service. This example assumes that OS_AUTHENT_PREFIX = "".

```
CREATE USER scott IDENTIFIED EXTERNALLY;
```

Using CREATE USER...IDENTIFIED EXTERNALLY, you create database accounts that must be authenticated via the operating system or network service. Oracle relies on this external login authentication to ensure that a specific operating system user has access to a specific database user.

> **See Also:** The text of the OS_AUTHENT_PREFIX parameter is case sensitive on some operating systems. See your operating system-specific Oracle documentation for more information about this initialization parameter.
>
> For more information on external authentication, see *Oracle Advanced Security Administrator's Guide* and *Oracle8i Distributed Database Systems.*

### Operating System Authentication

By default, Oracle only allows operating system authenticated logins over secure connections. Therefore, if you want the operating system to authenticate a user, by default that user cannot connect to the database over Net8. This means the user cannot connect using a multi-threaded server, since this connection uses Net8. This default restriction prevents a remote user from impersonating another operating system user over a network connection.

If you are not concerned about remote users impersonating another operating system user over a network connection, and you want to use operating system user authentication with network clients, set the parameter REMOTE_OS_AUTHENT (default is FALSE) to TRUE in the database's initialization parameter file. Setting the initialization parameter REMOTE_OS_AUTHENT to TRUE allows the RDBMS to accept the client operating system username received over a non-secure connection and use it for account access. The change will take effect the next time you start the instance and mount the database.

Generally, user authentication via the host operating system offers the following benefits:

- Users can connect to Oracle faster and more conveniently without specifying a separate database username or password.

- User entries in the database and operating system audit trails correspond.

### Network Authentication

Network authentication is performed using Oracle Advanced Security, which may be configured to use a third party service such as Kerberos. If you are using Oracle Advanced Security as your only external authentication service, the setting of the parameter REMOTE_OS_AUTHENT is irrelevant, since Oracle Advanced Security only allows secure connections.

### Advantages of External Authentication

Following are advantages of external authentication:

- More choices of authentication mechanism are available, such as smart cards, fingerprints, Kerberos, or the operating system.
- Many network authentication services, such as Kerberos and DCE, support single signon. This means that users have fewer passwords to remember.
- If you are already using some external mechanism for authentication, such as one of those listed above, there may be less administrative overhead to use that mechanism with the database as well.

## Global Authentication and Authorization

Oracle Advanced Security allows you to centralize management of user-related information, including authorizations, in an LDAP-based directory service. Users can be identified in the database as *global users*, meaning that they are authenticated by SSL and that the management of these users is done outside of the database by the centralized directory service. *Global roles* are defined in a database and are known only to that database, but authorizations for such roles is done by the directory service.

---

**Note:** You can also have users authenticated by SSL, whose authorizations are not managed in a directory; that is, they have local database roles only. See the *Oracle Advanced Security Administrator's Guide* for details.

---

This centralized management enables the creation of *enterprise users* and *enterprise roles*. Enterprise users are defined and managed in the directory. They have unique identities across the enterprise, and can be assigned enterprise roles that determine

their access privileges across multiple databases. An enterprise role consists of one or more global roles, and might be thought of as a container for global roles.

### Creating a User Who is Authorized by a Directory Service

You have a couple of options as to how you specify users who are authorized by a directory service.

**Creating a Global User** The following statement illustrates the creation of a global user, who is authenticated by SSL and authorized by the enterprise directory service:

```
CREATE USER scott
    IDENTIFIED GLOBALLY AS 'CN=scott,OU=division1,O=oracle,C=US'
```

The string provided in the AS clause provides an identifier meaningful to the enterprise directory (DN, or *distinquished name*).

In this case, SCOTT is truly a global user. But, the downside here, is that user SCOTT must then be created in every database that he must access, plus the directory.

**Creating a Schema-Independent User** Creating schema-independent users allows multiple enterprise users to access a shared schema in the database. A schema-independent user is:

- Authenticated by SSL
- *Not* created in the database with a CREATE USER statement of any type
- A user whose privileges are managed in a directory
- A user who connects to a shared schema

The process of creating a schema-independent user is as follows:

1. Create a shared schema in the database as follows.

   ```
   CREATE USER appschema INDENTIFIED GLOBALLY AS '';
   ```

2. In the directory, you now create multiple enterprise users, and a mapping object.

   The mapping object tells the database how you want to map users' DNs to the shared schema. You can either do a full DN mapping (one directory entry for each unique DN), or you can map, for example, every user containing the following DN components to the APPSCHEMA:

```
OU=division,O=Oracle,C=US
```

See the *Oracle Internet Directory Administrator's Guide* for an explanation of these mappings.

Most users do not need their own schemas, and implementing schema-independent users divorces users from databases. You create multiple users who share the same schema in a database, and as enterprise users, they can access shared schemas in other databases as well.

### Advantages of Global Authentication and Global Authorization

Some of the advantages of global user authentication and authorization are the following:

- Provides strong authentication using SSL or NT native authentication.
- Enables centralized management of users and privileges across the enterprise.
- Is easy to administer—for every user you do not have to create a schema in every database in the enterprise.
- Facilitates single signon—users only need to sign on once to access multiple databases and services.
- CURRENT_USER database links connect 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.

**See Also:** For more information on global authentication and authorization, and enterprise users and roles, refer to the following books:

- *Oracle Advanced Security Administrator's Guide*
- *Oracle8i Distributed Database Systems*
- *Oracle Internet Directory Administrator's Guide*

## Multi-Tier Authentication and Authorization

It is possible to design an application server (middle tier) to proxy clients in a secure fashion. It is not necessary for the application server to know a clients's password in order to connect on behalf of the client. As long as the client authenticates itself with the middle tier and the middle tier authenticates itself with the database, and the middle tier is authorized to act on behalf of the client by the administrator, client

identities can be maintained all the way into the database without compromising the security of the client.

The application server must be designed for this functionality. OCI (Oracle Call Interface) provides this capability, which is discussed in *Oracle Call Interface Programmer's Guide.*

To authorize an application server to proxy a client you use the GRANT CONNECT THROUGH clause of the ALTER USER statement. You can also specify roles that the application server is permitted to activate when connecting as the client. The following example authorizes the application server APPSERVE to connect as user BILL, and allows APPSERVE to activate all roles associated with BILL, except PAYROLL.

```
ALTER USER bill
    GRANT CONNECT THROUGH appserv
    WITH ROLE ALL EXCEPT payroll;
```

You use the REVOKE CONNECT THROUGH clause to disallow a proxy connection.

The PROXY_USERS view can be queried to see which users are currently authorized to connect through a proxy.

Operations done on behalf of a client by an application server can be audited. See "Auditing in a Multi-Tier Environment" on page 24-11.

> **See Also:** For more information on multi-tier authentication and authorization, see *Oracle8i Concepts* and *Oracle8i Application Developer's Guide - Fundamentals.*
>
> For a description and syntax of the *proxy clause* of ALTER USER, see *Oracle8i SQL Reference.*

## Oracle Users

Each Oracle database has a list of valid database users. To access a database, a user must run a database application and connect to the database instance using a valid username defined in the database. This section explains how to manage users for a database, and includes the following topics:

- Creating Users
- Altering Users
- Dropping Users

**See Also:** For more information on the SQL statements for managing users, as presented in succeeding sections, see the *Oracle8i SQL Reference*.

## Creating Users

To create a database user, you must have the CREATE USER system privilege. When creating a new user, tablespace quotas can be specified for tablespaces in the database, even if the creator does not have a quota on a specified tablespace. Because it is a powerful privilege, a security administrator is normally the only user who has the CREATE USER system privilege.

You create a user with the SQL statement CREATE USER. The following example creates a user and specifies that user's password, default tablespace, temporary tablespace where temporary segments are created, tablespace quota, and profile.

```
CREATE USER jward
    IDENTIFIED BY AIRPLANE
    DEFAULT TABLESPACE data_ts
    TEMPORARY TABLESPACE temp_ts
    QUOTA 100M ON test_ts
    QUOTA 500K ON data_ts
    PROFILE clerk;
GRANT connect TO jward;
```

A newly created user cannot connect to the database until granted the CREATE SESSION system privilege. Usually, a newly created user is granted a role, similar to the predefined roll CONNECT, as shown in this example, that specifies the CREATE SESSION and other basic privileges required to access a database. See "Granting System Privileges and Roles" on page 23-10 for specific information.

### Specifying a Name

Within each database a username must be unique with respect to other usernames and roles; a user and role cannot have the same name. Furthermore, each user has an associated schema. Within a schema, each schema object must have a unique name.

### Setting a User's Authentication

In the previous CREATE USER statement, the new user is to be authenticated using the database. In this case, the connecting user must supply the correct password to the database to connect successfully.

The methods of specifying the type of user authentication were discussed earlier in "User Authentication" on page 22-7.

### Assigning a Default Tablespace

Each user should have a default tablespace. When a user creates a schema object and specifies no tablespace to contain it, Oracle stores the object in the user's default tablespace.

The default setting for every user's default tablespace is the SYSTEM tablespace. If a user does not create objects, this default setting is fine. However, if a user creates any type of object, consider specifically setting the user's default tablespace. You can set a user's default tablespace during user creation, and change it later. Changing the user's default tablespace affects only objects created after the setting is changed.

Consider the following issues when deciding which tablespace to specify:

- Set a user's default tablespace only if the user has the privileges to create objects (such as tables, views, and clusters).
- Set a user's default tablespace to a tablespace for which the user has a quota.
- If possible, set a user's default tablespace to a tablespace other than the SYSTEM tablespace to reduce contention between data dictionary objects and user objects for the same datafiles.

In the previous CREATE USER statement, JWARD's default tablespace is DATA_TS.

### Assigning a Temporary Tablespace

Each user also should be assigned a temporary tablespace. When a user executes a SQL statement that requires a temporary segment, Oracle stores the segment in the user's temporary tablespace. You do not set a quota for temporary tablespaces. These temporary segments are created by the system when doing sorts or joins and are owned by SYS, which has resource privileges in all tablespaces.

If a user's temporary tablespace is not explicitly set, the default is the SYSTEM tablespace. Setting each user's temporary tablespace reduces file contention among temporary segments and other types of segments, as the temporary tablespace is used exclusively for temporary segments. You can set a user's temporary tablespace at user creation, and change it later.

In the previous CREATE USER statement, JWARD's temporary tablespace is TEMP_TS, a tablespace created explicitly to only contain temporary segments.

### Assigning Tablespace Quotas

You can assign each user a tablespace quota for any tablespace, but quotas are not necessary for a temporary tablespace. Assigning a quota does two things:

- Users with privileges to create certain types of objects can create those objects in the specified tablespace.
- Oracle limits the amount of space that can be allocated for storage of a user's objects within the specified tablespace to the amount of the quota.

By default, a user has no quota on any tablespace in the database. If the user has the privilege to create a schema object, you must assign a quota to allow the user to create objects. Minimally, assign users a quota for the default tablespace, and additional quotas for other tablespaces in which they will create objects.

You can assign a user either individual quotas for a specific amount of disk space in each tablespace or an unlimited amount of disk space in all tablespaces. Specific quotas prevent a user's objects from consuming too much space in the database.

You can assign a user's tablespace quotas when you create the user, or add or change quotas later. If a new quota is less than the old one, then the following conditions hold true:

- If a user has already exceeded a new tablespace quota, the user's objects in the tablespace cannot be allocated more space until the combined space of these objects falls below the new quota.
- If a user has not exceeded a new tablespace quota, or if the space used by the user's objects in the tablespace falls under a new tablespace quota, the user's objects can be allocated space up to the new quota.

**Revoking Tablespace Access** You can revoke a user's tablespace access by changing the user's current quota to zero. After a quota of zero is assigned, the user's objects in the revoked tablespace remain, but the objects cannot be allocated any new space.

**UNLIMITED TABLESPACE System Privilege** To permit a user to use an unlimited amount of any tablespace in the database, grant the user the UNLIMITED TABLESPACE system privilege. This overrides all explicit tablespace quotas for the user. If you later revoke the privilege, explicit quotas again take effect. You can grant this privilege only to users, not to roles.

Before granting the UNLIMITED TABLESPACE system privilege, consider the consequences of doing so:

Advantage

- You can grant a user unlimited access to all tablespaces of a database with one statement.

Disadvantages

- The privilege overrides all explicit tablespace quotas for the user.
- You cannot selectively revoke tablespace access from a user with the UNLIMITED TABLESPACE privilege. You can grant access selectively only after revoking the privilege.

### Specifying a Profile

You also specify a profile when you create a user. A profile is a set of limits on database resources. If no profile is specified, the user is assigned a default profile. For information on profiles see "Managing Resources with Profiles" on page 22-21 and "Password Management Policy" on page 21-12.

### Setting Default Roles

You cannot set a user's default roles in the CREATE USER statement. When you first create a user, the user's default role setting is ALL, which causes all roles subsequently granted to the user to be default roles. Use the ALTER USER statement to change the user's default roles. See "Specifying Default Roles" on page 23-18.

---

**WARNING: When you create a role (other than a user role), it is granted to you implicitly and added as a default role. You will get an error at login if you have more than MAX_ENABLED_ROLES. You can avoid this error by altering the user's default roles to be less than MAX_ENABLED_ROLES. Thus, you should change the DEFAULT ROLE settings of SYS and SYSTEM before creating user roles.**

---

## Altering Users

Users can change their own passwords. However, to change any other option of a user's security domain, you must have the ALTER USER system privilege. Security administrators are normally the only users that have this system privilege, as it allows a modification of *any* user's security domain. This privilege includes the ability to set tablespace quotas for a user on any tablespace in the database, even if

the user performing the modification does not have a quota for a specified tablespace.

You can alter a user's security settings with the SQL statement ALTER USER. Changing a user's security settings affects the user's future sessions, not current sessions.

The following statement alters the security settings for user AVYRROS:

```
ALTER USER avyrros
    IDENTIFIED EXTERNALLY
    DEFAULT TABLESPACE data_ts
    TEMPORARY TABLESPACE temp_ts
    QUOTA 100M ON data_ts
    QUOTA 0 ON test_ts
    PROFILE clerk;
```

The ALTER USER statement here changes AVYRROS's security settings as follows:

- Authentication is changed to use AVYRROS's operating system account.
- AVYRROS's default and temporary tablespaces are explicitly set.
- AVYRROS is given a 100M quota for the DATA_TS tablespace.
- AVYRROS's quota on the TEST_TS is revoked.
- AVYRROS is assigned the CLERK profile.

### Changing a User's Authentication Mechanism

Most non-DBA users can still change their own passwords with the ALTER USER statement, as follows:

```
ALTER USER andy
   IDENTIFIED BY swordfish;
```

Users can change their own passwords this way, without any special privileges (other than those to connect to the database). Users should be encouraged to change their passwords frequently.

Users must have the ALTER USER privilege to switch between Oracle database authentication or a form of external authentication. Usually, only DBAs should have this privilege.

### Changing a User's Default Roles

A default role is one that is automatically enabled for a user when the user creates a session. You can assign a user zero or more default roles. For more information on changing users' default roles, see Chapter 23, "Managing User Privileges and Roles".

## Dropping Users

When a user is dropped, the user and associated schema are removed from the data dictionary and all schema objects contained in the user's schema, if any, are immediately dropped.

> **Note:** If a user's schema and associated objects must remain but the user must be denied access to the database, revoke the CREATE SESSION privilege from the user.

A user that is currently connected to a database cannot be dropped. To drop a connected user, you must first terminate the user's sessions using the SQL statement ALTER SYSTEM with the KILL SESSION clause. For more information about terminating sessions, see "Terminating Sessions" on page 4-20.

You can drop a user from a database using the DROP USER statement. To drop a user and all the user's schema objects (if any), you must have the DROP USER system privilege. Because the DROP USER system privilege is so powerful, a security administrator is typically the only type of user that has this privilege.

If the user's schema contains any schema objects, use the CASCADE option to drop the user and all associated objects and foreign keys that depend on the tables of the user successfully. If you do not specify CASCADE and the user's schema contains objects, an error message is returned and the user is not dropped. Before dropping a user whose schema contains objects, thoroughly investigate which objects the user's schema contains and the implications of dropping them before the user is dropped. Pay attention to any unknown cascading effects. For example, if you intend to drop a user who owns a table, check whether any views or procedures depend on that particular table.

The following statement drops user JONES and all associated objects and foreign keys that depend on the tables owned by JONES.

```
DROP USER jones CASCADE;
```

# Managing Resources with Profiles

A profile is a named set of resource limits. A user's profile limits database usage and instance resources as defined in the profile. You can assign a profile to each user, and a default profile to all users who do not have specific profiles. For profiles to take effect, resource limits must be turned on for the database as a whole.

This section describes aspects of profile management, and includes the following topics:

- Enabling and Disabling Resource Limits
- Creating Profiles
- Assigning Profiles
- Altering Profiles
- Using Composite Limits
- Dropping Profiles

> **See Also:** For more information on the SQL statements for managing profiles, see the *Oracle8i SQL Reference.*

## Enabling and Disabling Resource Limits

A profile can be created, assigned to users, altered, and dropped at any time by any authorized database user, but the resource limits set for a profile are enforced only when you enable resource limitation for the associated database. Resource limitation enforcement can be enabled or disabled by two different methods, as described in the next two sections.

To alter the enforcement of resource limitation while the database remains open, you must have the ALTER SYSTEM system privilege.

### Enabling and Disabling Resource Limits Before Startup

If a database can be temporarily shut down, resource limitation can be enabled or disabled by the RESOURCE_LIMIT initialization parameter in the database's initialization parameter file. Valid values for the parameter are TRUE (enables enforcement) and FALSE; by default, this parameter's value is set to FALSE. Once the parameter file has been edited, the database instance must be restarted to take effect. Every time an instance is started, the new parameter value enables or disables the enforcement of resource limitation.

### Enabling and Disabling Resource Limits While the Database is Open

If a database cannot be temporarily shut down or the resource limitation feature must be altered temporarily, you can enable or disable the enforcement of resource limitation using the SQL statement ALTER SYSTEM. After an instance is started, an ALTER SYSTEM statement overrides the value set by the RESOURCE_LIMIT parameter. For example, the following statement enables the enforcement of resource limitation for a database:

```
ALTER SYSTEM
   SET RESOURCE_LIMIT = TRUE;
```

> **Note:** This does not apply to password resources.

An ALTER SYSTEM statement does not permanently determine the enforcement of resource limitation. If the database is shut down and restarted, the enforcement of resource limits is determined by the value set for the RESOURCE_LIMIT parameter.

## Creating Profiles

To create a profile, you must have the CREATE PROFILE system privilege. You can create profiles using the SQL statement CREATE PROFILE. At the same time, you can explicitly set particular resource limits.

The following statement creates the profile CLERK:

```
CREATE PROFILE clerk LIMIT
    SESSIONS_PER_USER 2
    CPU_PER_SESSION unlimited
    CPU_PER_CALL 6000
    LOGICAL_READS_PER_SESSION unlimited
    LOGICAL_READS_PER_CALL 100
    IDLE_TIME 30
    CONNECT_TIME 480;
```

All unspecified resource limits for a new profile take the limit set by a DEFAULT profile.

Each database has a DEFAULT profile, and its limits are used in two cases:

- If a user is not explicitly assigned a profile, then the user conforms to *all* the limits of the DEFAULT profile.

- All unspecified limits of any profile use the corresponding limit of the DEFAULT profile.

Initially, all limits of the DEFAULT profile are set to UNLIMITED. However, to prevent unlimited resource consumption by users of the DEFAULT profile, the security administrator should change the default limits using the ALTER PROFILE statement:

```
ALTER PROFILE default LIMIT
   ...;
```

Any user with the ALTER PROFILE system privilege can adjust the limits in the DEFAULT profile. The DEFAULT profile cannot be dropped.

## Assigning Profiles

After a profile has been created, you can assign it to database users. Each user can be assigned only one profile at any given time. If a profile is assigned to a user who already has a profile, the new profile assignment overrides the previously assigned profile. Profile assignments do not affect current sessions. Profiles can be assigned only to users and not to roles or other profiles.

Profiles can be assigned to users using the SQL statements CREATE USER or ALTER USER. For more information about assigning a profile to a user, see "Creating Users" on page 22-15 and "Altering Users" on page 22-18.

## Altering Profiles

You can alter the resource limit settings of any profile using the SQL statement ALTER PROFILE. To alter a profile, you must have the ALTER PROFILE system privilege.

Any adjusted profile limit overrides the previous setting for that profile limit. By adjusting a limit with a value of DEFAULT, the resource limit reverts to the default limit set for the database. All profiles not adjusted when altering a profile retain the previous settings. Any changes to a profile do not affect current sessions. New profile settings are used only for sessions created after a profile is modified.

The following statement alters the CLERK profile:

```
ALTER PROFILE clerk LIMIT
    CPU_PER_CALL default
    LOGICAL_READS_PER_SESSION 20000;
```

## Using Composite Limits

You can limit the total resource cost for a session via composite limits. In addition to setting specific resource limits explicitly for a profile, you can set a single composite limit that accounts for resource limits in a profile. You can set a profile's composite limit using the COMPOSITE_LIMIT clause of the SQL statements CREATE PROFILE or ALTER PROFILE. A composite limit is set via *service units*, which are weighted amounts of each resource.

The following CREATE PROFILE statement is defined using the COMPOSITE_ LIMIT clause:

```
CREATE PROFILE clerk LIMIT
    COMPOSITE_LIMIT 20000
    SESSIONS_PER_USER 2
    CPU_PER_CALL 1000;
```

Notice that both explicit resource limits and a composite limit can exist concurrently for a profile. The limit that is reached first stops the activity in a session. Composite limits allow additional flexibility when limiting the use of system resources.

### Determining the Value of the Composite Limit

The correct composite limit depends on the total amount of resource used by an average profile user. As with each specific resource limit, historical information should be gathered to determine the normal range of composite resource usage for a typical profile user.

> **See Also:** For information on how to calculate the composite limit, see the *Oracle8i SQL Reference.*

### Setting Resource Costs

Each system has its own characteristics; some system resources may be more valuable than others. Oracle enables you to give each system resource a *cost*. Costs weight each system resource at the database level. Costs are only applied to the composite limit of a profile; costs do not apply to set individual resource limits explicitly.

To set resource costs, you must have the ALTER RESOURCE system privilege.

Only certain resources can be given a cost: CPU_PER_ SESSION, LOGICAL_ READS_PER_SESSION, CONNECT_TIME, and PRIVATE_SGA. Set costs for a database using the SQL statement ALTER RESOURCE COST:

```
ALTER RESOURCE COST
```

```
CPU_PER_SESSION 1
LOGICAL_READS_PER_SESSION 50;
```

A large cost means that the resource is very expensive, while a small cost means that the resource is not expensive. By default, each resource is initially given a cost of 0. A cost of 0 means that the resource should not be considered in the composite limit (that is, it does not cost anything to use this resource). No resource can be given a cost of NULL.

> **See Also:** For additional information and recommendations on setting resource costs, see your operating system-specific Oracle documentation and the *Oracle8i SQL Reference*.

### Dropping Profiles

To drop a profile, you must have the DROP PROFILE system privilege. You can drop a profile using the SQL statement DROP PROFILE. To successfully drop a profile currently assigned to a user, use the CASCADE option.

The following statement drops the profile CLERK, even though it is assigned to a user:

```
DROP PROFILE clerk CASCADE;
```

Any user currently assigned to a profile that is dropped is automatically assigned to the DEFAULT profile. The DEFAULT profile cannot be dropped. Note that when a profile is dropped, the drop does not affect currently active sessions; only sessions created after a profile is dropped abide by any modified profile assignments.

## Listing Information About Database Users and Profiles

The data dictionary stores information about every user and profile, including the following:

- All users in a database
- Each user's default tablespace for tables, clusters, and indexes
- Each user's tablespace for temporary segments
- Each user's space quotas, if any
- Each user's assigned profile and resource limits
- The cost assigned to each applicable system resource

- Each current session's memory usage

The following data dictionary views may be of interest when you work with database users and profiles:

| View | Description |
|---|---|
| ALL_USERS | Lists all users of the database visible to the current user. This view does not describe the users. See the related views. |
| DBA_USERS | Describes all users of the database. |
| USER_USERS | Same columns as DBA_USERS, but only describes the current user. |
| DBA_TS_QUOTAS | Describes tablespace quotas for all users. |
| USER_TS_QUOTAS | Same columns as DBA_TA_QUOTAS, but contains information about tablespace quotas for the current user only. |
| USER_PASSWORD_LIMITS | Describes the password profile parameters that are assigned to the user. |
| USER_RESOURCE_LIMITS | Displays the resource limits for the current user. |
| DBA_PROFILES | Displays all profiles and their limits. |
| RESOURCE_COST | Lists the cost for each resource. |
| V$SESSION | Lists session information for each current session. Includes user name. |
| V$SESSTAT | Lists user session statistics. |
| V$STATNAME | Displays decoded statistic names for the statistics shown in the V$SESSTAT view. |
| PROXY_USER | This view describes users who can assume the identity of other users. |

**See Also:** See the *Oracle8i Reference* for detailed information about each view.

## Listing Information about Users and Profiles: Examples

The examples in this section assume a database in which the following statements have been executed:

```
CREATE PROFILE clerk LIMIT
    SESSIONS_PER_USER 1
    IDLE_TIME 30
    CONNECT_TIME 600;

CREATE USER jfee
    IDENTIFIED BY wildcat
    DEFAULT TABLESPACE users
    TEMPORARY TABLESPACE temp_ts
    QUOTA 500K ON users
    PROFILE clerk;

CREATE USER dcranney
    IDENTIFIED BY bedrock
    DEFAULT TABLESPACE users
    TEMPORARY TABLESPACE temp_ts
    QUOTA unlimited ON users;

CREATE USER userscott
     IDENTIFIED BY scott1
```

### Listing All Users and Associated Information

The following query lists users and their associated information as defined in the database:

```
SELECT username, profile, account_status from dba_users;
USERNAME        PROFILE         ACCOUNT_STATUS
--------------- --------------- ---------------
SYS             DEFAULT         OPEN
SYSTEM          DEFAULT         OPEN
USERSCOTT       DEFAULT         OPEN
JFEE            CLERK           OPEN
DCRANNEY        DEFAULT         OPEN
```

All passwords are encrypted to preserve security. If a user queries the PASSWORD column, that user will not be able to determine another user's password.

### Listing All Tablespace Quotas

The following query lists all tablespace quotas specifically assigned to each

```
user:
SELECT * FROM sys.dba_ts_quotas;
TABLESPACE    USERNAME    BYTES     MAX_BYTES    BLOCKS    MAX_BLOCKS
----------    ---------  --------   ----------   -------   ----------
USERS         JFEE              0       512000         0          250
USERS         DCRANNEY          0           -1         0           -1
```

When specific quotas are assigned, the exact number is indicated in the MAX_ BYTES column. Note that this number will always be a multiple of the database block size, so if you specify a tablespace quota that is not a multiple of the database block size, it will be rounded up accordingly. Unlimited quotas are indicated by "-1".

### Listing All Profiles and Assigned Limits

The following query lists all profiles in the database and associated settings for each limit in each profile:

```
SELECT * FROM sys.dba_profiles
   ORDER BY profile;
PROFILE             RESOURCE_NAME              RESOURCE   LIMIT
-----------------   --------------             ---------- --------------
CLERK               COMPOSITE_LIMIT            KERNEL     DEFAULT
CLERK               FAILED_LOGIN_ATTEMPTS      PASSWORD   DEFAULT
CLERK               PASSWORD_LIFE_TIME         PASSWORD   DEFAULT
CLERK               PASSWORD_REUSE_TIME        PASSWORD   DEFAULT
CLERK               PASSWORD_REUSE_MAX         PASSWORD   DEFAULT
CLERK               PASSWORD_VERIFY_FUNCTION   PASSWORD   DEFAULT
CLERK               PASSWORD_LOCK_TIME         PASSWORD   DEFAULT
CLERK               PASSWORD_GRACE_TIME        PASSWORD   DEFAULT
CLERK               PRIVATE_SGA                KERNEL     DEFAULT
CLERK               CONNECT_TIME               KERNEL     600
CLERK               IDLE_TIME                  KERNEL     30
CLERK               LOGICAL_READS_PER_CALL     KERNEL     DEFAULT
CLERK               LOGICAL_READS_PER_SESSION  KERNEL     DEFAULT
CLERK               CPU_PER_CALL               KERNEL     DEFAULT
CLERK               CPU_PER_SESSION            KERNEL     DEFAULT
CLERK               SESSIONS_PER_USER          KERNEL     1
DEFAULT             COMPOSITE_LIMIT            KERNEL     UNLIMITEDT
DEFAULT             PRIVATE_SGA                KERNEL     UNLIMITED
DEFAULT             SESSIONS_PER_USER          KERNEL     UNLIMITED
DEFAULT             CPU_PER_CALL               KERNEL     UNLIMITED
DEFAULT             LOGICAL_READS_PER_CALL     KERNEL     UNLIMITED
DEFAULT             CONNECT_TIME               KERNEL     UNLIMITED
DEFAULT             IDLE_TIME                  KERNEL     UNLIMITED
```

```
DEFAULT              LOGICAL_READS_PER_SESSION  KERNEL     UNLIMITED
DEFAULT              CPU_PER_SESSION            KERNEL     UNLIMITED
DEFAULT              FAILED_LOGIN_ATTEMPTS      PASSWORD   UNLIMITED
DEFAULT              PASSWORD_LIFE_TIME         PASSWORD   UNLIMITED
DEFAULT              PASSWORD_REUSE_MAX         PASSWORD   UNLIMITED
DEFAULT              PASSWORD_LOCK_TIME         PASSWORD   UNLIMITED
DEFAULT              PASSWORD_GRACE_TIME        PASSWORD   UNLIMITED
DEFAULT              PASSWORD_VERIFY_FUNCTION   PASSWORD   UNLIMITED
DEFAULT              PASSWORD_REUSE_TIME        PASSWORD   UNLIMITED
32 rows selected.
```

### Viewing Memory Use Per User Session

The following query lists all current sessions, showing the Oracle user and current UGA (user global area) memory use per session:

```
SELECT username, value || 'bytes' "Current UGA memory"
   FROM v$session sess, v$sesstat stat, v$statname name
WHERE sess.sid = stat.sid
   AND stat.statistic# = name.statistic#
   AND name.name = 'session uga memory';

USERNAME                       Current UGA memory
------------------------------ ----------------------------------------------
                               18636bytes
                               17464bytes
                               19180bytes
                               18364bytes
                               39384bytes
                               35292bytes
                               17696bytes
                               15868bytes
USERSCOTT                      42244bytes
SYS                            98196bytes
SYSTEM                         30648bytes

11 rows selected.
```

To see the maximum UGA memory ever allocated to each session since the instance started, replace `'session uga memory'` in the query above with `'session uga memory max'`.

# Examples

The following are examples that further demonstrate the use of SQL statements and views discussed in this chapter.

1. The following statement creates the profile PROF:

```
CREATE PROFILE prof LIMIT
   FAILED_LOGIN_ATTEMPTS 5
   PASSWORD_LIFE_TIME 60
   PASSWORD_REUSE_MAX 60
   PASSWORD_REUSE_TIME UNLIMITED
   PASSWORD_VERIFY_FUNCTION verify_function
   PASSWORD_LOCK_TIME 1
   PASSWORD_GRACE_TIME 10;
```

2. The following statement attempts to creates a user with the same password as the username.

```
CREATE USER userscott IDENTIFIED BY userscott PROFILE prof;
ORA-28003: Password verification for the specified password failed
ORA-20001: Password same as user
```

3. The following statement creates user userscott identified by SCOTT% with profile PROF;

```
CREATE USER userscott IDENTIFIED BY "scott%" PROFILE prof;
```

4. The following statement attempts to change the user's password to SCOTT% again:

```
ALTER USER userscott IDENTIFIED BY "scott%";
ORA-28007: The password cannot be reused
```

5. The following statement locks the user account:

```
ALTER USER userscott ACCOUNT LOCK;
```

6. The following statement checks the user account status:

```
SELECT username, user_id, account_status, lock_date
   FROM dba_users
   WHERE username='USERSCOTT';

USERNAME             USER_ID ACCOUNT_STATUS           LOCK_DATE
-------------------- ------- ---------------------- ---------
USERSCOTT                 38 LOCKED                 11-OCT-99
```

7. The following statement unlocks the user:

```
ALTER USER userscott ACCOUNT UNLOCK;
```

8. The following statement expires the password:

```
ALTER USER userscott PASSWORD EXPIRE;
```

# 23

# Managing User Privileges and Roles

This chapter explains how to use privileges and roles to control access to schema objects and to control the ability to execute system operations. The following topics are included:

- Identifying User Privileges
- Managing User Roles
- Granting User Privileges and Roles
- Revoking User Privileges and Roles
- When Do Grants and Revokes Take Effect?
- Granting Roles Using the Operating System or Network
- Listing Privilege and Role Information

For information about controlling access to a database, see Chapter 22, "Managing Users and Resources", and for suggested general database security policies, read Chapter 21, "Establishing Security Policies".

# Identifying User Privileges

This section describes Oracle user privileges, and includes the following topics:

- System Privileges
- Object Privileges

A user *privilege* is a right to execute a particular type of SQL statement, or a right to access another user's object. Oracle also provides shortcuts for grouping privileges that are commonly granted or revoked together.

## System Privileges

There are over 100 distinct system privileges. Each system privilege allows a user to perform a particular database operation or class of database operations.

**WARNING: System privileges can be very powerful, and should be cautiously granted to roles and trusted users of the database.**

For the complete list, including descriptions, of system privileges, see the *Oracle8i SQL Reference*.

### System Privilege Restrictions

Because system privileges are so powerful, Oracle recommends that you configure your database to prevent regular (non-DBA) users exercising ANY system privileges (such as UPDATE ANY TABLE) on the data dictionary. In order to secure the data dictionary, set the O7_DICTIONARY_ACCESSIBILITY initialization parameter to FALSE. This feature is called the dictionary protection mechanism.

> **Note:** The O7_DICTIONARY_ACCESSIBILITY initialization parameter controls restrictions on SYSTEM privileges when you migrate from Oracle7 to Oracle8i. If the parameter is set to TRUE, access to objects in the SYS schema is allowed (Oracle7 behavior). If this parameter is set to FALSE, system privileges that allow access to objects in "any schema" do not allow access to objects in SYS schema. The default is TRUE.
>
> If you do not explicitly set this initialization parameter to FALSE, then ANY privilege applies to the data dictionary, and a malicious user with ANY privilege could access or alter data dictionary tables.
>
> See the *Oracle8i Reference* for more information on this parameter. See *Oracle8i Migration* to understand the usage of this parameter.

If you enable dictionary protection, access to objects in the SYS schema (dictionary objects) is restricted to users with the SYS schema. This includes user SYS and users who connect as SYSDBA. System privileges providing access to objects in other schemas do *not* give other users access to objects in the SYS schema. For example, the SELECT ANY TABLE privilege allows users to access views and tables in other schemas, but does not enable them to select dictionary objects (base tables of dynamic performance views, views, packages, and synonyms). These users can, however, be granted explicit object privileges to access objects in the SYS schema.

### Accessing Frequently Used Dictionary Objects

Users with explicit object privileges or with administrative privileges (SYSDBA) can access dictionary objects. If, however, other users need access to dictionary objects and do not have these privileges, they can be granted the following roles:

- SELECT_CATALOG_ROLE

  Enables users to SELECT all exported catalog views and tables granted to this role. Grant this role to users who must access all exported views and tables in the data dictionary.

- EXECUTE_CATALOG_ROLE

  Provides EXECUTE privilege on exported packages in the dictionary.

- DELETE_CATALOG_ROLE

Enables users to delete records from the AUD$ table.

These roles enable some database administrators to access certain objects in the dictionary while maintaining dictionary security.

---

**Note:** You should not grant any user the object privileges for nonexported objects in the dictionary; doing so may compromise the integrity of the database.

---

**See Also:** For details about any exported table or view, see the *Oracle8i Reference*.

## Object Privileges

Each type of object has different privileges associated with it. For a detailed list of objects and associated privileges, see the *Oracle8i SQL Reference*.

You can specify ALL [PRIVILEGES] to grant or revoke all available object privileges for an object. ALL is not a privilege; rather, it is a shortcut, or a way of granting or revoking all object privileges with one word in GRANT and REVOKE statements. Note that if all object privileges are granted using the ALL shortcut, individual privileges can still be revoked.

Likewise, all individually granted privileges can be revoked by specifying ALL. However, if you REVOKE ALL, and revoking causes integrity constraints to be deleted (because they depend on a REFERENCES privilege that you are revoking), you must include the CASCADE CONSTRAINTS option in the REVOKE statement.

# Managing User Roles

A *role* groups several privileges and roles, so that they can be granted to and revoked from users simultaneously. Roles can be enabled and disabled per user.

This section describes aspects of managing roles, and includes the following topics:

- Predefined Roles
- Creating a Role
- Role Authorization
- Dropping Roles

**See Also:** For information about roles, see *Oracle8i Concepts*.

## Predefined Roles

The roles listed in Table 23–1are automatically defined for Oracle databases when you run the standard scripts that are part of database creation. You can grant and revoke privileges and roles to these predefined roles, much the way you do with any role you define.

***Table 23–1 Predefined Roles*** **(Page 1 of 2)**

| Role Name | Created By (Script) | Description |
|---|---|---|
| CONNECT | SQL.BSQ | Includes the following system privileges: ALTER SESSION, CREATE CLUSTER, CREATE DATABASE LINK, CREATE SEQUENCE, CREATE SESSION, CREATE SYNONYM, CREATE TABLE, CREATE VIEW. |
| RESOURCE | SQL.BSQ | Includes the following system privileges: CREATE CLUSTER, CREATE INDEXTYPE, CREATE OPERATOR, CREATE PROCEDURE, CREATE SEQUENCE, CREATE TABLE, CREATE TRIGGER, CREATE TYPE. |
| DBA | SQL.BSQ | All system privileges WITH ADMIN OPTION. |
| **Note:** The previous three roles are provided to maintain compatibility with previous versions of Oracle and may not be created automatically in future versions of Oracle. Oracle Corporation recommends that you design your own roles for database security, rather than relying on these roles. | | |
| EXP_FULL_DATABASE | CATEXP.SQL | Provides the privileges required to perform full and incremental database exports. Includes: SELECT ANY TABLE, BACKUP ANY TABLE, EXECUTE ANY PROCEDURE, EXECUTE ANY TYPE, ADMINISTER RESOURCE MANAGER, and INSERT, DELETE, and UPDATE on the tables SYS.INCVID, SYS.INCFIL, and SYS.INCEXP. Also the following roles: EXECUTE_CATALOG-ROLE and SELECT_CATALOG_ROLE. |
| IMP_FULL_DATABASE | CATEXP.SQL | Provides the privileges required to perform full database imports. Includes an extensive list of system privileges (use view DBA_ SYS_PRIVS to view privileges) and the following roles: EXECUTE_ CATALOG-ROLE and SELECT_ CATALOG_ROLE. |
| DELETE_CATALOG_ROLE | SQL.BSQ | DELETE privileges on all dictionary packages for this role. |

*Table 23–1 Predefined Roles* **(Page 2 of 2)**

| Role Name | Created By (Script) | Description |
|---|---|---|
| EXECUTE_CATALOG_ROLE | SQL.BSQ | EXECUTE privilege on all dictionary packages for this role. Also, HS_ADMIN_ ROLE. |
| SELECT_CATALOG_ROLE | SQL.BSQ | SELECT privilege on all catalog tables and views for this role. Also, HS_ADMIN_ ROLE. |
| RECOVERY_CATALOG_OWNER | CATALOG.SQL | Provides privileges for owner of the recovery catalog. Includes: CREATE SESSION, ALTER SESSION, CREATE SYNONYM, CREATE VIEW, CREATE DATABASE LINK, CREATE TABLE, CREATE CLUSTER, CREATE SEQUENCE, CREATE TRIGGER, and CREATE PROCEDURE. |
| HS_ADMIN_ROLE | CATHS.SQL | Used to protect access to the HS (Heterogeneous Services) data dictionary tables (grants SELECT) and packages (grants EXECUTE). It is granted to SELECT_CATALOG_ROLE, and EXECUTE_CATALOG_ROLE such that users with generic data dictionary access also can access the HS data dictionary. |
| AQ_USER_ROLE | CATQUEUE.SQL | Obsoleted, but kept mainly for 8.0 compatibility. Provides execute privilege on DBMS_AQ and DBMS_AQIN. |
| AQ_ADMINISTRATOR_ROLE | CATQUEUE.SQL | Provides privileges to administer Advance Queuing. Includes ENQUEUE ANY QUEUE, DEQUEUE ANY QUEUE, and MANAGE ANY QUEUE, SELECT privileges on AQ tables and EXECUTE privileges on AQ packages. |
| SNMPAGENT | CATSNMP.SQL | This role is used by Enterprise Manager/Intelligent Agent. Includes ANALYZE ANY and grants SELECT on various views. |

If you install other options or products, other predefined roles may be created.

## Creating a Role

You can create a role using the CREATE ROLE statement, but you must have the CREATE ROLE system privilege to do so. Typically, only security administrators have this system privilege.

**Note:** Immediately after creation, a role has no privileges associated with it. To associate privileges with a new role, you must grant privileges or other roles to the new role.

You must give each role you create a unique name among existing usernames and role names of the database. Roles are not contained in the schema of any user. In a database that uses a multi-byte character set, Oracle recommends that each role name contain at least one single-byte character. If a role name contains only multi-byte characters, the encrypted role name / password combination is considerably less secure.

The following statement creates the CLERK role, which is authorized by the database using the password BICENTENNIAL:

```
CREATE ROLE clerk
IDENTIFIED BY bicentennial;
```

The IDENTIFIED BY clause specifies the form of authorization that must be provided before the role can be enabled for use by a specific user to which it has been granted. If this clause is not specified, or NOT IDENTIFIED is specified, then no authorization is required when the role is enabled. Roles can be specified to be authorized by the database, externally, or globally. These authorizations are discussed in following sections.

Later, you can set or change the authorization method for a role using the ALTER ROLE statement. The following statement alters the CLERK role to be authorized externally:

```
ALTER ROLE clerk
IDENTIFIED EXTERNALLY;
```

To alter the authorization method for a role, you must have the ALTER ANY ROLE system privilege or have been granted the role with the ADMIN OPTION.

**See Also:** For syntax, restrictions, and authorization information about the SQL statements used to manage roles and privileges, see the *Oracle8i SQL Reference*.

## Role Authorization

A database role can optionally require authorization when a user attempts to enable the role. The methods of authorizing roles are discussed in this section. Enabling roles is discussed in "When Do Grants and Revokes Take Effect?" on page 23-17.

### Role Authorization by the Database

The use of a role authorized by the database can be protected by an associated password. If you are granted a role protected by a password, you can enable or disable the role by supplying the proper password for the role in a SET ROLE statement. See "The SET ROLE Statement" on page 23-17. However, if the role is made a default role and enabled at connect time, the user is not required to enter a password.

An example of specifying a role for database authorization was presented previously.

---

**Note:** In a database that uses a multi-byte character set, passwords for roles must include only single-byte characters. Multi-byte characters are not accepted in passwords.

---

**See Also:** For more information about valid passwords, see the *Oracle8i SQL Reference*.

### Role Authorization by the Operating System

The following statement creates a role named ACCTS_REC and requires that the operating system authorize its use:

```
CREATE ROLE accts_rec IDENTIFIED EXTERNALLY;
```

Role authentication via the operating system is useful only when the operating system is able to dynamically link operating system privileges with applications. When a user starts an application, the operating system grants an operating system privilege to the user. The granted operating system privilege corresponds to the role associated with the application. At this point, the application can enable the application role. When the application is terminated, the previously granted operating system privilege is revoked from the user's operating system account.

If a role is authorized by the operating system, you must configure information for each user at the operating system level. This operation is operating system dependent.

If roles are granted by the operating system, you do not need to have the operating system authorize them also; this is redundant. For more information about roles granted by the operating system, see "Granting Roles Using the Operating System or Network" on page 23-18.

### Role Authorization and Network Clients

If users connect to the database over Net8, by default their roles cannot be authenticated by the operating system. This includes connections through a multi-threaded server, as this connection requires Net8. This restriction is the default because a remote user could impersonate another operating system user over a network connection.

If you are not concerned with this security risk and want to use operating system role authentication for network clients, set the parameter REMOTE_OS_ROLES in the database's parameter file to TRUE. The change will take effect the next time you start the instance and mount the database. (The parameter is FALSE by default.)

> **See Also:** For more information about network roles, see *Oracle8i Distributed Database Systems.*

### Role Authorization by an Enterprise Directory Service

A role can be defined as a global role, whereby a (global) user can only be authorized to use the role by an enterprise directory service. You define the global role locally in the database by granting privileges and roles to it, but you cannot grant the global role itself to any user or other role in the database. When a global user attempts to connect to the database, the enterprise directory is queried to obtain any global roles associated with the user.

The following statement creates a global role:

```
CREATE ROLE supervisor IDENTIFIED GLOBALLY
```

Global roles are one component of enterprise user management. A global role only applies to one database, but it can be granted to an enterprise role defined in the enterprise directory. An enterprise role is a directory structure which contains global roles on multiple databases, and which can be granted to enterprise users.

A general discussion of global authentication and authorization of users, and its role in enterprise user management, was presented earlier in "Global Authentication and Authorization" on page 22-11.

**See Also:** To learn more about enterprise user management and how to implement it, see the *Oracle Advanced Security Administrator's Guide* and the *Oracle Internet Directory Administrator's Guide*

## Dropping Roles

In some cases, it may be appropriate to drop a role from the database. The security domains of all users and roles granted a dropped role are immediately changed to reflect the absence of the dropped role's privileges. All indirectly granted roles of the dropped role are also removed from affected security domains. Dropping a role automatically removes the role from all users' default role lists.

Because the creation of objects is not dependent on the privileges received via a role, tables and other objects are not dropped when a role is dropped.

You can drop a role using the SQL statement DROP ROLE. To drop a role, you must have the DROP ANY ROLE system privilege or have been granted the role with the ADMIN OPTION.

The following statement drops the role CLERK:

```
DROP ROLE clerk;
```

# Granting User Privileges and Roles

This section describes aspects of granting privileges and roles, and includes the following topics:

- Granting System Privileges and Roles
- Granting Object Privileges and Roles
- Granting Privileges on Columns

It is also possible to grant roles to a user connected through a middle tier or proxy. This was discussed in "Multi-Tier Authentication and Authorization" on page 22-13.

## Granting System Privileges and Roles

You can grant system privileges and roles to other roles and users using the SQL statement GRANT. To grant a system privilege or role, you must have the ADMIN OPTION for all system privileges and roles being granted. Also, any user with the GRANT ANY ROLE system privilege can grant any role in a database.

> **Note:** You cannot grant a roll that is IDENTIFIED GLOBALLY to anything. The granting (and revoking) of global roles is controlled entirely by the enterprise directory service.

The following statement grants the system privilege CREATE SESSION and the ACCTS_PAY role to the user JWARD:

```
GRANT CREATE SESSION, accts_pay
TO jward;
```

> **Note:** Object privileges *cannot* be granted along with system privileges and roles in the same GRANT statement.

When a user creates a role, the role is automatically granted to the creator with the ADMIN OPTION. A grantee with the ADMIN option has several expanded capabilities:

- The grantee can grant or revoke the system privilege or role to or from *any* user or other role in the database. (Users cannot revoke a role from themselves.)
- The grantee can further grant the system privilege or role with the ADMIN OPTION.
- The grantee of a role can alter or drop the role.

In the following statement, the security administrator grants the NEW_DBA role to MICHAEL:

```
GRANT new_dba TO michael WITH ADMIN OPTION;
```

The user MICHAEL can not only use all of the privileges implicit in the NEW_DBA role, but can grant, revoke, or drop the NEW_DBA role as deemed necessary. Because of these powerful capabilities, exercise caution when granting system privileges or roles with the ADMIN OPTION. Such privileges are usually reserved for a security administrator and rarely granted to other administrators or users of the system.

## Granting Object Privileges and Roles

You also use the GRANT statement to grant object privileges to roles and users. To grant an object privilege, you must fulfill one of the following conditions:

- You own the object specified.
- You have been granted the object privileges being granted with the GRANT OPTION.

> **Note:** System privileges and roles cannot be granted along with object privileges in the same GRANT statement.

The following statement grants the SELECT, INSERT, and DELETE object privileges for all columns of the EMP table to the users JFEE and TSMITH:

```
GRANT SELECT, INSERT, DELETE ON emp TO jfee, tsmith;
```

To grant the INSERT object privilege for only the ENAME and JOB columns of the EMP table to the users JFEE and TSMITH, issue the following statement:

```
GRANT INSERT(ename, job) ON emp TO jfee, tsmith;
```

To grant all object privileges on the SALARY view to the user JFEE, use the ALL keyword, as shown in the following example:

```
GRANT ALL ON salary TO jfee;
```

The user whose schema contains an object is automatically granted all associated object privileges with the GRANT OPTION. This special privilege allows the grantee several expanded privileges:

- The grantee can grant the object privilege to any users in the database, with or without the GRANT OPTION, or to any role in the database.
- If the grantee receives object privileges for a table with the GRANT OPTION and the grantee has the CREATE VIEW or CREATE ANY VIEW system privilege, the grantee can create views on the table and grant the corresponding privileges on the view to any user or role in the database.

The GRANT OPTION is not valid when granting an object privilege to a role. Oracle prevents the propagation of object privileges via roles so that grantees of a role cannot propagate object privileges received by means of roles.

## Granting Privileges on Columns

You can grant INSERT, UPDATE, or REFERENCES privileges on individual columns in a table.

**WARNING: Before granting a column-specific INSERT privilege, determine if the table contains any columns on which NOT NULL constraints are defined. Granting selective insert capability without including the NOT NULL columns prevents the user from inserting any rows into the table. To avoid this situation, make sure that each NOT NULL column is either insertable or has a non-NULL default value. Otherwise, the grantee will not be able to insert rows into the table and will receive an error.**

Grant INSERT privilege on the ACCT_NO column of the ACCOUNTS table to SCOTT:

```
GRANT INSERT (acct_no)
ON accounts TO scott;
```

# Revoking User Privileges and Roles

This section describes aspects of revoking user privileges and roles, and includes the following topics:

- Revoking System Privileges and Roles
- Revoking Object Privileges and Roles
- Effects of Revoking Privileges
- Granting to and Revoking from the User Group PUBLIC

## Revoking System Privileges and Roles

You can revoke system privileges and roles using the SQL statement REVOKE.

Any user with the ADMIN OPTION for a system privilege or role can revoke the privilege or role from any other database user or role The revoker does not have to be the user that originally granted the privilege or role. Also, users with the GRANT ANY ROLE can revoke *any* role.

The following statement revokes the CREATE TABLE system privilege and the ACCTS_REC role from TSMITH:

```
REVOKE CREATE TABLE, accts_rec FROM tsmith;
```

**Note:** The ADMIN OPTION for a system privilege or role cannot be selectively revoked. The privilege or role must be revoked and then the privilege or role re-granted without the ADMIN OPTION.

## Revoking Object Privileges and Roles

The REVOKE statement is also used to revoke object privileges. To revoke an object privilege, the revoker must be the original grantor of the object privilege being revoked.

For example, assuming you are the original grantor, to revoke the SELECT and INSERT privileges on the EMP table from the users JFEE and TSMITH, you would issue the following statement:

```
REVOKE SELECT, insert ON emp
FROM jfee, tsmith;
```

The following statement revokes all privileges (which were originally granted to the role HUMAN_RESOURCE) from the table DEPT:

```
REVOKE ALL ON dept FROM human_resources;
```

**Note:** This statement above would only revoke the privileges that the grantor authorized, not the grants made by other users. The GRANT OPTION for an object privilege cannot be selectively revoked. The object privilege must be revoked and then re-granted without the GRANT OPTION. Users cannot revoke object privileges from themselves.

### Revoking Column-Selective Object Privileges

Although users can grant column-selective INSERT, UPDATE, and REFERENCES privileges for tables and views, they cannot selectively revoke column specific privileges with a similar REVOKE statement. Instead, the grantor must first revoke the object privilege for all columns of a table or view, and then selectively re-grant the column-specific privileges that should remain.

For example, assume that role HUMAN_RESOURCES has been granted the UPDATE privilege on the DEPTNO and DNAME columns of the table DEPT. To revoke the UPDATE privilege on just the DEPTNO column, you would issue the following two statements:

```
REVOKE UPDATE ON dept FROM human_resources;
GRANT UPDATE (dname) ON dept TO human_resources;
```

The REVOKE statement revokes UPDATE privilege on all columns of the DEPT table from the role HUMAN_RESOURCES. The GRANT statement re-grants UPDATE privilege on the DNAME column to the role HUMAN_RESOURCES.

### Revoking the REFERENCES Object Privilege

If the grantee of the REFERENCES object privilege has used the privilege to create a foreign key constraint (that currently exists), the grantor can revoke the privilege only by specifying the CASCADE CONSTRAINTS option in the REVOKE statement:

```
REVOKE REFERENCES ON dept FROM jward CASCADE CONSTRAINTS;
```

Any foreign key constraints currently defined that use the revoked REFERENCES privilege are dropped when the CASCADE CONSTRAINTS options is specified.

## Effects of Revoking Privileges

Depending on the type of privilege, there may be cascading effects when a privilege is revoked.

### System Privileges

There are no cascading effects when revoking a system privilege related to DDL operations, regardless of whether the privilege was granted with or without the ADMIN OPTION. For example, assume the following:

1. The security administrator grants the CREATE TABLE system privilege to JFEE with the ADMIN OPTION.
2. JFEE creates a table.
3. JFEE grants the CREATE TABLE system privilege to TSMITH.
4. TSMITH creates a table.
5. The security administrator revokes the CREATE TABLE system privilege from JFEE.
6. JFEE's table continues to exist. TSMITH still has the table and the CREATE TABLE system privilege.

Cascading effects can be observed when revoking a system privilege related to a DML operation. For example, if SELECT ANY TABLE is granted to a user, and that user has created any procedures, all procedures contained in the user's schema must be re-authorized before they can be used again.

### Object Privileges

Revoking an object privilege may have cascading effects that should be investigated before issuing a REVOKE statement.

- Object definitions that depend on a DML object privilege can be affected if the DML object privilege is revoked. For example, assume the procedure body of the TEST procedure includes a SQL statement that queries data from the EMP table. If the SELECT privilege on the EMP table is revoked from the owner of the TEST procedure, the procedure can no longer be executed successfully.
- Object definitions that require the ALTER and INDEX DDL object privileges are not affected if the ALTER or INDEX object privilege is revoked. For example, if the INDEX privilege is revoked from a user that created an index on someone else's table, the index continues to exist after the privilege is revoked.
- When a REFERENCES privilege for a table is revoked from a user, any foreign key integrity constraints defined by the user that require the dropped REFERENCES privilege are automatically dropped. For example, assume that the user JWARD is granted the REFERENCES privilege for the DEPTNO column of the DEPT table and creates a foreign key on the DEPTNO column in the EMP table that references the DEPTNO column. If the REFERENCES privilege on the DEPTNO column of the DEPT table is revoked, the foreign key constraint on the DEPTNO column of the EMP table is dropped in the same operation.
- The object privilege grants propagated using the GRANT OPTION are revoked if a grantor's object privilege is revoked. For example, assume that USER1 is granted the SELECT object privilege with the GRANT OPTION, and grants the SELECT privilege on EMP to USER2. Subsequently, the SELECT privilege is revoked from USER1. This revoke is cascaded to USER2 as well. Any objects that depended on USER1's and USER2's revoked SELECT privilege can also be affected, as described in previous bullet items.

## Granting to and Revoking from the User Group PUBLIC

Privileges and roles can also be granted to and revoked from the user group PUBLIC. Because PUBLIC is accessible to every database user, all privileges and roles granted to PUBLIC are accessible to every database user.

Security administrators and database users should grant a privilege or role to PUBLIC only if every database user requires the privilege or role. This recommendation reinforces the general rule that at any given time, each database user should only have the privileges required to accomplish the group's current tasks successfully.

Revoking a privilege from PUBLIC can cause significant cascading effects. If any privilege related to a DML operation is revoked from PUBLIC (for example, `SELECT ANY TABLE, UPDATE ON emp`), all procedures in the database, including functions and packages, must be *reauthorized* before they can be used again. Therefore, exercise caution when granting DML-related privileges to PUBLIC.

For more information about object dependencies, see "Managing Object Dependencies" on page 19-23.

# When Do Grants and Revokes Take Effect?

Depending on what is granted or revoked, a grant or revoke takes effect at different times:

- All grants / revokes of system and object privileges to anything (users, roles, and PUBLIC) are immediately observed.
- All grants / revokes of roles to anything (users, other roles, PUBLIC) are only observed when a current user session issues a SET ROLE statement to re-enable the role after the grant / revoke, or when a new user session is created after the grant / revoke.

You can see which roles are currently enabled by examining the `SESSION_ROLES` data dictionary view.

## The SET ROLE Statement

During the session, the user or an application can use the SET ROLE statement any number of times to change the roles currently enabled for the session. You must already have been granted the roles that you name in the SET ROLE statement. The number of roles that can be concurrently enabled is limited by the initialization parameter `MAX_ENABLED_ROLES`.

This example enables the role CLERK, which you have already been granted, and specifies the password.

```
SET ROLE clerk IDENTIFIED BY bicentennial;
```

You can disable all roles with the following statement:

```
SET ROLE NONE;
```

## Specifying Default Roles

When a user logs on, Oracle enables all privileges granted explicitly to the user and all privileges in the user's default roles.

A user's list of default roles can be set and altered using the ALTER USER statement. The ALTER USER statement allows you to specify roles that are to be enabled when a user connects to the database, without requiring the user to specify the roles' passwords. The user must have already been directly granted the roles with a GRANT statement. You cannot specify as a default role any role managed by an external service including a directory service (external roles or global roles).

The following example establishes default roles for user JANE:

```
ALTER USER jane DEFAULT ROLE payclerk, pettycash;
```

You cannot set a user's default roles in the CREATE USER statement. When you first create a user, the user's default role setting is ALL, which causes all roles subsequently granted to the user to be default roles. Use the ALTER USER statement to limit the user's default roles.

## Restricting the Number of Roles that a User Can Enable

A user can enable as many roles as specified by the initialization parameter MAX_ENABLED_ROLES. All indirectly granted roles enabled as a result of enabling a primary role are included in this count. The database administrator can alter this limitation by modifying the value for this parameter. Higher values permit each user session to have more concurrently enabled roles. However, the larger the value for this parameter, the more memory space is required on behalf of each user session; this is because the PGA size is affected for each user session, and requires four bytes per role. Determine the highest number of roles that will be concurrently enabled by any one user and use this value for the MAX_ENABLED_ROLES parameter.

# Granting Roles Using the Operating System or Network

This section describes aspects of granting roles via your operating system or network, and includes the following topics:

- Using Operating System Role Identification

- Using Operating System Role Management
- Granting and Revoking Roles When OS_ROLES=TRUE
- Enabling and Disabling Roles When OS_ROLES=TRUE
- Using Network Connections with Operating System Role Management

Instead of a security administrator explicitly granting and revoking database roles to and from users using GRANT and REVOKE statements, the operating system that operates Oracle can grant roles to users at connect time. Roles can be administered using the operating system and passed to Oracle when a user creates a session. As part of this mechanism, each user's default roles and the roles granted to a user with the ADMIN OPTION can be identified. Even if the operating system is used to authorize users for roles, all roles must be created in the database and privileges assigned to the role with GRANT statements.

Roles can also be granted through a network service. For information about network roles, see *Oracle8i Distributed Database Systems.*

The advantage of using the operating system to identify a user's database roles is that privilege management for an Oracle database can be externalized. The security facilities offered by the operating system control a user's privileges. This option may offer advantages of centralizing security for a number of system activities. For example, MVS Oracle administrators may want RACF groups to identify a database user's roles, UNIX Oracle administrators may want UNIX groups to identify a database user's roles, or VMS Oracle administrators may want to use rights identifiers to identify a database user's roles.

The main disadvantage of using the operating system to identify a user's database roles is that privilege management can only be performed at the role level. Individual privileges cannot be granted using the operating system, but can still be granted inside the database using GRANT statements.

A secondary disadvantage of using this feature is that by default users cannot connect to the database through the multi-threaded server, or any other network connection, if the operating system is managing roles. However, you can change this default; see "Using Network Connections with Operating System Role Management" on page 23-22.

> **See Also:** The features described in this section are available only on some operating systems. This information is operating system-dependent; see your operating system-specific Oracle documentation.

## Using Operating System Role Identification

To operate a database so that it uses the operating system to identify each user's database roles when a session is created, set the initialization parameter OS_ROLES to TRUE (and restart the instance, if it is currently running). When a user attempts to create a session with the database, Oracle initializes the user's security domain using the database roles identified by the operating system.

To identify database roles for a user, each Oracle user's operating system account must have operating system identifiers (these may be called groups, rights identifiers, or other similar names) that indicate which database roles are to be available for the user. Role specification can also indicate which roles are the default roles of a user and which roles are available with the ADMIN OPTION. No matter which operating system is used, the role specification at the operating system level follows the format:

```
ora_<ID>_<ROLE>[_[d][a]]
```

Where:

**ID**
The definition of ID varies on different operating systems. For example, on VMS, ID is the instance identifier of the database; on MVS, it is the machine type; on UNIX, it is the system ID.

> **Note:** ID is case sensitive to match your ORACLE_SID. ROLE is not case sensitive.

**D**
This optional character indicates that this role is to be a default role of the database user.

**A**
This optional character indicates that this role is to be granted to the user with the ADMIN OPTION. This allows the user to grant the role to other roles only. (Roles cannot be granted to users if the operating system is used to manage roles.)

> **Note:** If either the D or A characters are specified, they must be preceded by an underscore.

For example, an operating system account might have the following roles identified in its profile:

```
ora_PAYROLL_ROLE1
ora_PAYROLL_ROLE2_a
ora_PAYROLL_ROLE3_d
ora_PAYROLL_ROLE4_da
```

When the corresponding user connects to the PAYROLL instance of Oracle, ROLE3 and ROLE4 are defaults, while ROLE2 and ROLE4 are available with the ADMIN OPTION.

## Using Operating System Role Management

When you use operating system managed roles, it is important to note that database roles are being granted to an operating system user. Any database user to which the OS user is able to connect will have the authorized database roles enabled. For this reason, you should consider defining all Oracle users as IDENTIFIED EXTERNALLY if you are using OS_ROLES = TRUE, so that the database accounts are tied to the OS account that was granted privileges.

## Granting and Revoking Roles When OS_ROLES=TRUE

If OS_ROLES is set to TRUE, the operating system completely manages the grants and revokes of roles *to users*. Any previous grants of roles to users via GRANT statements do not apply; however, they are still listed in the data dictionary. Only the role grants made at the operating system level to users apply. Users can still grant privileges to roles and users.

---

**Note:** If the operating system grants a role to a user with the ADMIN OPTION, the user can grant the role only to other roles.

---

## Enabling and Disabling Roles When OS_ROLES=TRUE

If OS_ROLES is set to TRUE, any role granted by the operating system can be dynamically enabled using the SET ROLE statement. If the role was defined to require a password or operating system authorization, that still applies. However, any role not identified in a user's operating system account cannot be specified in a SET ROLE statement, even if a role has been granted using a GRANT statement when OS_ROLES = FALSE. (If you specify such a role, Oracle ignores it.)

When OS_ROLES = TRUE, a user can enable as many roles as specified by the parameter MAX_ENABLED_ROLES.

### Using Network Connections with Operating System Role Management

If you want to have the operating system manage roles, by default users cannot connect to the database through the multi-threaded server. This restriction is the default because a remote user could impersonate another operating system user over a non-secure connection.

If you are not concerned with this security risk and want to use operating system role management with the multi-threaded server, or any other network connection, set the parameter REMOTE_OS_ROLES in the database's parameter file to TRUE. The change will take effect the next time you start the instance and mount the database. (The default setting of this parameter is FALSE.)

## Listing Privilege and Role Information

To list the grants made for objects, a user can query the following data dictionary views:

- ALL_COL_PRIVS, USER_COL_PRIVS, DBA_COL_PRIVS
- ALL_COL_PRIVS_MADE, USER_COL_PRIVS_MADE
- ALL_COL_PRIVS_RECD, USER_COL_PRIVS_RECD
- ALL_TAB_PRIVS, USER_TAB_PRIVS, DBA_TAB_PRIVS
- ALL_TAB_PRIVS_MADE, USER_TAB_PRIVS_MADE
- ALL_TAB_PRIVS_RECD, USER_TAB_PRIVS_RECD
- DBA_ROLES
- USER_ROLE_PRIVS, DBA_ROLE_PRIVS
- USER_SYS_PRIVS, DBA_SYS_PRIVS
- COLUMN_PRIVILEGES
- ROLE_ROLE_PRIVS, ROLE_SYS_PRIVS, ROLE_TAB_PRIVS
- SESSION_PRIVS, SESSION_ROLES

Some examples of using these views follow. For these examples, assume the following statements are issued:

```
CREATE ROLE security_admin IDENTIFIED BY honcho;

GRANT CREATE PROFILE, ALTER PROFILE, DROP PROFILE,
    CREATE ROLE, DROP ANY ROLE, GRANT ANY ROLE, AUDIT ANY,
    AUDIT SYSTEM, CREATE USER, become user, ALTER USER, DROP USER
    TO security_admin WITH ADMIN OPTION;

GRANT SELECT, DELETE ON sys.aud$ TO security_admin;

GRANT security_admin, CREATE SESSION TO swilliams;

GRANT security_admin TO system_administrator;

GRANT CREATE SESSION TO jward;

GRANT SELECT, DELETE ON emp TO jward;

GRANT INSERT (ename, job) ON emp TO swilliams, jward;
```

**See Also:** See the *Oracle8i Reference* for a detailed description of these data dictionary views

## Listing All System Privilege Grants

The following query indicates all system privilege grants made to roles and users:

```
SELECT * FROM sys.dba_sys_privs;

GRANTEE            PRIVILEGE                        ADM
--------------     -------------------------------- ---
SECURITY_ADMIN     ALTER PROFILE                    YES
SECURITY_ADMIN     ALTER USER                       YES
SECURITY_ADMIN     AUDIT ANY                        YES
SECURITY_ADMIN     AUDIT SYSTEM                     YES
SECURITY_ADMIN     BECOME USER                      YES
SECURITY_ADMIN     CREATE PROFILE                   YES
SECURITY_ADMIN     CREATE ROLE                      YES
SECURITY_ADMIN     CREATE USER                      YES
SECURITY_ADMIN     DROP ANY ROLE                    YES
SECURITY_ADMIN     DROP PROFILE                     YES
SECURITY_ADMIN     DROP USER                        YES
SECURITY_ADMIN     GRANT ANY ROLE                   YES
SWILLIAMS          CREATE SESSION                   NO
JWARD              CREATE SESSION                   NO
```

## Listing All Role Grants

The following query returns all the roles granted to users and other roles:

```
SELECT * FROM sys.dba_role_privs;

GRANTEE            GRANTED_ROLE                       ADM
------------------ ---------------------------------- ---
SWILLIAMS          SECURITY_ADMIN                     NO
```

## Listing Object Privileges Granted to a User

The following query returns all object privileges (not including column-specific privileges) granted to the specified user:

```
SELECT table_name, privilege, grantable FROM sys.dba_tab_privs
    WHERE grantee = 'JWARD';

TABLE_NAME   PRIVILEGE    GRANTABLE
-----------  ------------ ----------
EMP          SELECT       NO
EMP          DELETE       NO
```

To list all the column-specific privileges that have been granted, use the following query:

```
SELECT grantee, table_name, column_name, privilege
    FROM sys.dba_col_privs;

GRANTEE      TABLE_NAME     COLUMN_NAME      PRIVILEGE
-----------  ------------   -------------    --------------
SWILLIAMS    EMP            ENAME            INSERT
SWILLIAMS    EMP            JOB              INSERT
JWARD        EMP            NAME             INSERT
JWARD        EMP            JOB              INSERT
```

## Listing the Current Privilege Domain of Your Session

The following query lists all roles currently enabled for the issuer:

```
SELECT * FROM session_roles;
```

If SWILLIAMS has enabled the SECURITY_ADMIN role and issues this query, Oracle returns the following information:

```
ROLE
```

```
------------------------------
SECURITY_ADMIN
```

The following query lists all system privileges currently available in the issuer's security domain, both from explicit privilege grants and from enabled roles:

```
SELECT * FROM session_privs;
```

If SWILLIAMS has the SECURITY_ADMIN role enabled and issues this query, Oracle returns the following results:

```
PRIVILEGE
----------------------------------------
AUDIT SYSTEM
CREATE SESSION
CREATE USER
BECOME USER
ALTER USER
DROP USER
CREATE ROLE
DROP ANY ROLE
GRANT ANY ROLE
AUDIT ANY
CREATE PROFILE
ALTER PROFILE
DROP PROFILE
```

If the SECURITY_ADMIN role is disabled for SWILLIAMS, the first query would have returned no rows, while the second query would only return a row for the CREATE SESSION privilege grant.

## Listing Roles of the Database

The DBA_ROLES data dictionary view can be used to list all roles of a database and the authentication used for each role. For example, the following query lists all the roles in the database:

```
SELECT * FROM sys.dba_roles;

ROLE                  PASSWORD
----------------      --------
CONNECT               NO
RESOURCE              NO
DBA                   NO
SECURITY_ADMIN        YES
```

## Listing Information About the Privilege Domains of Roles

The ROLE_ROLE_PRIVS, ROLE_SYS_PRIVS, and ROLE_TAB_PRIVS data dictionary views contain information on the privilege domains of roles.

For example, the following query lists all the roles granted to the SYSTEM_ADMIN role:

```
SELECT granted_role, admin_option
   FROM role_role_privs
   WHERE role = 'SYSTEM_ADMIN';

GRANTED_ROLE              ADM
----------------          ----
SECURITY_ADMIN            NO
```

The following query lists all the system privileges granted to the SECURITY_ADMIN role:

```
SELECT * FROM role_sys_privs WHERE role = 'SECURITY_ADMIN';

ROLE                     PRIVILEGE                      ADM
------------------------ ------------------------------ ---
SECURITY_ADMIN            ALTER PROFILE                 YES
SECURITY_ADMIN            ALTER USER                    YES
SECURITY_ADMIN            AUDIT ANY                     YES
SECURITY_ADMIN            AUDIT SYSTEM                  YES
SECURITY_ADMIN            BECOME USER                   YES
SECURITY_ADMIN            CREATE PROFILE                YES
SECURITY_ADMIN            CREATE ROLE                   YES
SECURITY_ADMIN            CREATE USER                   YES
SECURITY_ADMIN            DROP ANY ROLE                 YES
SECURITY_ADMIN            DROP PROFILE                  YES
SECURITY_ADMIN            DROP USER                     YES
SECURITY_ADMIN            GRANT ANY ROLE                YES
```

The following query lists all the object privileges granted to the SECURITY_ADMIN role:

```
SELECT table_name, privilege FROM role_tab_privs
    WHERE role = 'SECURITY_ADMIN';

TABLE_NAME                    PRIVILEGE
---------------------------   ----------------
AUD$                          DELETE
AUD$                          SELECT
```

# 24

# Auditing Database Use

This chapter describes how to use the Oracle auditing facilities, and includes the following topics:

- Guidelines for Auditing
- Creating and Deleting the Database Audit Trail Views
- Managing Audit Trail Information
- Viewing Database Audit Trail Information
- Auditing Through Database Triggers

# Guidelines for Auditing

This section describes guidelines for auditing and includes the following topics:

- Audit via the Database or Operating System
- Keep Audited Information Manageable

## Audit via the Database or Operating System

The data dictionary of every database has a table named SYS.AUD$, commonly referred to as the database *audit trail*, that is designed to store records auditing database statements, privileges, or schema objects.

Your operating system can also contain an audit trail that stores audit records generated by the operating system auditing facility. This operating system-specific auditing facility may or may not support database auditing to the operating system audit trail. If this option is available, consider the advantages and disadvantages of using either the database or operating system auditing trail to store database audit records.

Using the database audit trail offers the following advantages:

- You can view selected portions of the audit trail with the predefined audit trail views of the data dictionary.
- You can use Oracle tools (such as Oracle Reports) to generate audit reports.

Alternatively, your operating system audit trail may allow you to consolidate audit records from multiple sources including Oracle and other applications. Therefore, examining system activity might be more efficient because all audit records are in one place.

> **See Also:** Refer to your operating system-specific documentation for information about its auditing capabilities.

## Keep Audited Information Manageable

Although auditing is relatively inexpensive, limit the number of audited events as much as possible. This will minimize the performance impact on the execution of statements that are audited, and minimize the size of the audit trail.

Use the following general guidelines when devising an auditing strategy:

- Evaluate your purpose for auditing.

After you have a clear understanding of the reasons for auditing, you can devise an appropriate auditing strategy and avoid unnecessary auditing.

For example, suppose you are auditing to investigate suspicious database activity. This information by itself is not specific enough. What types of suspicious database activity do you suspect or have you noticed? A more focused auditing purpose might be to audit unauthorized deletions from arbitrary tables in the database. This purpose narrows the type of action being audited and the type of object being affected by the suspicious activity.

- Audit knowledgeably.

  Audit the minimum number of statements, users, or objects required to get the targeted information. This prevents unnecessary audit information from cluttering the meaningful information and consuming valuable space in the SYSTEM tablespace. Balance your need to gather sufficient security information with your ability to store and process it.

  For example, if you are auditing to gather information about database activity, determine exactly what types of activities you are tracking, audit only the activities of interest, and audit only for the amount of time necessary to gather the information you desire. Do not audit objects if you are only interested in each session's logical I/O information.

### Auditing Suspicious Database Activity

When you audit to monitor suspicious database activity, use the following guidelines:

- Audit generally, then specifically.

  When starting to audit for suspicious database activity, it is common that not much information is available to target specific users or schema objects. Therefore, audit options must be set more generally at first. Once preliminary audit information is recorded and analyzed, the general audit options should be turned off and more specific audit options enabled. This process should continue until enough evidence is gathered to make concrete conclusions about the origin of the suspicious database activity.

- Protect the audit trail.

  When auditing for suspicious database activity, protect the audit trail so that audit information cannot be added, changed, or deleted without being audited. For more information and guidance, see "Protecting the Audit Trail" on page 24-16.

### Auditing Normal Database Activity

When your purpose for auditing is to gather historical information about particular database activities, use the following guidelines:

- Audit only pertinent actions.

  To avoid cluttering meaningful information with useless audit records and reduce the amount of audit trail administration, only audit the targeted database activities.

- Archive audit records and purge the audit trail.

  After you have collected the required information, archive the audit records of interest and purge the audit trail of this information.

# Creating and Deleting the Database Audit Trail Views

The database audit trail (SYS.AUD$) is a single table in each Oracle database's data dictionary. To help you view meaningful auditing information in this table, several predefined views are provided. They must be created for you to use auditing; you can later delete them if you decide not to use auditing.

Audit trail views are created automatically when you run the script CATALOG.SQL. The USER views are created by the CATAUDIT.SQL script.

## Creating the Audit Trail Views

The following views are created by the CATALOG.SQL and CATAUDIT scripts:

| View | Description |
|---|---|
| STMT_AUDIT_OPTION_MAP | Contains information about auditing option type codes. |
| AUDIT_ACTIONS | Contains descriptions for audit trail action type codes. |
| ALL_DEF_AUDIT_OPTS | Contains default object-auditing options that will be applied when objects are created. |
| DBA_STMT_AUDIT_OPTS | Describes current system auditing options across the system and by user. |
| DBA_PRIV_AUDIT_OPTS | Describes current system privileges being audited across the system and by user. |

| View | Description |
|---|---|
| DBA_OBJ_AUDIT_OPTS, USER_OBJ_AUDIT_OPTS | Describes auditing options on all objects. USER view describes auditing options on all objects owned by the current user. |
| DBA_AUDIT_TRAIL, USER_AUDIT_TRAIL | Lists all audit trail entries. USER view shows audit trail entries relating to current user. |
| DBA_AUDIT_OBJECT,USER_AUDIT_OBJECT | Contains audit trail records for all objects in the system. USER view lists audit trail records for statements concerning objects that are accessible to the current user. |
| DBA_AUDIT_SESSION, USER_AUDIT_SESSION | Lists all audit trail records concerning CONNECT and DISCONNECT. USER view lists all audit trail records concerning connections and disconnections for the current user. |
| DBA_AUDIT_STATEMENT, USER_AUDIT_STATEMENT | Lists audit trail records concerning GRANT, REVOKE, AUDIT, NOAUDIT, and ALTER SYSTEM statements throughout the database, or for the USER view, issued by the user. |
| DBA_AUDIT_EXISTS | Lists audit trail entries produced by AUDIT EXISTS and AUDIT NOT EXISTS. |

For examples of audit information interpretations, see "Viewing Database Audit Trail Information" on page 24-17.

> **See Also:** For information about these views, see the *Oracle8i Reference*.

### Deleting the Audit Trail Views

If you disable auditing and no longer need the audit trail views, delete them by connecting to the database as SYS and running the script file CATNOAUD.SQL. The name and location of the CATNOAUD.SQL script are operating system-dependent.

## Managing Audit Trail Information

The audit trail records can contain different types of information, depending on the events audited and the auditing options set. The following information is always included in each audit trail record, provided that the information is meaningful to the particular audit action:

- User name
- Session identifier
- Terminal identifier
- Name of the schema object accessed
- Operation performed or attempted
- Completion code of the operation
- Date and time stamp
- System privileges used

Audit trail records written to an operating system audit trail are encoded and not readable, but they can be decoded in data dictionary files and error messages as follows:

| | |
|---|---|
| Action Code | This describes the operation performed or attempted. The AUDIT_ACTIONS data dictionary table contains a list of these codes and their descriptions. |
| Privileges Used | This describes any system privileges used to perform the operation. The SYSTEM_PRIVILEGE_MAP table lists all of these codes and their descriptions. |
| Completion Code | This describes the result of the attempted operation. Successful operations return a value of zero; unsuccessful operations return the Oracle error code describing why the operation was unsuccessful. These codes are listed in *Oracle8i Error Messages*. |

This section describes various aspects of managing audit trail information, and includes the following topics:

- Events Audited by Default
- Setting Auditing Options
- Enabling and Disabling Database Auditing
- Controlling the Growth and Size of the Audit Trail
- Protecting the Audit Trail

## Events Audited by Default

Regardless of whether database auditing is enabled, Oracle will always audit certain database-related actions into the operating system audit trail. These events include the following:

- Instance startup

  An audit record is generated that lists the OS user starting the instance, the user's terminal identifier, the date and time stamp, and whether database auditing was enabled or disabled. This is stored in the OS audit trail because the database audit trail is not available until after startup has successfully completed. Recording the state of database auditing at startup also prevents an administrator from restarting a database with database auditing disabled (so they can perform unaudited actions).

- Instance shutdown

  An audit record is generated that lists the OS user shutting down the instance, the user's terminal identifier, the date and time stamp.

- Connections to the database with administrator privileges

  An audit record is generated that lists the OS user connecting to Oracle as SYSOPER or SYSDBA, to provide accountability of users with administrator privileges.

On operating systems that do not make an audit trail accessible to Oracle, these audit trail records are placed in an Oracle audit trail file in the same directory as background process trace files.

> **See Also:** You use the AUDIT statement to specify statements or schema objects to audit. For additional information on the AUDIT statement, including syntax and required levels of authorization, see *Oracle8i SQL Reference*.

## Setting Auditing Options

Depending on the auditing options set, audit records can contain different types of information. However, all auditing options generate the following information:

- The user that executed the audited statement
- The action code (a number) that indicates the audited statement executed by the user
- The object or objects referenced in the audited statement

- The date and time that the audited statement was executed

The audit trail does not store information about any data values that might be involved in the audited statement. For example, old and new data values of updated rows are not stored when an UPDATE statement is audited. However, this specialized type of auditing can be performed on DML statements involving tables by using database triggers. For examples of trigger usage for this specialized type of auditing, see "Auditing Through Database Triggers" on page 24-20.

Oracle allows you to set audit options at three levels:

| | |
|---|---|
| Statement | Audits on the type of SQL statement used, such as any SQL statement on a table (which records each CREATE, TRUNCATE, and DROP TABLE statement) |
| Privilege | Audits use of a particular system privilege, such as CREATE TABLE |
| Object | Audits specific statements on specific objects, such as ALTER TABLE on the EMP table |

### Statement Audit Options

Valid statement audit options that can be included in AUDIT and NOAUDIT statements are listed in the *Oracle8i SQL Reference*.

### Auditing Connections and Disconnections

The SESSION statement option is unique because it does not generate an audit record when a particular type of statement is issued; this option generates a single audit record for each session created by connections to an instance. An audit record is inserted into the audit trail at connect time and updated at disconnect time. Cumulative information about a session such as connection time, disconnection time, logical and physical I/Os processed, and more is stored in a single audit record that corresponds to the session.

### Privilege Audit Options

Privilege audit options exactly match the corresponding system privileges. For example, the option to audit use of the DELETE ANY TABLE privilege is DELETE ANY TABLE. To turn this option on, you would use a statement similar to the following example:

```
AUDIT DELETE ANY TABLE
    BY ACCESS
```

```
WHENEVER NOT SUCCESSFUL;
```

Oracle's system privileges are listed in the *Oracle8i SQL Reference*.

### Object Audit Options

The *Oracle8i SQL Reference* lists valid object audit options and the schema object types for which each option is available.

### Enabling Audit Options

The AUDIT statement turns on statement and privilege audit options, and object audit options. To use it to set statement and privilege options, you must have the AUDIT SYSTEM privilege. To use it to set object audit options, you must own the object to be audited or have the AUDIT ANY privilege. Audit statements that set statement and privilege audit options can include a BY clause to specify a list of users or application proxies to limit the scope of the statement and privilege audit options.

You can set any auditing option, and specify the following conditions for auditing:

- WHENEVER SUCCESSFUL / WHENEVER NOT SUCCESSFUL
- BY SESSION / BY ACCESS

A new database session picks up auditing options from the data dictionary when the session is created. These auditing options remain in force for the duration of the database connection. Setting new system or object auditing options causes all subsequent database sessions to use these options; existing sessions will continue using the audit options in place at session creation.

---

**WARNING: The AUDIT statement only specifies auditing options; it does not enable auditing as a whole. To turn auditing on and control whether Oracle generates audit records based on the audit options currently set, set the parameter AUDIT_TRAIL in the database's parameter file.**

---

For more information about enabling and disabling auditing, see "Enabling and Disabling Database Auditing" on page 24-13.

**See Also:** For a complete description of the AUDIT statement, see the *Oracle8i SQL Reference*.

**Enabling Statement Privilege Auditing** To audit all successful and unsuccessful connections to and disconnections from the database, regardless of user, BY SESSION (the default and only value for this option), enter the following statement:

```
AUDIT SESSION;
```

You can set this option selectively for individual users also, as in the next example:

```
AUDIT SESSION
BY scott, lori;
```

To audit all successful and unsuccessful uses of the DELETE ANY TABLE system privilege, enter the following statement:

```
AUDIT DELETE ANY TABLE;
```

To audit all unsuccessful SELECT, INSERT, and DELETE statements on all tables and unsuccessful uses of the EXECUTE PROCEDURE system privilege, by all database users, and by individual audited statement, issue the following statement:

```
AUDIT SELECT TABLE, INSERT TABLE, DELETE TABLE,
        EXECUTE PROCEDURE
      BY ACCESS
      WHENEVER NOT SUCCESSFUL;
```

The AUDIT SYSTEM system privilege is required to set any statement or privilege audit option. Normally, the security administrator is the only user granted this system privilege.

**Enabling Object Auditing** To audit all successful and unsuccessful DELETE statements on the SCOTT.EMP table, BY SESSION (the default value), enter the following statement:

```
AUDIT DELETE ON scott.emp;
```

To audit all successful SELECT, INSERT, and DELETE statements on the DEPT table owned by user JWARD, BY ACCESS, enter the following statement:

```
AUDIT SELECT, INSERT, DELETE
     ON jward.dept
     BY ACCESS
     WHENEVER SUCCESSFUL;
```

To set the default object auditing options to audit all unsuccessful SELECT statements, BY SESSION (the default), enter the following statement:

```
AUDIT SELECT
      ON DEFAULT
      WHENEVER NOT SUCCESSFUL;
```

A user can set any object audit option for the objects contained in the user's schema. The AUDIT ANY system privilege is required to set an object audit option for an object contained in another user's schema or to set the default object auditing options; normally, the security administrator is the only user granted this system privilege.

### Auditing in a Multi-Tier Environment

In a multi-tier environment, Oracle preserves the identity of the client through all tiers. This enables auditing of actions taken on behalf of the client. To do so, you use the BY *proxy* clause in your AUDIT statement.

This clause allows you a few options. You can:

- Audit SQL statements issued by the specified proxy on its own behalf.
- Audit statements executed on behalf of a specified user or users.
- Audit all statements executed on behalf of any user.

The following example audits SELECT TABLE statements issued on behalf of client JACKSON by the proxy application server APPSERVE.

```
AUDIT SELECT TABLE
    BY appserve ON BEHALF OF jackson;
```

> **See Also:** See *Oracle8i Concepts* and *Oracle8i Application Developer's Guide - Fundamentals* for more information on proxies and multi-tier applications.

### Disabling Audit Options

The NOAUDIT statement turns off the various audit options of Oracle. Use it to reset statement and privilege audit options, and object audit options. A NOAUDIT statement that sets statement and privilege audit options can include the BY USER option to specify a list of users to limit the scope of the statement and privilege audit options.

You can use a NOAUDIT statement to disable an audit option selectively using the WHENEVER clause. If the clause is not specified, the auditing option is disabled entirely, for both successful and unsuccessful cases.

The BY SESSION / BY ACCESS option pair is *not* supported by the NOAUDIT statement; audit options, no matter how they were turned on, are turned off by an appropriate NOAUDIT statement.

---

**WARNING: The NOAUDIT statement only specifies auditing options; it does not disable auditing as a whole. To turn auditing off and stop Oracle from generating audit records, even though you have audit options currently set, set the parameter AUDIT_TRAIL in the database's parameter file.**

---

**See Also:** For a complete syntax listing of the NOAUDIT statement, see the *Oracle8i SQL Reference.*

### Disabling Statement and Privilege Auditing

The following statements turn off the corresponding audit options:

```
NOAUDIT session;
NOAUDIT session BY scott, lori;
NOAUDIT DELETE ANY TABLE;
NOAUDIT SELECT TABLE, INSERT TABLE, DELETE TABLE,
    EXECUTE PROCEDURE;
```

The following statements turn off all statement (system) and privilege audit options:

```
NOAUDIT ALL;
NOAUDIT ALL PRIVILEGES;
```

To disable statement or privilege auditing options, you must have the AUDIT SYSTEM system privilege.

**Disabling Object Auditing** The following statements turn off the corresponding auditing options:

```
NOAUDIT DELETE
   ON emp;
NOAUDIT SELECT, INSERT, DELETE
   ON jward.dept;
```

Furthermore, to turn off all object audit options on the EMP table, enter the following statement:

```
NOAUDIT ALL
```

```
   ON emp;
```

**Disabling Default Object Audit Options** To turn off all default object audit options, enter the following statement:

```
NOAUDIT ALL
   ON DEFAULT;
```

Note that all schema objects created before this NOAUDIT statement is issued continue to use the default object audit options in effect at the time of their creation, unless overridden by an explicit NOAUDIT statement after their creation.

To disable object audit options for a specific object, you must be the owner of the schema object. To disable the object audit options of an object in another user's schema or to disable default object audit options, you must have the AUDIT ANY system privilege. A user with privileges to disable object audit options of an object can override the options set by any user.

## Enabling and Disabling Database Auditing

Any authorized database user can set statement, privilege, and object auditing options at any time, but Oracle does not generate and store audit records in the audit trail unless database auditing is enabled. The security administrator is normally responsible for this operation.

Database auditing is enabled and disabled by the AUDIT_TRAIL initialization parameter in the database's parameter file. The parameter can be set to the following values:

| | |
|---|---|
| DB | Enables database auditing and directs all audit records to the database audit trail |
| OS | Enables database auditing and directs all audit records to the operating system audit trail |
| NONE | Disables auditing (This value is the default.) |

The AUDIT_FILE_DEST initialization parameter can be used to specify the directory where auditing files are stored.

If you edit the parameter file, restart the database instance to enable or disable database auditing as intended. These parameters are not dynamic.

> **See Also:** For more information these initialization parameters and about editing parameter files, see the *Oracle8i Reference*.

## Controlling the Growth and Size of the Audit Trail

If the audit trail becomes completely full and no more audit records can be inserted, audited statements cannot be successfully executed until the audit trail is purged. Warnings are returned to all users that issue audited statements. Therefore, the security administrator must control the growth and size of the audit trail.

When auditing is enabled and audit records are being generated, the audit trail grows according to two factors:

- The number of audit options turned on
- The frequency of execution of audited statements

To control the growth of the audit trail, you can use the following methods:

- Enable and disable database auditing. If it is enabled, audit records are generated and stored in the audit trail; if it is disabled, audit records are not generated.
- Be very selective about the audit options that are turned on. If more selective auditing is performed, useless or unnecessary audit information is not generated and stored in the audit trail.
- Tightly control the ability to perform object auditing. This can be done two different ways:

  1. A security administrator owns all objects and the AUDIT ANY system privilege is never granted to any other user. Alternatively, all schema objects can belong to a schema for which the corresponding user does not have CREATE SESSION privilege.
  2. All objects are contained in schemas that do not correspond to real database users (that is, the CREATE SESSION privilege is not granted to the corresponding user) and the security administrator is the only user granted the AUDIT ANY system privilege.

  In both scenarios, object auditing is controlled entirely by the security administrator.

The maximum size of the database audit trail (SYS.AUD$ table) is predetermined during database creation. By default, up to 99 extents, each 10K in size, can be allocated for this table.You should not move SYS.AUD$ to another tablespace as a means of controlling the growth and size of the audit trail. However, you can modify the default storage parameters in SYS.AUD$.

**Note:** Moving the SYS.AUD$ table out of the SYSTEM tablespace is not supported because the Oracle code makes implicit assumptions about the data dictionary tables such as SYS.AUD$, which could cause problems with upgrades and backup / recovery scenarios.

**See Also:** If you are directing audit records to the operating system audit trail, see your operating system-specific Oracle documentation for more information about managing the operating system audit trail.

### Purging Audit Records from the Audit Trail

After auditing is enabled for some time, the security administrator may want to delete records from the database audit trail both to free audit trail space and to facilitate audit trail management.

For example, to delete *all* audit records from the audit trail, enter the following statement:

```
DELETE FROM sys.aud$;
```

Alternatively, to delete all audit records from the audit trail generated as a result of auditing the table EMP, enter the following statement:

```
DELETE FROM sys.aud$
     WHERE obj$name='EMP';
```

If audit trail information must be archived for historical purposes, the security administrator can copy the relevant records to a normal database table (for example, using "INSERT INTO table SELECT...FROM sys.aud$ ...") or export the audit trail table to an operating system file.

Only the user SYS, a user who has the DELETE ANY TABLE privilege, or a user to whom SYS has granted DELETE privilege on SYS.AUD$ can delete records from the database audit trail.

**Note:** If the audit trail is completely full and connections are being audited (that is, if the SESSION option is set), typical users cannot connect to the database because the associated audit record for the connection cannot be inserted into the audit trail. In this case, the security administrator must connect as SYS (operations by SYS are not audited) and make space available in the audit trail.

**See Also:** For information about exporting tables, see *Oracle8i Utilities*.

### Reducing the Size of the Audit Trail

As with any database table, after records are deleted from the database audit trail, the extents allocated for this table still exist.

If the database audit trail has many extents allocated for it, but many of them are not being used, the space allocated to the database audit trail can be reduced using the following steps:

1. If you want to save information currently in the audit trail, copy it to another database table or export it using the EXPORT utility.
2. Connect as with administrator privileges.
3. Truncate SYS.AUD$ using the TRUNCATE statement.
4. Reload archived audit trail records generated from step 1.

The new version of SYS.AUD$ is allocated only as many extents as are necessary to contain current audit trail records.

**Note:** SYS.AUD$ is the only SYS object that should ever be directly modified.

## Protecting the Audit Trail

When auditing for suspicious database activity, protect the integrity of the audit trail's records to guarantee the accuracy and completeness of the auditing information.

To protect the database audit trail from unauthorized deletions, grant the DELETE ANY TABLE system privilege to security administrators only.

To audit changes made to the database audit trail, use the following statement:

```
AUDIT INSERT, UPDATE, DELETE
    ON sys.aud$
    BY ACCESS;
```

Audit records generated as a result of object audit options set for the SYS.AUD$ table can only be deleted from the audit trail by someone connected with administrator privileges, which itself has protection against unauthorized use. As a final measure of protecting the audit trail, any operation performed while connected with administrator privileges is audited in the operating system audit trail, if available.

> **See Also:** For more information about the availability of an operating system audit trail and possible uses, see your operating system-specific Oracle documentation.

## Viewing Database Audit Trail Information

This section offers examples that demonstrate how to examine and interpret the information in the audit trail. Consider the following situation.

You would like to audit the database for the following suspicious activities:

- Passwords, tablespace settings, and quotas for some database users are being altered without authorization.
- A high number of deadlocks are occurring, most likely because of users acquiring exclusive table locks.
- Rows are arbitrarily being deleted from the EMP table in SCOTT's schema.

You suspect the users JWARD and SWILLIAMS of several of these detrimental actions.

To enable your investigation, you issue the following statements (in order):

```
AUDIT ALTER, INDEX, RENAME ON DEFAULT
    BY SESSION;
CREATE VIEW scott.employee AS SELECT * FROM scott.emp;
AUDIT SESSION BY jward, swilliams;
AUDIT ALTER USER;
AUDIT LOCK TABLE
    BY ACCESS
    WHENEVER SUCCESSFUL;
AUDIT DELETE ON scott.emp
```

```
    BY ACCESS
    WHENEVER SUCCESSFUL;
```

The following statements are subsequently issued by the user JWARD:

```
ALTER USER tsmith QUOTA 0 ON users;
DROP USER djones;
```

The following statements are subsequently issued by the user SWILLIAMS:

```
LOCK TABLE scott.emp IN EXCLUSIVE MODE;
DELETE FROM scott.emp WHERE mgr = 7698;
ALTER TABLE scott.emp ALLOCATE EXTENT (SIZE 100K);
CREATE INDEX scott.ename_index ON scott.emp (ename);
CREATE PROCEDURE scott.fire_employee (empid NUMBER) AS
  BEGIN
    DELETE FROM scott.emp WHERE empno = empid;
  END;
/

EXECUTE scott.fire_employee(7902);
```

The following sections show the information that can be listed using the audit trail views in the data dictionary:

- Listing Active Statement Audit Options
- Listing Active Privilege Audit Options
- Listing Active Object Audit Options for Specific Objects
- Listing Default Object Audit Options
- Listing Audit Records
- Listing Audit Records for the AUDIT SESSION Option

## Listing Active Statement Audit Options

The following query returns all the statement audit options that are set:

```
SELECT * FROM sys.dba_stmt_audit_opts;

USER_NAME            AUDIT_OPTION         SUCCESS         FAILURE
-------------------- -------------------- ----------      ---------
JWARD                SESSION              BY SESSION      BY SESSION
SWILLIAMS            SESSION              BY SESSION      BY SESSION
                     LOCK TABLE           BY ACCESS       NOT SET
```

Notice that the view reveals the statement audit options set, whether they are set for success or failure (or both), and whether they are set for BY SESSION or BY ACCESS.

## Listing Active Privilege Audit Options

The following query returns all the privilege audit options that are set:

```
SELECT * FROM sys.dba_priv_audit_opts;

USER_NAME           PRIVILEGE            SUCCESS      FAILURE
------------------- -------------------- ---------    ----------
ALTER USER          BY SESSION           BY SESSION
```

## Listing Active Object Audit Options for Specific Objects

The following query returns all audit options set for any objects contained in SCOTT's schema:

```
SELECT * FROM sys.dba_obj_audit_opts
    WHERE owner = 'SCOTT' AND object_name LIKE 'EMP%';

OWNER OBJECT_NAME OBJECT_TY ALT AUD COM DEL GRA IND INS LOC ...
----- ----------- --------- --- --- --- --- --- --- --- --- ...
SCOTT EMP         TABLE     S/S -/- -/- A/- -/- S/S -/- -/- ...
SCOTT EMPLOYEE    VIEW      -/- -/- -/- A/- -/- S/S -/- -/- ...
```

Notice that the view returns information about all the audit options for the specified object. The information in the view is interpreted as follows:

- The character "-" indicates that the audit option is not set.
- The character "S" indicates that the audit option is set, BY SESSION.
- The character "A" indicates that the audit option is set, BY ACCESS.
- Each audit option has two possible settings, WHENEVER SUCCESSFUL and WHENEVER NOT SUCCESSFUL, separated by "/". For example, the DELETE audit option for SCOTT.EMP is set BY ACCESS for successful delete statements and not set at all for unsuccessful delete statements.

## Listing Default Object Audit Options

The following query returns all default object audit options:

```
SELECT * FROM all_def_audit_opts;

ALT AUD COM DEL GRA IND INS LOC REN SEL UPD REF EXE
--- --- --- --- --- --- --- --- --- --- --- --- ---
S/S -/- -/- -/- -/- S/S -/- -/- S/S -/- -/- -/- -/-
```

Notice that the view returns information similar to the USER_OBJ_AUDIT_OPTS and DBA_OBJ_AUDIT_OPTS views (see previous example).

### Listing Audit Records

The following query lists audit records generated by statement and object audit options:

```
SELECT * FROM sys.dba_audit_object;
```

### Listing Audit Records for the AUDIT SESSION Option

The following query lists audit information corresponding to the AUDIT SESSION statement audit option:

```
SELECT username, logoff_time, logoff_lread, logoff_pread,
    logoff_lwrite, logoff_dlock
    FROM sys.dba_audit_session;

USERNAME   LOGOFF_TI LOGOFF_LRE LOGOFF_PRE LOGOFF_LWR LOGOFF_DLO
---------- --------- ---------- ---------- ---------- ----------
JWARD      02-AUG-91         53          2         24          0
SWILLIAMS  02-AUG-91       3337        256        630          0
```

## Auditing Through Database Triggers

You can use triggers to supplement the built-in auditing features of Oracle. Although you can write triggers to record information similar to that recorded by the AUDIT statement, do so only when you need more detailed audit information. For example, you can use triggers to provide value-based auditing on a per-row basis for tables.

---

**Note:** In some fields, the Oracle AUDIT statement is considered a *security* audit facility, while triggers can provide a *financial* audit facility.

---

When deciding whether to create a trigger to audit database activity, consider the advantages that the standard Oracle database auditing features provide compared to auditing by triggers:

- Standard auditing options cover DML and DDL statements regarding all types of schema objects and structures.
- All database audit information is recorded centrally and automatically using the auditing features of Oracle.
- Auditing features enabled using the standard Oracle features are easier to declare and maintain and less prone to errors than are auditing functions defined through triggers.
- Any changes to existing auditing options can also be audited to guard against malicious database activity.
- Using the database auditing features, you can generate records once every time an audited statement is issued (BY ACCESS) or once for every session that issues an audited statement (BY SESSION). Triggers cannot audit by session; an audit record is generated each time a trigger-audited table is referenced.
- Database auditing can audit unsuccessful data access. In comparison, any audit information generated by a trigger is rolled back if the triggering statement is rolled back.
- Connections and disconnections, as well as session activity (such as physical I/Os, logical I/Os, and deadlocks), can be recorded by standard database auditing.

When using triggers to provide sophisticated auditing, normally use AFTER triggers. By using AFTER triggers, you record auditing information after the triggering statement is subjected to any applicable integrity constraints, preventing cases where audit processing is carried out unnecessarily for statements that generate exceptions to integrity constraints.

When you should use AFTER row as opposed to AFTER statement triggers depends on the information being audited. For example, row triggers provide value-based auditing on a per-row basis for tables. Triggers can also allow the user to supply a "reason code" for issuing the audited SQL statement, which can be useful in both row and statement-level auditing situations.

The following trigger audits modifications to the EMP table on a per-row basis. It requires that a "reason code" be stored in a global package variable before the update. The trigger demonstrates the following:

- How triggers can provide value-based auditing

- How to use public package variables

Comments within the code explain the functionality of the trigger.

```
CREATE TRIGGER audit_employee
AFTER INSERT OR DELETE OR UPDATE ON emp
FOR EACH ROW
BEGIN
/* AUDITPACKAGE is a package with a public package
   variable REASON. REASON could be set by the
   application by a command such as EXECUTE
   AUDITPACKAGE.SET_REASON(reason_string). Note that a
   package variable has state for the duration of a
   session and that each session has a separate copy of
   all package variables. */
IF auditpackage.reason IS NULL THEN
   raise_application_error(-20201,'Must specify reason with ',
   'AUDITPACKAGE.SET_REASON(reason_string)');
END IF;

/* If the above conditional evaluates to TRUE, the
    user-specified error number and message is raised,
    the trigger stops execution, and the effects of the
    triggering statement are rolled back. Otherwise, a
    new row is inserted into the pre-defined auditing
    table named AUDIT_EMPLOYEE containing the existing
    and new values of the EMP table and the reason code
    defined by the REASON variable of AUDITPACKAGE. Note
    that the "old" values are NULL if triggering
    statement is an INSERT and the "new" values are NULL
    if the triggering statement is a DELETE. */
INSERT INTO audit_employee VALUES
    (:old.ssn, :old.name, :old.job_classification, :old.sal,
    :new.ssn, :new.name, :new.job_classification, :new.sal,
    auditpackage.reason, user, sysdate );
END;
```

Optionally, you can also set the reason code back to NULL if you want to force the reason code to be set for every update. The following AFTER statement trigger sets the reason code back to NULL after the triggering statement is executed:

```
CREATE TRIGGER audit_employee_reset
   AFTER INSERT OR DELETE OR UPDATE ON emp
BEGIN
   auditpackage.set_reason(NULL);
END;
```

The previous two triggers are both fired by the same type of SQL statement. However, the AFTER row trigger is fired once for each row of the table affected by the triggering statement, while the AFTER statement trigger is fired only once after the triggering statement execution is completed.

# Part VI

# Database Resource Management

Part VI discusses database resource management. It includes the following chapter:

- Chapter 25, "The Database Resource Manager"

# 25

# The Database Resource Manager

Oracle8i provides database resource management capability through its Database Resource Manager. This chapter introduces you to its use.

The following topics are included:

# What is the Database Resource Manager?

Typically, 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 servers when the number of servers is high.

- Inefficient scheduling

  The operating system de-schedules Oracle servers while they hold latches, which is inefficient.

- Poor allocation of resources

  The operating system fails to allocate CPU resources appropriately among tasks of varying importance.

- Inability to manage database-specific resources, such as parallel slaves and active sessions

Oracle's Database Resource Manager helps to overcome these problems by allowing the database more control over how machine resources are allocated.

Specifically, using the Database Resource Manager, you can:

- Guarantee certain users 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 may be given to ROLAP applications than to batch jobs.
- Limit the degree of parallelism that a set of users can use.
- Configure an instance to use a particular method of allocating resources. A DBA can dynamically change the method, for example, from a daytime setup to a nighttime setup, without having to shut down and restart the instance.

The elements of Oracle's database resource management, which you define through the Database Resource Manager packages, are described below.

| Element | Description |
|---|---|
| Resource consumer group | User sessions grouped together based on resource processing requirements. |

| Element | Description |
|---|---|
| Resource plan | Contains directives that specify which resources are allocated to resource consumer groups. |
| Resource allocation method | The method / policy used by Database Resource Manager when allocating for a particular resource; used by resource consumer groups and resource plans. |
| Resource plan directive | Used by administrators to associate resource consumer groups with particular plans and allocate resources among resource consumer groups. |

You will learn how to create and use these elements in the remaining sections of this chapter:

- Administering the Database Resource Manager
- Creating and Managing Resource Plans
- Managing Resource Consumer Groups
- Enabling the Database Resource Manager
- Putting it All Together: Examples
- Database Resource Manager Views

> **See Also:** For detailed conceptual information about the Database Resource Manager, see *Oracle8i Concepts*. Before attempting to use the Database Resource Manager it is recommended you read the related material contained in that book.

## Administering the Database Resource Manager

You must have the system privilege ADMINISTER_RESOURCE_MANAGER to administer the Database Resource Manager. Typically, database administrators have this privilege with the ADMIN option as part of the DBA (or equivalent) role.

Being an administrator for the Database Resource Manager allows you to execute all of the procedures in the DBMS_RESOURCE_MANAGER package. These are listed in table Table 25–1, and their use is explained is succeeding sections of this chapter.

***Table 25–1 DBMS_RESOURCE_MANAGER Procedures***

| Procedure | Description |
|---|---|
| CREATE_PLAN | Names a resource plan and specifies its allocation methods. |
| UPDATE_PLAN | Updates a resource plan's comment. |
| DELETE_PLAN | Deletes a resource plan and its directives. |
| DELETE_PLAN_CASCADE | Deletes a resource plan and all of its descendents. |
| CREATE_CONSUMER_GROUP | Names a resource consumer group and specifies its allocation method. |
| UPDATE_CONSUMER_GROUP | Updates a consumer group's comment. |
| DELETE_CONSUMER_GROUP | Deletes a consumer group. |
| CREATE_PLAN_DIRECTIVE | Specifies the resource plan directives that allocate resources to resource consumer groups within a plan or among subplans in a multilevel *plan schema*. |
| 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 to a plan schema. |
| SET_INITIAL_CONSUMER_GROUP | Sets the initial consumer group for a user. |
| 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. |

The use of these procedures will be explained later in this chapter.

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 package. This package contains the procedures listed in table Table 25–2.

*Table 25–2 DBMS_RESOURCE_MANAGER_PRIVS Procedures*

| Procedure | Description |
|---|---|
| GRANT_SYSTEM_PRIVILEGE | Grants ADMINISTER_RESOURCE_MANAGER system privilege to a user or role. |
| REVOKE_SYSTEM_PRIVILEGE | Revokes ADMINISTER_RESOURCE_MANAGER system privilege to a user or role. |
| 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. |

The following example, grants the administrative privilege to user SCOTT, but does not grant SCOTT the ADMIN option. Therefore, SCOTT will be able to 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.

```
EXEC DBMS_RESOURCE_MANAGER_PRIVS.GRANT_SYSTEM_PRIVILEGE -
    (GRANTEE_NAME => 'scott', PRIVILEGE_NAME => 'ADMINISTER_RESOURCE_MANAGER', -
     ADMIN_OPTION => FALSE);
```

You can revoke this privilege using the REVOKE_SYSTEM_PRVILEGE procedure.

---

**Note:** The ADMINISTER_RESOURCE_MANAGER system privilege can only be granted or revoked by using the DBMS_ RESOURCE_MANAGER_PRIVS package. It cannot be granted through the SQL GRANT or REVOKE statements.

---

The other procedures in the DBMS_RESOURCE_MANAGER_PRIVS package are discussed in "Granting the Switch Privilege" on page 25-16.

**See Also:** Refer to the *Oracle8i Supplied PL/SQL Packages Reference.* for detailed information on the Database Resource Manager packages:

- DBMS_RESOURCE_MANAGER
- DBMS_RESOURCE_MANAGER_PRIVS

# Creating and Managing Resource Plans

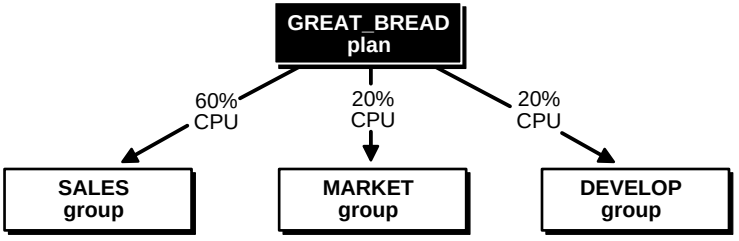
Resource plans specify the resource consumer groups belonging to the plan and contain directives for how resources are to be allocated among these groups. You use the DBMS_RESOURCE_MANAGER package to create and maintain the elements of the Database Resource Manager: resource consumer groups, resource plan directives, and resource plans. Plan information is stored in tables in the data dictionary. Several views are available for viewing plan data.

You also use this package to assign an initial consumer group to a user, and to switch the consumer group for a particular session or user. These are discussed in "Managing Resource Consumer Groups" on page 25-14.

The following are examples of very simple resource plans. A more complex plan is presented later in this chapter, after it has been explained how to build and maintain the elements.

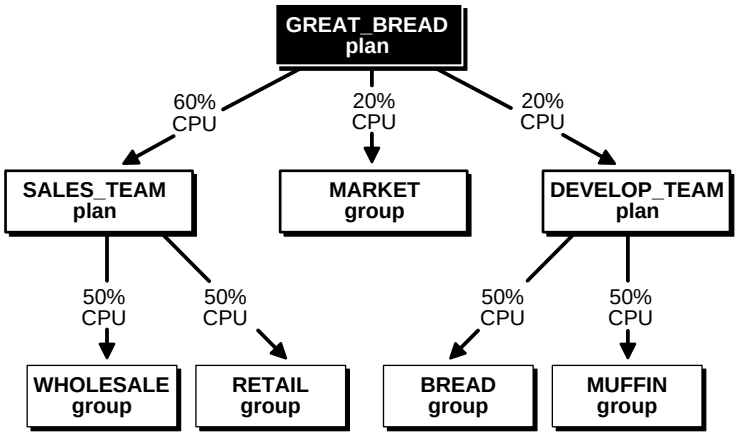
The first example, shown in Figure 25–1, is of a single-level plan, where the plan allocates resources among resource consumer groups. The Great Bread Company has a plan called GREAT_BREAD that allocates CPU resources among three resource consumer groups. Specifically, SALES is allotted 60% of the CPU time, MARKET[ing] is allotted 20%, and DEVELOP[ment] receives the remaining 20%.

***Figure 25–1 A Simple Plan***




But a plan can not only contain resource consumer groups, it can also contain other plans, called *subplans*. Maybe the Great Bread Company chooses to divide their CPU resource as shown in Figure 25–2.

***Figure 25–2 A Simple Plan With Subplans***




In this case, the GREAT_BREAD plan still allocates CPU resources to the consumer group MARKET, but now it allocates CPU resources to subplans SALES_TEAM and MARKET_TEAM, who in turn allocate resources to consumer groups. Figure 25–2 illustrates a *plan schema*, which contains a *top plan* (GREAT_BREAD) and all of its descendents.

It is possible for a subplan or consumer group to have more than one parent (owning plan), but there cannot be any loops in a plan schema. An example of a subplan having more that one parent would be if the Great Bread Company had a night plan and a day plan. Both the night plan and the day plan contain the SALES subplan as a member, but perhaps with a different CPU resource allocation in each instance.

---

**Note:** As explained later, the above plans should also contain a plan directive for OTHER_GROUPS. To present a simplified view, however, this plan directive is not shown.

---

## Using the Pending Area for Creating Plan Schemas

The first thing you must do to create or modify plan schemas is to create a *pending area*. This is a scratch area allowing you to stage your changes and to validate them before they are made active.

### Creating a Pending Area

To create a pending area, you use the following statement:

```
EXEC DBMS_RESOURCE_MANAGER.CREATE_PENDING_AREA;
```

In effect, what is really happening here is that you are making the pending area active and "loading" all existing, or active, plan schemas into the pending area so that they can be updated or new plans added. Active plan schemas are those schemas already stored in the data dictionary for use by the Database Resource Manager. If you attempt to update a plan or add a new plan without first activating (creating) the pending area, you will receive an error message notifying you that the pending area is not active.

Views are available for inspecting all active resource plan schemas as well as the pending ones. These views are listed in Database Resource Manager Views on page 25-21.

### Validating Changes

At any time when you are making changes in the pending area you can call the validate procedure as shown here.

```
EXEC DBMS_RESOURCE_MANAGER.VALIDATE_PENDING_AREA;
```

This procedure checks whether changes that have been made are valid. The following rules must be adhered to, and are checked by the validate procedure.

1. No plan schema can contain any loops.
2. All plan and / or resource consumer groups referred to by plan directives must exist.
3. All plans must have plan directives that point to either plans or resource consumer groups.
4. All percentages in any given level must not add up to greater than 100 for the EMPHASIS resource allocation method.
5. A plan that is currently being used as a top plan by an active instance cannot be deleted.
6. The plan directive parameter PARALLEL_DEGREE_LIMIT_P1 can appear only in plan directives that refer to resource consumer groups (not other resource plans).
7. There can be no more than 32 resource consumer groups in any active plan schema. Also, at most, a plan can have 32 children. All leaves of a top plan must

be resource consumer groups; at the lowest level in a plan schema the plan directives must refer to consumer groups.

8. Plans and resource consumer groups cannot have the same name.
9. There must be a plan directive for OTHER_GROUPS somewhere in any active plan schema. This ensures that a session not covered by the currently active plan is allocated resources as specified by the OTHER_GROUPS directive.

You will receive an error message if any of the above rules are not adhered to. You can then make changes to fix the problem(s) and again call the validate procedure.

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 may be part of some plan to be implemented in the future.

### Submitting Changes

After you have validated your changes, you call the submit procedure to make your changes active.

```
EXEC DBMS_RESOURCE_MANAGER.SUBMIT_PENDING_AREA;
```

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 plan schemas, debugging problems is often easier if you incrementally validate your changes.

The SUBMIT_PENDING_AREA procedure clears (deactivates) the pending area after successfully validating and committing the changes.

---

**Note:** A call to SUBMIT_PENDING_AREA may 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.

---

### Clearing the Pending Area

There is also a procedure for clearing the pending area at any time. This statement causes all of your changes to be aborted.

```
EXEC DBMS_RESOURCE_MANAGER.CLEAR_PENDING_AREA;
```

You must call the CREATE_PENDING_AREA procedure before you can again attempt to make changes.

## Creating Resource Plans

When you create a resource plan, you can specify the following parameters:

| Parameter | Description |
|---|---|
| PLAN | Name of the plan. |
| COMMENT | Any comment. |
| CPU_MTH | CPU resource allocation method. EMPHASIS is the default and the only method as of this Oracle release. |
| MAX_ACTIVE_SESS_TARGET_MTH | Reserved for a future release. |
| PARALLEL_DEGREE_LIMIT_MTH | The resource allocation method for specifying a limit on the degree of parallelism of any operation. The default is PARALLEL_DEGREE_LIMIT_ABSOLUTE. |

Oracle provides one resource plan, SYSTEM_PLAN, that contains a simple structure that may be adequate for some environments. It is illustrated later in "An Oracle Supplied Plan" on page 25-20.

### Creating a Plan

You create a plan using the CREATE_PLAN procedure. The following creates a plan called GREAT_BREAD.

```
EXEC DBMS_RESOURCE_MANAGER.CREATE_PLAN(PLAN => 'great_bread', -
    COMMENT => 'great plan');
```

### Updating a Plan

Use the UPDATE_PLAN procedure to update plan information. If you do not specify the arguments for the UPDATE_PLAN procedure, they remain unchanged in the data dictionary. The following statement updates the COMMENT parameter.

```
EXEC DBMS_RESOURCE_MANAGER.UPDATE_PLAN(PLAN => 'great_bread', -
     NEW_COMMENT => 'great plan for great bread');
```

### Deleting a Plan

The DELETE_PLAN procedure deletes the specified plan as well as all the plan directives associated with it. The following statement deletes the GREAT_BREAD plan and its directives.

```
EXEC DBMS_RESOURCE_MANAGER.DELETE_PLAN(PLAN => 'great_bread');
```

The resource consumer groups themselves 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, subplans, resource consumer groups). If DELETE_PLAN_CASCADE encounters an error, it will roll back, leaving the plan schema unchanged.

## Creating Resource Consumer Groups

When you create a resource consumer group, you can specify the following parameters:

| Parameter | Description |
|---|---|
| CONSUMER_GROUP | Name of the consumer group. |
| COMMENT | Any comment. |
| CPU_MTH | The CPU resource allocation method for consumer groups. The default is ROUND-ROBIN. This is the only method currently available for resource consumer groups. |

There are two special consumer groups that are always present in the data dictionary, and they cannot be modified or deleted. These are:

- OTHER_GROUPS

  This group applies to all sessions that belong to a consumer group that is not part of the currently active plan schema. OTHER_GROUPS must have a resource directive specified in the schema of any active plan.

- DEFAULT_CONSUMER_GROUP

  This is the initial consumer group for all users/sessions that have not been explicitly assigned an initial consumer group. DEFAULT_CONSUMER_GROUP has switch privileges granted to PUBLIC; therefore, all users are

automatically granted switch privilege for this consumer group (see "Granting the Switch Privilege" on page 25-16).

Additionally, two other groups, SYS_GROUP and LOW_GROUP, are provided as part of the Oracle supplied SYSTEM_PLAN that is described in "An Oracle Supplied Plan" on page 25-20.

### Creating a Consumer Group

You create a consumer group using the CREATE_CONSUMER_GROUP procedure. The following creates a consumer group called SALES. Remember, the pending area must be active to execute this statement successfully.

```
EXEC DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP (CONSUMER_GROUP => 'sales', -
    COMMENT => 'retail and wholesale sales');
```

### Updating a Consumer Group

Use the UPDATE_CONSUMER_GROUP procedure to update consumer group information. 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. Upon deletion of a consumer group, all users having the deleted group as their initial consumer group will have the DEFAULT_CONSUMER_GROUP set as their initial consumer group. All currently running sessions belonging to a deleted consumer group will be switched to DEFAULT_CONSUMER_GROUP.

## Specifying Resource Plan Directives

Resource plan directives assign consumer groups to resource plans and provide the parameters for each resource allocation method. When you create a resource plan directive, you specify the following parameters:

| Parameter | Description |
|---|---|
| PLAN | Name of the resource plan. |
| GROUP_OR_SUBPLAN | Name of the consumer group or subplan. |
| COMMENT | Any comment. |
| CPU_P1 | Specifies CPU percentage at the first level. |

| Parameter | Description |
|---|---|
| CPU_P2 | Specifies CPU percentage at the second level. |
| CPU_P3 | Specifies CPU percentage at the third level. |
| CPU_P4 | Specifies CPU percentage at the fourth level. |
| CPU_P5 | Specifies CPU percentage at the fifth level. |
| CPU_P6 | Specifies CPU percentage at the sixth level. |
| CPU_P7 | Specifies CPU percentage at the seventh level. |
| CPU_P8 | Specifies CPU percentage at the eighth level. |
| MAX_ACTIVE_SESS_TARGET_P1 | Reserved for future use. |
| PARALLEL_DEGREE_LIMIT_P1 | Sets a limit on the degree of parallelism for any operation. |

The multiple levels of CPU resource allocation provide a means of prioritizing CPU usage within a plan schema. Level 2 gets resources only after level 1 is unable to use all of its resources. Note that no consumer group is allowed to use more than the specified percentage of available CPU. 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.

### Creating a Resource Plan Directive

You use the CREATE_PLAN_DIRECTIVE to create a resource plan directive. The following statement creates a resource plan directive for plan GREAT_BREAD.

```
EXEC DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE (PLAN => 'great_bread', -
     GROUP_OR_SUBPLAN => 'sales', COMMENT => 'sales group', -
     CPU_P1 => 60, PARALLEL_DEGREE_LIMIT_P1 => 4);
```

To complete the plan, similar to that shown in Figure 25–1, you would also execute the following statements:

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE (PLAN => 'great_bread',
     GROUP_OR_SUBPLAN => 'market', COMMENT => 'marketing group',
     CPU_P1 => 20);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE (PLAN => 'great_bread',
     GROUP_OR_SUBPLAN => 'develop', COMMENT => 'development group',
     CPU_P1 => 20);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE (PLAN => 'great_bread',
```

```
     GROUP_OR_SUBPLAN => 'OTHER_GROUPS', COMMENT => 'this one is required',
     CPU_P1 => 0, CPU_P2 => 100);
END;
```

In this plan, consumer group SALES has a maximum degree of parallelism for any operation of 4, while none of the other consumer groups are limited in their degree of parallelism. Also, whenever there are leftover level 1 CPU resources, they are allocated (100%) to OTHER_GROUPS.

### Updating Resource Plan Directives

Use the UPDATE_PLAN_DIRECTIVE procedure to update plan directives. This example changes CPU allocation for resource consumer group DEVELOP.

```
EXEC DBMS_RESOURCE_MANAGER.UPDATE_PLAN_DIRECTIVE (PLAN => 'great_bread', -
     GROUP_OR_SUBPLAN => 'develop', NEW_CPU_P1 => 15);
```

If you do not specify the arguments for the `UPDATE_PLAN_DIRECTIVE` procedure, they remain unchanged in the data dictionary.

### Deleting Resource Plan Directives

To delete a resource plan directive, use the DELETE_PLAN_DIRECTIVE procedure.

## Managing Resource Consumer Groups

Before you enable the Database Resource Manager, you must assign resource consumer groups to users. In addition to providing procedures to create, update, or delete the elements used by the Database Resource Manager, the DBMS_RESOURCE_MANAGER package contains the procedure to assign resource consumer groups to users. It also provides procedures that allow you to temporarily switch a user session to another consumer group.

The DBMS_RESOURCE_MANAGER_PRIVS package, described earlier for granting the Database Resource Manager system privilege, can also be used to grant the switch privilege to another user, who can then alter their own consumer group.

You do not use a pending area for any of the procedures discussed below.

### Assigning an Initial Resource Consumer Group

The initial consumer group of a user is the consumer group to which any session created by that user initially belongs. If you have not set the initial consumer group

for a user, the user's initial consumer group will automatically be the consumer group DEFAULT_CONSUMER_GROUP.

You must grant switch privilege to a consumer group directly to the user or PUBLIC before that consumer group can be the user's initial consumer group (see "Granting the Switch Privilege" on page 25-16). The switch privilege for the initial consumer group cannot come from a role granted to that user.

The following statements illustrate setting a user's initial consumer group.

```
EXEC DBMS_RESOURCE_MANAGER_PRIVS.GRANT_SWITCH_CONSUMER_GROUP ('scott', 'sales',-
    TRUE);
EXEC DBMS_RESOURCE_MANAGER.SET_INITIAL_CONSUMER_GROUP('scott', 'sales');
```

## Changing Resource Consumer Groups

There are two procedures, as part of the DBMS_RESOURCE_MANAGER package, that allow administrators to change the resource consumer group of running sessions. Both of these procedures will also change the consumer group of any parallel query slave sessions associated with the coordinator's session. They do not change the initial consumer group.

### Switching a Session

The SWITCH_CONSUMMER_GROUP_FOR_SESS causes the specified session to immediately be moved into the specified resource consumer group. In effect, this statement can raise or lower priority. The following statement changes the resource consumer group of a specific session to a new consumer group. The session identifier (SID) is 17, the session serial number (SERIAL#) is 12345, and the session is to be changed to the HIGH_PRIORITY consumer group.

```
EXEC DBMS_RESOURCE_MANAGER.SWITCH_CONSUMER_GROUP_FOR_SESS ('17', '12345', -
   'high_priorty');
```

### Switching Sessions for a User

The SWITCH_CONSUMER_GROUP_FOR_USER procedure changes the resource consumer group for all sessions with a given user id.

```
EXEC DBMS_RESOURCE_MANAGER.SWITCH_CONSUMER_GROUP_FOR_USER ('scott', -
    'low_group');
```

## Granting the Switch Privilege

Using the DBMS_RESOURCE_MANAGER_PRIVS package, you can grant or revoke the switch privilege to a user, role, or PUBLIC. The switch privilege gives users the privilege to switch their current resource consumer group to a specified resource consumer group. The package also allows you to revoke the switch privilege.

The actual switching is done by executing a procedure in the DBMS_SESSION package. A user who has been granted the switch privilege (or a procedure owned by that user) can use the SWITCH_CURRENT_CONSUMER_GROUP procedure to switch to another resource consumer group. The new group must be one to which the user has been specifically authorized to switch.

### Granting the Switch Privilege

The following example grants the privilege to switch to a consumer group. User SCOTT is granted the privilege to switch to consumer group BUG_BATCH_ GROUP.

```
EXEC DBMS_RESOURCE_MANAGER_PRIVS.GRANT_SWITCH_CONSUMER_GROUP ('scott', -
     'bug_batch_group', TRUE);
```

SCOTT is also granted permission to grant switch privileges for BUG_BATCH_ GROUP to others.

If you grant a user permission to switch to a particular consumer group, then that user can switch their current consumer group to the new consumer group.

If you grant a role permission to switch to a particular resource consumer group, then any users who have been granted that role and have enabled that role can immediately switch their current consumer group to the new 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 BUG_BATCH_GROUP.

```
EXEC DBMS_RESOURCE_MANAGER_PRIVS.REVOKE_SWITCH_CONSUMER_GROUP ('scott', -
     'bug_batch_group');
```

If you revoke a user's switch privileges to a particular consumer group, then any subsequent attempts by that user to switch to that consumer group will fail. If you revoke the initial consumer group from a user, then that user will automatically be part of the DEFAULT_CONSUMER_GROUP when logging in.

If you revoke a role's switch privileges to a consumer group, then any users who only had switch privilege for the consumer group via that role will not be able to subsequently switch to that consumer group.

If you revoke from PUBLIC switch privileges to a consumer group, then any users who could previously only use the consumer group via PUBLIC will not be able to subsequently switch to that consumer group.

### Using the DBMS_SESSION Package to Switch Consumer Group

If granted the switch privilege, users can switch their current consumer group using the SWITCH_CURRENT_CONSUMER_GROUP procedure in the DBMS_SESSION package.

This procedure enables users to switch to a consumer group 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:

| Parameter | Description |
|---|---|
| NEW_CONSUMER_GROUP | The consumer group being switched to. |
| OLD_CONSUMER_GROUP | An output parameter. Stores the name of the consumer group being switched from. Can be used to switch back later. |
| INITIAL_GROUP_ON_ERROR | Controls behavior if a switching error occurs.<br>If TRUE, in the event of an error, the user is switched to the initial consumer group.<br>If FALSE, raise an error. |

**See Also:** For more information about the DBMS_SESSION package, see the *Oracle8i Supplied PL/SQL Packages Reference.*

# Enabling the Database Resource Manager

You enable the Database Resource Manager by setting the RESOURCE_ MANAGER_PLAN initialization parameter. This parameter specifies the top plan, identifying the plan schema to be used for this instance. If no plan is specified with this parameter, the Database Resource Manager is not activated.

You can also activate or deactivate the Database Resource Manager, or change the current top plan, using the ALTER SYSTEM statement. In this example, the top plan is specified as MYDB_PLAN.

ALTER SYSTEM SET RESOURCE _MANAGER_PLAN = mydb_plan;

An error message is returned if the specified plan does not exist in the data dictionary.

# Putting it All Together: Examples

This section provides some examples of resource plan schemas.

## A Multilevel Schema

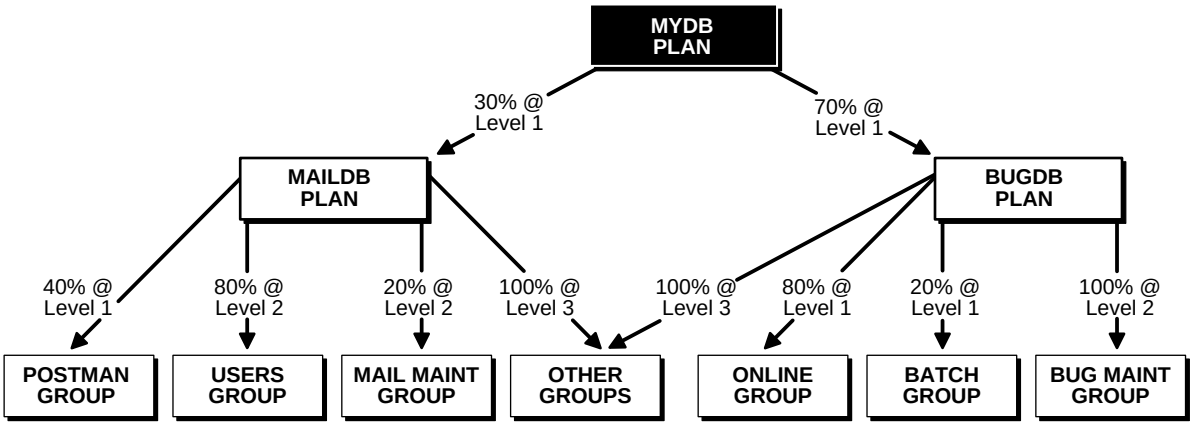
The following statements create a multilevel schema as illustrated in Figure 25–3. They use the default plan and resource consumer group methods.

```
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 => 'Bug_Online_group',
   COMMENT => 'Resource consumer group/method for online bug users sessions');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'Bug_Batch_group',
COMMENT => 'Resource consumer group/method for bug users sessions who run batch jobs');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'Bug_Maintenance_group',
   COMMENT => 'Resource consumer group/method for users sessions who maintain
   the bug  db');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'Mail_users_group',
   COMMENT => 'Resource consumer group/method for mail users sessions');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'Mail_Postman_group',
   COMMENT => 'Resource consumer group/method for mail postman');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'Mail_Maintenance_group',
   COMMENT => 'Resource consumer group/method for users sessions who maintain the mail
   db');
```

```
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'bugdb_plan', GROUP_OR_SUBPLAN =>
'Bug_Online_group',
   COMMENT => 'online bug users sessions at level 1', CPU_P1 => 80, CPU_P2=> 0,
   PARALLEL_DEGREE_LIMIT_P1 => 8);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'bugdb_plan', GROUP_OR_SUBPLAN =>
'Bug_Batch_group',
   COMMENT => 'batch bug users sessions at level 1', CPU_P1 => 20, CPU_P2 => 0,
   PARALLEL_DEGREE_LIMIT_P1 => 2);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'bugdb_plan', GROUP_OR_SUBPLAN =>
'Bug_Maintenance_group',
   COMMENT => 'bug maintenance users sessions at level 2', CPU_P1 => 0, CPU_P2 => 100,
PARALLEL_DEGREE_LIMIT_P1 => 3);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'bugdb_plan', GROUP_OR_SUBPLAN =>
'OTHER_GROUPS',
   COMMENT => 'all other users sessions at level 3', CPU_P1 => 0, CPU_P2 => 0, CPU_P3 =>
100);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'maildb_plan', GROUP_OR_SUBPLAN =>
'Mail_Postman_group',
   COMMENT => 'mail postman at level 1', CPU_P1 => 40, CPU_P2 => 0,
   PARALLEL_DEGREE_LIMIT_P1 => 4);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'maildb_plan', GROUP_OR_SUBPLAN =>
'Mail_users_group',
   COMMENT => 'mail users sessions at level 2', CPU_P1 => 0, CPU_P2 => 80,
   PARALLEL_DEGREE_LIMIT_P1 => 4);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'maildb_plan', GROUP_OR_SUBPLAN =>
'Mail_Maintenance_group',
   COMMENT => 'mail maintenance users sessions at level 2', CPU_P1 => 0, CPU_P2 => 20,
   PARALLEL_DEGREE_LIMIT_P1 => 2);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'maildb_plan', GROUP_OR_SUBPLAN =>
'OTHER_GROUPS',
   COMMENT => 'all other users sessions at level 3', CPU_P1 => 0, CPU_P2 => 0, CPU_P3 =>
100);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'mydb_plan', GROUP_OR_SUBPLAN =>
'maildb_plan',
   COMMENT=> 'all mail users sessions at level 1', CPU_P1 => 30);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'mydb_plan', GROUP_OR_SUBPLAN =>
'bugdb_plan',
   COMMENT => 'all bug users sessions at level 1', CPU_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 Schema*




## An Oracle Supplied Plan

Oracle provides one default resource manager plan, SYSTEM_PLAN, which gives priority to system sessions. SYSTEM_PLAN is defined as follows:

| | CPU Resource Allocation | | |
|---|---|---|---|
| **Resource Consumer Group** | **Level 1** | **Level 2** | **Level 3** |
| SYS_GROUP | 100% | 0% | 0% |
| OTHER_GROUPS | 0% | 100% | 0% |
| LOW_GROUP | 0% | 0% | 100% |

Two new Oracle provided consumer groups are introduced here. They are defined as:

- SYS_GROUP is the initial consumer group for the users SYS and SYSTEM.
- LOW_GROUP provides a group having lower priority than SYS_GROUP and OTHER_GROUPS in this plan. It is up to you to decide which user sessions will be part of LOW_GROUP. Switch privilege is granted to PUBLIC for this group.

These groups can be used, or not used, and can be modified or deleted.

You can use this simple Oracle provided plan if it is appropriate for your environment.

# Database Resource Manager Views

Table 25–3 lists views that are associated with Database Resource Manager:

***Table 25–3 Database Resource Manager Views***

| View | Description |
|---|---|
| DBA_RSRC_CONSUMER_GROUP_PRIVS | Lists all resource consumer groups and the users and roles to which they have been granted. |
| DBA_RSRC_CONSUMER_GROUPS | Lists all resource consumer groups that exist in the database. |
| DBA_RSRC_MANAGER_SYSTEM_PRIVS | Lists all users and roles that have been granted Database Resource Manager system privileges. |
| DBA_RSRC_PLAN_DIRECTIVES | Lists all resource plan directives that exist in the database. |
| DBA_RSRC_PLANS | List all resource plans that exist in the database. |
| DBA_USERS | Contains information about all users of the database. Specifically, for the Database Resource Manager, it contains the initial resource consumer group for the user. |
| USER_RSRC_CONSUMER_GROUP_PRIVS | Lists all resource consumer groups granted to the user. |
| USER_RSRC_MANAGER_SYSTEM_PRIVS | Shows all the users that are granted system privileges for the DBMS_RESOURCE_MANAGER package. |
| USERS_USERS | Contains information about the current user. Specifically, for the Database Resource Manager, it contains the current user's initial resource consumer group. |
| V$PARALLEL_DEGREE_LIMIT_MTH | Displays all available parallel degree limit resource allocation methods. |
| V$RSRC_CONSUMER_GROUP | Displays information about active resource consumer groups that can be used for tuning. |
| V$RSRC_CONSUMER_GROUP_CPU_MTH | Displays all available CPU resource allocation methods for resource consumer groups. |
| V$RSRC_PLAN | Displays the names of all currently active resource plans. |
| V$RSRC_PLAN_CPU_MTH | Displays all available CPU resource allocation methods for resource plans. |
| V$SESSION | Lists session information for each current session. Specifically, lists the name of each current session's resource consumer group. |

You can use these views for viewing plan schemas, or you might want to monitor them to gather information for tuning the Database Resource Manager.

> **See Also:** For detailed information about the contents of each of these views, see the *Oracle8i Reference.*

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