Oracle9*i*

Database Administrator's Guide

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Oracle9*i* Database Administrator's Guide, Release 1 (9.0.1)

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Preface

This guide is for people who administer the operation of an Oracle database system. Referred to as database administrators (DBAs), they are responsible for creating Oracle databases, ensuring their smooth operation, and monitoring their use.

This preface contains these topics:

Note: The *Oracle9i Database Administrator's Guide* contains information that describes the features and functionality of the Oracle9*i* [Standard Edition], Oracle9*i* Enterprise Edition, and Oracle9*i* Personal Edition products. These products have the same basic features. However, several advanced features are available only with the Oracle9*i* Enterprise Edition or Oracle9*i* Personal Edition, and some of these are optional. For example, to create partitioned tables and indexes, you must have the Oracle9*i* Enterprise Edition or Oracle9*i* Personal Edition.

For information about the differences between the various editions of Oracle9*i* and the features and options that are available to you, please refer to *Oracle9i Database New Features.*

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 8 databases to Oracle9*i* format). This guide is not an installation or migration manual.

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

If your primary interest is database or application migration, see the *Oracle9i Database 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 *Oracle9i Application Developer's Guide - Fundamentals* and the documentation for the tool or language product they are using to develop Oracle database applications.

Organization

This document contains:

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 discusses considerations for creating a database and takes you through the steps of creating one. Consult this chapter when in the database planning and creation stage.

Chapter 3, "Using Oracle-Managed Files"

This chapter describes how you can direct the Oracle database server to create and manage your:

- Datafiles
- Tempfiles
- Online redo log files
- Control files

Chapter 4, "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 Processes and Storage Structure

Chapter 5, "Managing Oracle Processes"

This chapter helps you to identify different Oracle processes, such as dedicated server processes and shared server processes. Consult this chapter when configuring, modifying, tracking and managing processes.

Chapter 6, "Managing Control Files"

This chapter describes all aspects of managing control files: naming, creating, troubleshooting, and dropping control files.

Chapter 7, "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 8, "Managing Archived Redo Logs"

Consult this chapter for information about archive modes and tuning archiving.

Chapter 9, "Using LogMiner to Analyze Redo Log Files"

This chapter describes the use of LogMiner to analyze redo log files.

Chapter 10, "Managing Job Queues"

Consult this chapter before working with job queues. All aspects of submitting, removing, altering, and fixing job queues are described.

Chapter 11, "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 12, "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 13, "Managing Undo Space"

Consult this chapter to learn how to manage undo space, either by using an undo tablespace or rollback segments.

Part III: Schema Objects

Chapter 14, "Managing Space for Schema Objects"

Consult this chapter for descriptions of common tasks, such as setting storage parameters, deallocating space and managing space.

Chapter 15, "Managing Tables"

Consult this chapter for general table management guidelines, as well as information about creating, altering, maintaining and dropping tables.

Chapter 16, "Managing Indexes"

Consult this chapter for general guidelines about indexes, including creating, altering, monitoring and dropping indexes.

Chapter 17, "Managing Partitioned Tables and Indexes"

Consult this chapter to learn about partitioned tables and indexes and how to create and manage them.

Chapter 18, "Managing Clusters"

Consult this chapter for general guidelines to follow when creating, altering, or dropping clusters.

Chapter 19, "Managing Hash Clusters"

Consult this chapter for general guidelines to follow when creating, altering, or dropping hash clusters.

Chapter 20, "Managing Views, Sequences, and Synonyms"

This chapter describes all aspects of managing views, sequences and synonyms.

Chapter 21, "General Management of Schema Objects"

This chapter covers more varied aspects of schema management. The operations described in this chapter are not unique to any one type of schema objects. Consult this chapter for information about analyzing objects, truncation of tables and clusters, database triggers, integrity constraints, and object dependencies.

Chapter 22, "Detecting and Repairing Data Block Corruption"

This chapter describes methods for detecting and repairing data block corruption.

Part IV: Database Security

Chapter 23, "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 24, "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 25, "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 26, "Auditing Database Use"

This chapter describes how to create, manage and view audit information.

Part V: Database Resource Management

Chapter 27, "Using the Database Resource Manager"

This chapter describes how to use the Database Resource Manager to allocate resources.

Part VI: Distributed Database Management

Chapter 28, "Distributed Database Concepts"

This chapter describes the basic concepts and terminology of Oracle's distributed database architecture.

Chapter 29, "Managing a Distributed Database"

This chapter describes how to manage and maintain a distributed database system.

Chapter 30, "Developing Applications for a Distributed Database System"

This chapter describes considerations important when developing an application to run in a distributed database system.

Chapter 31, "Distributed Transactions Concepts"

This chapter describes what distributed transactions are and how Oracle maintains their integrity.

Chapter 32, "Managing Distributed Transactions"

This chapter describes how to manage and troubleshoot distributed transactions.

Related Documentation

For more information, see these Oracle resources:

- *Oracle9i Database Concepts*

  Chapter 1 of *Oracle9i Database Concepts* contains an overview of the concepts and terminology related to Oracle and provides a foundation for the more detailed information in this guide. This chapter is a starting point to become familiar with the Oracle database server, and is recommended reading before starting *Oracle9i Database Administrator's Guide*. The remainder of *Oracle9i Database Concepts* explains the Oracle architecture and features, and how they operate in more detail.

- *Oracle9i Backup and Recovery Concepts*

  This book introduces you to the concepts of backup and recovery.

- *Oracle9i User-Managed Backup and Recovery Guide*

  This guide contains details of backup and recovery and enables you back up, copy, restore, and recover datafiles, control files, and archived redo logs.

- *Oracle9i Recovery Manager User's Guide and Reference*

  This guide contains information for using Recovery Manager (RMAN). RMAN is an Oracle tool that manages and automates backup and recovery operations.

- *Oracle9i Database Performance Methods*

  This book exposes important considerations in setting up a database system and can help you understand tuning your database. It is mainly conceptual, defining terms, architecture, and design principles, and then outlines proactive and reactive tuning methods.

- *Oracle9i Database Performance Guide and Reference*

  This book can be used as a reference guide for tuning your Oracle database system.

- *Oracle9i Application Developer's Guide - Fundamentals*

  Many of the tasks done by DBAs are shared by application developers. In some cases, descriptions of tasks seemed better located in an application level book, and in those cases, this fundamentals book is the primary reference.

In North America, printed documentation is available for sale in the Oracle Store at

http://oraclestore.oracle.com/

Customers in Europe, the Middle East, and Africa (EMEA) can purchase documentation from

http://www.oraclebookshop.com/

Other customers can contact their Oracle representative to purchase printed documentation.

To download free release notes, installation documentation, white papers, or other collateral, please visit the Oracle Technology Network (OTN). You must register online before using OTN; registration is free and can be done at

http://technet.oracle.com/membership/index.htm

If you already have a username and password for OTN, then you can go directly to the documentation section of the OTN Web site at

http://technet.oracle.com/docs/index.htm

Conventions

This section describes the conventions used in the text and code examples of this documentation set. It describes:

Conventions in Text

Conventions in Code Examples

Conventions in Text

We use various conventions in text to help you more quickly identify special terms. The following table describes those conventions and provides examples of their use.

Convention	Meaning	Example
Bold	Bold typeface indicates terms that are defined in the text or terms that appear in a glossary, or both.	When you specify this clause, you create an **index-organized table**.
Italics	Italic typeface indicates book titles or emphasis.	*Oracle9i Database Concepts* Ensure that the recovery catalog and target database do *not* reside on the same disk.
`UPPERCASE monospace (fixed-width font)`	Uppercase monospace typeface indicates elements supplied by the system. Such elements include parameters, privileges, datatypes, RMAN keywords, SQL keywords, SQL*Plus or utility commands, packages and methods, as well as system-supplied column names, database objects and structures, usernames, and roles.	You can specify this clause only for a `NUMBER` column. You can back up the database by using the `BACKUP` command. Query the `TABLE_NAME` column in the `USER_TABLES` data dictionary view. Use the `DBMS_STATS.GENERATE_STATS` procedure.

Convention	Meaning	Example
lowercase monospace (fixed-width font)	Lowercase monospace typeface indicates executables, filenames, directory names, and sample user-supplied elements. Such elements include computer and database names, net service names, and connect identifiers, as well as user-supplied database objects and structures, column names, packages and classes, usernames and roles, program units, and parameter values. **Note:** Some programmatic elements use a mixture of UPPERCASE and lowercase. Enter these elements as shown.	Enter `sqlplus` to open SQL*Plus. The password is specified in the `orapwd` file. Back up the datafiles and control files in the `/disk1/oracle/dbs` directory. The `department_id`, `department_name`, and `location_id` columns are in the `hr.departments` table. Set the `QUERY_REWRITE_ENABLED` initialization parameter to `true`. Connect as `oe` user. The `JRepUtil` class implements these methods.
lowercase monospace (fixed-width font) italic	Lowercase monospace italic font represents placeholders or variables.	You can specify the *parallel_clause*. Run `U`*old_release*`.SQL` where *old_release* refers to the release you installed prior to upgrading.

Conventions in Code Examples

Code examples illustrate SQL, PL/SQL, SQL*Plus, or other command-line statements. They are displayed in a monospace (fixed-width) font and separated from normal text as shown in this example:

```
SELECT username FROM dba_users WHERE username = 'MIGRATE';
```

The following table describes typographic conventions used in code examples and provides examples of their use.

Convention	Meaning	Example
[ ]	Brackets enclose one or more optional items. Do not enter the brackets.	`DECIMAL (`*digits* `[ ,` *precision* `])`
{ }	Braces enclose two or more items, one of which is required. Do not enter the braces.	`{ENABLE | DISABLE}`
|	A vertical bar represents a choice of two or more options within brackets or braces. Enter one of the options. Do not enter the vertical bar.	`{ENABLE | DISABLE}` `[COMPRESS | NOCOMPRESS]`

Convention	Meaning	Example
...	Horizontal ellipsis points indicate either: ■ That we have omitted parts of the code that are not directly related to the example ■ That you can repeat a portion of the code	`CREATE TABLE ... AS subquery;` `SELECT col1, col2, ... , coln FROM employees;`
. . .	Vertical ellipsis points indicate that we have omitted several lines of code not directly related to the example.	
Other notation	You must enter symbols other than brackets, braces, vertical bars, and ellipsis points as shown.	`acctbal NUMBER(11,2);` `acct CONSTANT NUMBER(4) := 3;`
Italics	Italicized text indicates placeholders or variables for which you must supply particular values.	`CONNECT SYSTEM/system_password` `DB_NAME = database_name`

UPPERCASE	Uppercase typeface indicates elements supplied by the system. We show these terms in uppercase in order to distinguish them from terms you define. Unless terms appear in brackets, enter them in the order and with the spelling shown. However, because these terms are not case sensitive, you can enter them in lowercase.	`SELECT last_name, employee_id FROM employees;`
		`SELECT * FROM USER_TABLES;`
		`DROP TABLE hr.employees;`

lowercase	Lowercase typeface indicates programmatic elements that you supply. For example, lowercase indicates names of tables, columns, or files.
	Note: Some programmatic elements use a mixture of UPPERCASE and lowercase. Enter these elements as shown.
		`SELECT last_name, employee_id FROM employees;`
		`sqlplus hr/hr`
		`CREATE USER mjones IDENTIFIED BY ty3MU9;`

Documentation Accessibility

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technology vendors to address technical obstacles so that our documentation can be accessible to all of our customers. For additional information, visit the Oracle Accessibility Program Web site at

`http://www.oracle.com/accessibility/`

JAWS, a Windows screen reader, may not always correctly read the code examples in this document. The conventions for writing code require that closing braces should appear on an otherwise empty line; however, JAWS may not always read a line of text that consists solely of a bracket or brace.

What's New in Oracle9*i*?

This section introduces new administrative features of Oracle9*i* Release 1 (9.0.1) that are discussed in this book and provides pointers to additional information.

For a summary of all new features for Oracle9*i*, see *Oracle9i Database New Features*.

The following section describes the new features discussed in the *Oracle9i* Database Administrator's Guide.

Oracle9*i* Release 1 (9.0.1) New Features

Oracle9*i* brings a major new release of the Oracle database server. It includes features to make the database more available. More online operations reduce the need for offline maintenance. Management of the database requires less effort. Oracle9*i* can automatically create and manage the underlying operating system files required by the database. There is a theme of self management.

Performance is enhanced. The Database Resource Manager has new options that allow for more granular control of resources. The performance level required of a resource consumer group can be better sustained. Partitioning enhancements allow tables and indexes to be better partitioned for performance. Security enhancements are an important part of this release. Applications have available more and finer grained methods of implementing security and auditing.

The following are summaries of the new features of Oracle9*i* that are discussed in this book.

- **Online redefinition of tables**

  The new `DBMS_REDEFINITION` PL/SQL package provides a mechanism to redefine tables online. When a table is redefined online, it is accessible to DML during much of the redefinition process. This provides a significant increase in availability compared to traditional methods of redefining tables that require tables to be taken offline.

  See Also: "Redefining Tables Online" on page 15-14

- **ONLINE option for ANALYZE VALIDATE STRUCTURE statement**

  The `ANALYZE` statement can now perform validation while DML is ongoing within the object being analyzed.

  See Also: "Validating Tables, Indexes, Clusters, and Materialized Views" on page 21-9

- **Controlling Archive Lag**

  Oracle now provides a time-based means of switching the current online redo log group. In a primary/standby configuration, where all noncurrent logs of the primary site are archived and shipped to the standby database, this effectively limits the number of redo records, as measured in time, that will not be applied in the standby database.

See Also: "Controlling Archive Lag" on page 7-10

- **Suspending a database**

  Oracle9*i* includes a database suspend/resume feature. The `ALTER SYSTEM SUSPEND` statement suspends a database by halting all input and output (I/O) to datafiles and control files. When the database is suspended all preexisting I/O operations are allowed to complete and any new database accesses are placed in a queued state. The `ALTER SYSTEM RESUME` statement resumes normal database operation.

  See Also: "Suspending and Resuming a Database" on page 4-16

- **Quiescing a database**

  Oracle9*i* allows you to place the database into a quiesced state, where only DBA transactions, queries, or PL/SQL statements are allowed. This quiesced state allows you to perform administrative actions that cannot safely be done otherwise. The `ALTER SYSTEM QUIESCE RESTRICTED` statement places a database into a quiesced state.

  See Also: "Quiescing a Database" on page 4-13

- **Resumable Space Allocation**

  Oracle provides a means for suspending, and later resuming, the execution of large database operations in the event of space allocation failures. This enables you to take corrective action, instead of the Oracle database server returning an error to the user. After the error condition is corrected, the suspended operation automatically resumes.

  See Also: "Managing Resumable Space Allocation" on page 14-16

- **More archiving destinations**

  The maximum number of destinations to which you can archive the online redo log, has been increased from 5 to 10.

  See Also: "Specifying the Archive Destination" on page 8-9

- **Automatic segment- space management**

  Locally managed tablespaces allow extents to be managed automatically by Oracle. Oracle9*i* allows free and used space within segments stored in locally managed tablespaces to also be managed automatically. Using the SEGMENT SPACE MANAGEMENT clause of CREATE TABLESPACE you specify AUTO or MANUAL to specify the type of segment space management Oracle will use.

  See Also: "Specifying Segment Space Management in Locally Managed Tablespaces" on page 11-7

- **Update of global indexes when partition maintenance is performed**

  By default, many table maintenance operations on partitioned tables invalidate (mark UNUSABLE) global indexes. You must then rebuild the entire global index or, if partitioned, all of its partitions. Oracle9*i* allows you to override this default behavior. When you specify the UPDATE GLOBAL INDEX clause in your ALTER TABLE statement for the maintenance operation, the global index is updated in conjunction with the base table operation.

  See Also: "Maintaining Partitioned Tables" on page 17-16

- **Multiple block sizes**

  Oracle now supports multiple block sizes. It has a standard block size, as set by the DB_BLOCK_SIZE initialization parameter, and additionally up to 4 nonstandard block sizes. Nonstandard block sizes are specified when creating tablespaces. The standard block size is used for the SYSTEM tablespace and most other tablespaces. Multiple block size support allows for the transporting of tablespaces with unlike block sizes between databases.

  See Also: "Specifying Database Block Sizes" on page 2-30

- **Dynamic buffer cache**

  The size of the buffer cache subcomponent of the System Global Area is now dynamic. The DB_BLOCK_BUFFERS initialization parameter has been replaced by a new dynamic parameter, DB_CACHE_SIZE, where the user specifies the size of the buffer subcache for the standard database block size. The buffer cache now consists of subcaches when multiple block sizes are specified for the database. Up to four DB_*n*K_CACHE_SIZE initialization parameters allow you to specify the sizes of buffer subcaches for the additional block sizes.

See Also: "Setting Initialization Parameters that Affect the Size of the SGA" on page 2-31

- **Dynamic SGA**

  The initialization parameters affecting the size of SGA have been made dynamic. It is possible to alter the size of SGA dynamically through an `ALTER SYSTEM SET` statement.

  See Also: "Setting Initialization Parameters that Affect the Size of the SGA" on page 2-31

- **Automatic undo management**

  Historically, Oracle has used rollback segments to store undo. Undo is defined as information that can be used to roll back, or undo, changes to the database when necessary. Oracle now enables you to create an undo tablespace to store undo. Using an undo tablespace eliminates the complexities of managing rollback segment space, and enables you to exert control over how long undo is retained before being overwritten.

  See Also: Chapter 13, "Managing Undo Space"

- **Oracle managed files**

  The Oracle managed files feature of Oracle9*i* eliminates the need for you to directly manage the files comprising an Oracle database. Through the `DB_CREATE_FILE_DEST` and `DB_CREATE_ONLINE_LOG_DEST_`*n* initialization parameters, you specify the file system directory to be used for a particular type of file comprising a tablespace, online redo log file, or control file. Oracle then ensures that a unique file, an Oracle-managed file, is created and deleted when no longer needed.

  See Also: Chapter 3, "Using Oracle-Managed Files"

- **Automatic deletion of datafiles**

  Oracle9*i* provides an option to automatically remove a tablespaces's operating system files (datafiles) when the tablespace is dropped using the `DROP TABLESPACE` statement. A similar option for the `ALTER DATABASE TEMPFILE` statement, causes deletion the operating system files associated with a temporary file.

See Also:

- "Dropping Tablespaces" on page 11-27
- "Altering a Locally Managed Temporary Tablespace" on page 11-12

- **Metadata API**

  A new PL/SQL package, `DBMS_METADATA.GET_DDL`, allows you to obtain metadata (in the form of DDL used to create the object) about a schema object.

  See Also: "Using PL/SQL Packages to Display Information About Schema Objects" on page 21-31

- **External tables**

  Oracle9*i* allows you read-only access to data in external tables. External tables are defined as tables that do not reside in the database, and can be in any format for which an access driver is provided. The `CREATE TABLE ... ORGANIZATION EXTERNAL` statement specifies metadata describing the external table. Oracle currently provides the `ORACLE_LOADER` access driver which provides data mapping capabilities that are a subset of the SQL*Loader control file syntax.

  See Also: "Managing External Tables" on page 15-30

- **Constraint enhancements**

  Enhancements to the `USING INDEX` clause of `CREATE TABLE` or `ALTER TABLE` allow you to specify the creation or use of a specific index when a unique or primary key constraint is created or enabled. Additionally, you can prevent the dropping of the index enforcing a unique or primary key constraint when the constraint is dropped or disabled.

  See Also:

  - "Creating an Index Associated with a Constraint" on page 16-11
  - "Managing Integrity Constraints" on page 21-17

- **Server parameter file**

  Oracle has traditionally stored initialization parameters in a text initialization parameter file, often on a client machine. Starting with Oracle9*i*, you can elect to

maintain initialization parameters in a server parameter file, which is a binary parameter file stored on the database server. Initialization parameters stored in a server parameter file are persistent, in that any changes made to the parameters while an instance is running persist across instance shutdown and startup.

> **See Also:** "Managing Initialization Parameters Using a Server Parameter File" on page 2-36

- **Default temporary tablespace**

  The new `DEFAULT TEMPORARY TABLESPACE` clause of the `CREATE DATABASE` statement allows you to create a default temporary tablespace at database creation time. This tablespace is used as the default temporary tablespace for users who are not otherwise assigned a temporary tablespace.

  > **See Also:** "Creating a Default Temporary Tablespace" on page 2-21

- **Setting the database time zone**

  The `CREATE DATABASE` statement now has a `SET TIME_ZONE` clause that allows you to set the time zone of the database as a displacement from UTC (Coordinated Universal Time—formerly Greenwich Mean Time). Oracle normalizes all `TIMESTAMP WITH LOCAL TIME ZONE` data to the time zone of the database when the data is stored on disk. Additionally, a new session parameter `TIME_ZONE` has been added to the `SET` clause of `ALTER SESSION`.

  > **See Also:** "Step 6: Issue the CREATE DATABASE Statement" on page 2-16

- **Transaction Naming**

  Oracle now allows you to assign a name to a transaction. The transaction name is helpful in resolving in-doubt distributed transactions, and replaces a `COMMIT COMMENT`.

  > **See Also:** "Transaction Naming" on page 32-4

- **Oracle Database Configuration Assistant changes**

  The Oracle Database Configuration Assistant has been redesigned. It now provides templates, which are saved definitions of databases, from which you

can generate your database. Oracle provides templates, or you can create your own templates by modifying existing ones, defining new ones, or by capturing the definition of an existing database.

When creating a database with the Database Configuration Assistant, you can either initially include, or later add as an option, Oracle's new Sample Schemas. These schemas are the basis for many of the examples used in Oracle documentation.

> **See Also:** "The Oracle Database Configuration Assistant" on page 2-5

- **Monitoring index usage**

  A `MONITORING USAGE` clause has been added for the `ALTER INDEX` statement. It allows you to monitor an index to determine if it is actively being used.

  > **See Also:** "Monitoring Index Usage" on page 16-21

- **List partitioning**

  Oracle introduces list partitioning, which enables you to specify a list of discrete values for the partitioning column in the description for each partition. The list partitioning method is specifically designed for modeling data distributions that follow discrete values. This cannot be easily done by range or hash partitioning.

  > **See Also:** Chapter 17, "Managing Partitioned Tables and Indexes"

- **Hash partitioning of index-organized tables**

  In this release, support has been added for partitioning index-organized tables by the hash method. Previously, they could be partitioned, but only by the range method.

  > **See Also:** "Creating Partitioned Index-Organized Tables" on page 17-13

- **Dynamic job queue processes**

  The job queue process creation has been made dynamic so that only the required number of processes are created to execute the jobs that are ready for

execution. A job queue coordinator background process (CJQ) dynamically spawns J*nnn* processes to execute jobs.

> **See Also:** "Enabling Processes Used for Executing Jobs" on page 10-2

- **New in the Database Resource Manager for Oracle9*i***

  The following new functionality has been added to the Database Resource Manager:

  - Ability to create an active session pool. This pool consists of a specified maximum number of user sessions allowed to be concurrently active within a group of users. Additional sessions beyond the maximum are queued for execution, but you can specify a timeout period, after which queued jobs will abort.
  - Automatic switching of users from one group to another group based on administrator defined criteria. If a member of a particular group of users creates a session that executes for longer than a specified amount of time, that session can be automatically switched to another group of users with different resource requirements.
  - Ability to prevent the execution of operations that are estimated to run for a longer time than a predefined limit
  - Ability to create an undo pool. This pool consists of the amount of undo space that can be consumed in by a group of users.

  > **See Also:** Chapter 27, "Using the Database Resource Manager"

- **Proxy authentication and authorization**

  Oracle9*i* enables you to authorize a middle-tier server to act on behalf of a client. The `GRANT CONNECT THROUGH` clause of the `ALTER USER` statement specifies this functionality. You can also specify roles that the middle tier is permitted to activate when connecting as the client.

  > **See Also:** "Proxy Authentication and Authorization" on page 24-13

- **Application roles**

  Oracle provides a mechanism by which roles granted to application users are enabled using a designated PL/SQL package. This feature introduces the `IDENTIFIED USING` *`package`* clause for the `CREATE ROLE` statement.

  See Also: "Role Authorization by an Application" on page 25-8

- **Fine-grained auditing**

  In Oracle's traditional auditing methods, a fixed set of facts is recorded in the audit trail. Audit options can only be set to monitor access of objects or privileges. A new PL/SQL package, `DBMS_FGA`, allows applications to implement fine-grained auditing of data access based on content.

  See Also: "Fine-Grained Auditing" on page 26-16

- **New in LogMiner for Release 9.0.1**

  LogMiner release 9.0.1 has added support for many new features. Some of the new features work with any redo log files from an Oracle 8.0 or later database. Other features only work with redo log files produced on Oracle9*i* or later.

  New Features for Redo Log Files Generated by Oracle9*i* or Later

  For any redo log files generated by Oracle9*i* or later, LogMiner now provides support for the following:

  – Index clusters

  – Chained and migrated rows

  – Direct path inserts (with `ARCHIVELOG` mode enabled)

  – Extracting the data dictionary into the redo log files. See "Extracting the Dictionary to the Redo Log Files" on page 9-5.

  – Using the online catalog as the data dictionary. See "Using the Online Catalog" on page 9-5.

  – Tracking of all data definition language (DDL) operations, which enables you to monitor schema evolution. See "Tracking of DDL Statements" on page 9-5.

  – Viewing user-executed DDL in the `SQL_REDO` column. Information regarding the original database user is also returned.

– Generating SQL_REDO and SQL_UNDO with primary key information for updates. That is, updated rows are identified by primary keys and ROWIDs (provided supplemental logging is enabled), thereby making it easier to apply the statements to a different database.

New Features for Redo Log Files Generated by Oracle Release 8.0 or Later

For any redo log files generated by Oracle release 8.0 or later, LogMiner now provides support for the following:

– Limiting V$LOGMNR_CONTENTS data to rows belonging to committed transactions only. This option enables you to filter out rolled back transactions and transactions that are in progress. See the information about options in "Starting LogMiner" on page 9-13.

– Performing queries based on actual data values in the redo log files. See "Extracting Data Values from Redo Log Files" on page 9-6.

See Also: Chapter 9, "Using LogMiner to Analyze Redo Log Files"

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:

1

The Oracle Database Administrator

This chapter describes your responsibilities as a database administrator (DBA) who administers the Oracle database server.

The following topics are discussed:

Types of Oracle Users

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

This section contains the following topics:

Database Administrators

Each database requires at least one database administrator (DBA) to administer it. Because an Oracle database system can be large and can have many users, often this is not a one person job. In such cases, there is a group of DBAs who share responsibility.

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 site assigns one or more security officers to a database. A security officer enrolls users, controls and monitors user access to the database, and maintains system security. As a DBA, you might not be responsible for these duties if your site has a separate security officer.

Network Administrators

Some sites have one or more network administrators. A network administrator can administer Oracle networking products, such as Oracle Net.

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

Application Developers

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

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

Application developers can perform some of these tasks in collaboration with DBAs.

Application Administrators

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

Database Users

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

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

Tasks of a Database Administrator

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

Task 1: Evaluate the Database Server Hardware

Task 2: Install the Oracle Software

Task 3: Plan the Database

Task 4: Create and Open the Database

Task 5: Back Up the Database

Task 6: Enroll System Users

Task 7: Implement the Database Design

Task 8: Back Up the Fully Functional Database

Task 9: Tune Database Performance

These tasks are discussed in succeeding sections.

Note: If migrating to a new release, back up your existing production database before installation. For information on preserving your existing production database, see *Oracle9i Database Migration*.

Task 1: Evaluate the Database Server Hardware

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)

Task 2: Install the Oracle Software

As the database administrator, you install the Oracle database server software and any front-end tools and database applications that access the database. In some distributed processing installations, the database is controlled by a central computer and the database tools and applications are executed on remote computers. In this case, you must also install the Oracle Net 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 1-8.

> **See Also:** For specific requirements and instructions for installation, refer to the following documentation:
>
> - Your operating system specific Oracle documentation
> - Your installation guides for your front-end tools and Oracle Net drivers.

Task 3: Plan the Database

As the database administrator, you must plan:

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

It is important to plan how the logical storage structure of the database will affect system performance and various database management operations. For example, before creating any tablespaces for your database, you should know how many datafiles will make up the tablespace, what type of information will be stored in

each tablespace, and on which disk drives the datafiles will be physically stored. When planning the overall logical storage of the database structure, take into account the effects that this structure will have when the database is actually created and running. Such considerations include how the logical storage structure database will affect the following:

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

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

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

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

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

Task 4: Create and Open the Database

When you complete the database design, you can create the database and open it for normal use. You can create a database at installation time, using the Oracle 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 4, "Starting Up and Shutting Down" for guidance in starting up the database.

Task 5: Back Up the Database

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

> **See Also:** For instructions on customizing your backup operations and performing recovery procedures see either of the following:
>
> - *Oracle9i User-Managed Backup and Recovery Guide*
> - *Oracle9i Recovery Manager User's Guide*

Task 6: Enroll System Users

After you back up the database structure, you can enroll the users of the database in accordance with your Oracle license agreement, create appropriate roles for these users, and grant these roles.

The following chapters will help you in this endeavor:

- Chapter 23, "Establishing Security Policies"
- Chapter 24, "Managing Users and Resources"
- Chapter 25, "Managing User Privileges and Roles"

Task 7: Implement the Database Design

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

Part II, "Oracle Server Processes and Storage Structure" and Part III, "Schema Objects" contain information which can help you create logical storage structures and objects for your database.

Task 8: Back Up the Fully Functional Database

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

Task 9: Tune Database Performance

Optimizing the performance of the database is one of your ongoing responsibilities as a DBA. Additionally, Oracle provides a database resource management feature that enables you to control the allocation of resources to various user groups.

The database resource manager is described in Chapter 27, "Using the Database Resource Manager".

> **See Also:** *Oracle9i Database Performance Guide and Reference* contains information about tuning your database and applications.

Identifying Your Oracle Database Software Release

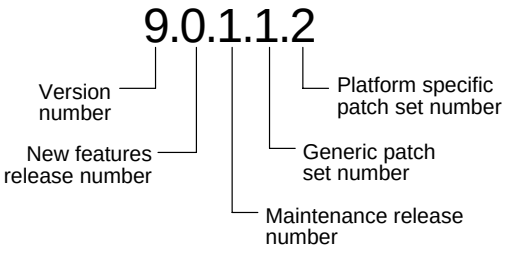
Because the Oracle database server continues to evolve and can require maintenance, Oracle periodically produces new releases. Because only some users initially subscribe to a new release or require specific maintenance, multiple releases of the product can exist simultaneously.

As many as five numbers may be required to fully identify a release. The significance of these numbers is discussed below.

Release Number Format

To understand the release level nomenclature used by Oracle, examine the following example of an Oracle database server labeled "Release 9.0.1.1.2."

Figure 1–1 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.

New Features Release Number

This number represents a new features release level.

Maintenance Release Number

This number represents a maintenance release level. A few new features may also be included.

Generic Patch Set Number

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

Platform Specific Patch Set Number

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

Checking Your Current Release Number

To identify the release of the Oracle database server that 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. Other product release levels may increment independently of the database server.

```
SELECT * FROM PRODUCT_COMPONENT_VERSION;

PRODUCT                        VERSION                        STATUS
-----------------------------  ------------------------------ --------------------
NLSRTL                         9.0.1.0.0                      Production
Oracle9i Enterprise Edition    9.0.1.0.0                      Production
PL/SQL                         9.0.1.0.0                      Production
TNS for Solaris:               9.0.1.0.0                      Production
```

It's important to convey to Oracle the information displayed by this query when you report problems with the software.

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

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 contains the following topics:

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

The Database Administrator's Operating System Account

To perform many of the administrative duties for a database, you must be able to execute operating system commands. Depending on the operating system 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:** Your operating system specific Oracle documentation. The method of distinguishing a database administrator's account is operating system specific.

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.

It is suggested that you create at least one additional administrator username to use when performing daily administrative tasks.

Note Regarding Security Enhancements: In this release of Oracle9*i* and in subsequent releases, several enhancements are being made to ensure the security of default database user accounts.

- Beginning with this release, during initial installation with the Oracle Database Configuration Assistant (DCBA), all default database user accounts except SYS, SYSTEM, SCOTT, DBSNMP, OUTLN, AURORAJISUTILITY$, AURORA$ORB$UNAUTHENTICATED and OSE$HTTP$ADMIN will be locked and expired. To activate a locked account, the DBA must manually unlock it and reassign it a new password.
- In the next release of the database server, the DBCA will prompt for passwords for users SYS and SYSTEM during initial installation of the database rather than assigning default passwords to them. In addition, a CREATE DATABASE SQL statement issued manually will require you to specify passwords for these two users.
- Oracle9*i* will be the last major release to support the user SYSTEM as a default database user created during any type of installation or by the CREATE DATABASE SQL statement.

The DBA Role

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

Note: The DBA role does not include the SYSDBA or SYSOPER system privileges. These are special administrative privileges that allow an administrator to perform basic database administration tasks, such as the start up and shut down of the database. These system privileges are discussed in "Administrative Privileges" on page 1-12.

SYS

When any database is created, the user SYS 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 user SYS. (However, you can change the storage parameters of the data dictionary settings if necessary.)

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

SYSTEM

When a database is created, the user SYSTEM is also automatically created and granted the DBA role.

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

Database Administrator Authentication

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

This section contains the following topics:

- Administrative Privileges
- Selecting an Authentication Method
- Using Operating System (OS) Authentication
- Using Password File Authentication

Administrative Privileges

Administrative privileges that are required for an administrator to perform basic database operations are granted through two special system privileges, SYSDBA

and SYSOPER. You must have one of these privileges granted to you, depending upon the level of authorization you require.

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

SYSDBA and SYSOPER

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

System Privilege	Operations Authorized
SYSDBA	■ Perform STARTUP and SHUTDOWN operations ■ ALTER DATABASE: open, mount, back up, or change character set ■ CREATE DATABASE ■ CREATE SPFILE ■ ARCHIVELOG and RECOVERY ■ Includes the RESTRICTED SESSION privilege Effectively, this system privilege allows a user to connect as user SYS.
SYSOPER	■ Perform STARTUP and SHUTDOWN operations ■ CREATE SPFILE ■ ALTER DATABASE OPEN/MOUNT/BACKUP ■ ARCHIVELOG and RECOVERY ■ Includes the RESTRICTED SESSION privilege This privilege allows a user to perform basic operational tasks, but without the ability to look at user data.

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

When you connect with SYSDBA or SYSOPER privileges using a username and password, you connect with a default schema, not with the schema that is generally

associated with your username. For SYSDBA this schema is SYS; for SYSOPER the schema is PUBLIC.

Connecting with Administrative Privileges: Example

This example illustrates that a user is assigned another (SYS) schema when connecting with the SYSDBA system privilege.

Assume that user scott has issued the following statements:

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

Later, scott issues these statements:

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

He now receives an error that scott_test does not exist. That is because scott now references the SYS schema by default. The table was created in the scott schema.

See Also:

- "Using Operating System (OS) Authentication" on page 1-16
- "Using Password File Authentication" on page 1-17

Selecting an Authentication Method

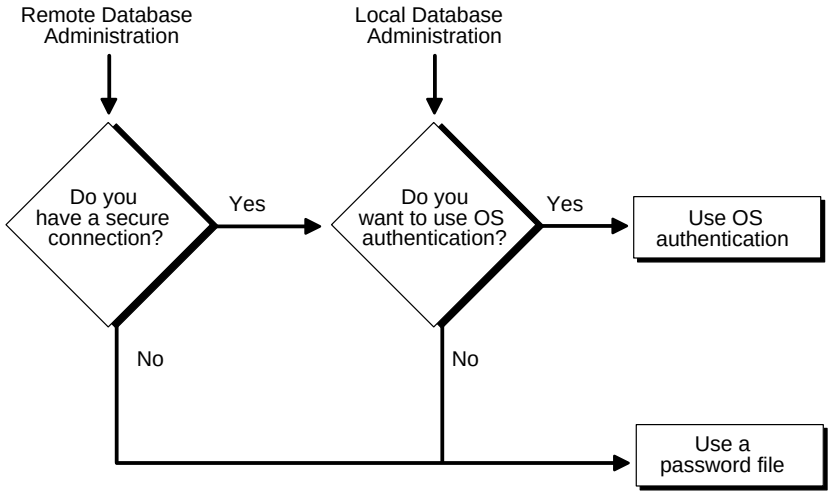
The following methods are available for authenticating database administrators:

- Operating system (OS) authentication
- Password files

Note: These methods replace the CONNECT INTERNAL syntax provided with earlier versions of Oracle. CONNECT INTERNAL is no longer allowed.

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

Figure 1–2 Database Administrator Authentication Methods



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

See Also:

- *Oracle9i Database Concepts* for additional information about user authentication
- "User Authentication" on page 23-2
- "User Authentication Methods" on page 24-7
- *Oracle Net Services Administrator's Guide*

Non-Secure Remote Connections

To connect to Oracle as a privileged user over a non-secure connection, you must use password file authentication. When using password file authentication, the database uses a password file to keep track of database usernames that have been granted the SYSDBA or SYSOPER system privilege.

This form of authentication is discussed in "Using Password File Authentication" on page 1-17.

Local Connections and Secure Remote Connections

To connect to Oracle as a privileged user over a local connection or a secure remote connection, you have the following options:

- You can connect using password file authentication, provided the database has a password file and you have been granted the SYSDBA or SYSOPER system privilege.
- If the server is not using a password file, or if you have not been granted SYSDBA or SYSOPER privileges and are therefore not in the password file, you can use OS authentication. On most operating systems, OS authentication for database administrators involves placing the OS username of the database administrator in a special group, generically referred to as OSDBA.

Using Operating System (OS) Authentication

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

Preparing to Use OS Authentication

To enable authentication of an administrative user using the operating system you must do the following:

1. Create an operating system account for the user.
2. Add the user to the OSDBA or OSOPER operating system defined groups.
3. Ensure that the initialization parameter, REMOTE_LOGIN_PASSWORDFILE, is set to NONE. This is the default value for this parameter.

Connecting Using OS Authentication

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

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

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

OSDBA and OSOPER

Two special operating system groups control database administrator logins when using OS authentication. These groups are generically referred to as OSDBA and OSOPER. The groups are created and assigned specific names as part of the database installation process. The specific names vary depending upon your operating system, and default names assumed by the Oracle Universal Installer can be overridden. How you create the OSDBA and OSOPER groups is operating system specific.

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

If you are a member of the OSOPER group, and specify AS SYSOPER when you connect to the database, you are granted the SYSOPER system privilege.

If you are not a member of the associated operating system group for SYSDBA or SYSOPER system privileges, the CONNECT command will fail.

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

Using Password File Authentication

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

Preparing to Use Password File Authentication

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

1. Create an operating system account for the user.
2. If not already created, Create the password file using the ORAPWD utility:

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

3. Set the REMOTE_LOGIN_PASSWORDFILE initialization parameter to EXCLUSIVE.
4. Connect to the database as user SYS (or as another user with the administrative privilege).
5. If the user does not already exist in the database, create the user. Grant the SYSDBA or SYSOPER system privilege to the user:

```
GRANT SYSDBA to scott;
```

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

> **See Also:** "Password File Administration" on page 1-18 for instructions for creating and maintaining a password file

Connecting Using Password File Authentication

Users can be authenticated and connect to a local or remote database by using the SQL*Plus CONNECT command. They must connect using their username and password and with the AS SYSDBA or AS SYSOPER clause. For example, user scott has been granted the SYSDBA privilege, so he can connect as follows:

```
CONNECT scott/tiger AS SYSDBA
```

However, since scott has not been granted the SYSOPER privilege, the following command will fail:

```
CONNECT scott/tiger as SYSOPER;
```

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

Password File Administration

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

This section contains the following topics:

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

> **See Also:** 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 (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:

```
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 path name for the file. The contents of this file are encrypted, and the file cannot be read directly. This parameter is mandatory.

The types of filenames allowed for the password file are operating system specific. Some operating systems require the password file to be a specific format and located in a specific directory. Other operating systems 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 Oracle9*i* Real Application Clusters, the environment variable for each instance should point to the same password file.

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

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

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

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 SYSDBA and SYSOPER privileges to users, this parameter is required.

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

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 as follows:

Value	Description
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 SYS. Using an EXCLUSIVE password file allows you to grant SYSDBA and SYSOPER system privileges to individual users and have them connect as themselves.

Value	Description
SHARED	A SHARED password file can be used by multiple databases. However, the only user recognized by a SHARED password file is SYS. 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 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 remains in the password file only as long as that user has at least one of these two privileges. If you revoke both of these privileges, the 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 as explained in "Using ORAPWD" on page 1-19.
2. Set the REMOTE_LOGIN_PASSWORDFILE initialization parameter to EXCLUSIVE.
3. Connect with SYSDBA privileges as shown in the following example:

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

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

Granting the SYSDBA or SYSOPER privilege to a user causes their username to be added to the password file. This enables the user to connect to the database as SYSDBA or SYSOPER by specifying 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 SYSDBA and SYSOPER Privileges

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

```
GRANT SYSDBA TO 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 a user currently connected as SYSDBA (or INTERNAL) can grant or revoke another user's SYSDBA or SYSOPER system privileges. These privileges cannot be granted to roles, because 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.

> **See Also:** Chapter 25, "Managing User Privileges and Roles" for more information on system privileges

Viewing Password File Members

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

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

Maintaining a Password File

This section describes how to:

- Expand the number of password file users if the password file becomes full
- Remove the password file
- 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 the users who 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 1-19. Ensure that the ENTRIES parameter is set to a number larger than you think you will ever need.
5. Follow the instructions in "Adding Users to a Password File" on page 1-21.

Removing a Password File

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

Caution: 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 initialization parameter REMOTE_LOGIN_PASSWORDFILE. When you start up an instance, Oracle retrieves the value of this parameter from the 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 the values do not match, Oracle overwrites the value stored in the file.

Caution: 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 the data in your Oracle database. This section introduces two of these utilities:

- SQL*Loader
- Export and Import

See Also: *Oracle9i Database Utilities*

SQL*Loader

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

Export and Import

The Export and Import utilities enable 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.

2

Creating an Oracle Database

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

- Considerations Before Creating a Database
- The Oracle Database Configuration Assistant
- Manually Creating an Oracle Database
- Oracle9i Features that Simplify Database Creation and Management
- Troubleshooting Database Creation
- Dropping a Database
- Considerations After Creating a Database
- Initialization Parameters and Database Creation
- Managing Initialization Parameters Using a Server Parameter File

See Also:

- Chapter 3, "Using Oracle-Managed Files" for information about creating a database whose underlying operating system files are automatically created and managed by the Oracle database server
- *Oracle9i Real Application Clusters Installation and Configuration* for additional information specific to an Oracle Real Application Clusters environment

Considerations Before Creating a Database

Database creation prepares several operating system files to work together as an Oracle database. You need only create a database once, regardless of how many datafiles it has or how many instances access it. 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
- Meeting Creation Prerequisites
- Deciding How to Create an Oracle Database

Planning for Database Creation

Prepare to create the database by research and careful planning. The following are some recommended actions:

Action	For more information...
■ Plan the database tables and indexes and estimate the amount of space they will require.	Part II, "Oracle Server Processes and Storage Structure" Part III, "Schema Objects"
■ Plan the layout of the underlying operating system files that are to comprise your database. Proper distribution of files can improve database performance dramatically by distributing the I/O for accessing the files. There are several ways to distribute I/O when you install Oracle and create your database. For example, placing redo log files on separate disks or striping; placing datafiles to reduce contention; and controlling density of data (number of rows to a data block).	*Oracle9i Database Performance Guide and Reference* Your Oracle operating system specific documentation
■ Consider using the Oracle Managed Files feature to create and manage the operating system files that comprise your database storage and ease their administration.	Chapter 3, "Using Oracle-Managed Files"
■ Select the **global database name**, which is the name and location of the database within the network structure. Create the global database name by setting both the `DB_NAME` and `DB_DOMAIN` initialization parameters.	"Determining the Global Database Name" on page 2-28

Action	For more information...
■ Familiarize yourself with the initialization parameters that comprise the initialization parameter file. Become familiar with the concept and operation of a **server parameter file**. A server parameter file allows you to store and manage your initialization parameters persistently in a server-side disk file.	"Initialization Parameters and Database Creation" on page 2-28 "What is a Server Parameter File?" on page 2-37 *Oracle9i Database Reference*
■ Select the database character set. All character data, including data in the data dictionary, is stored in the database character set. You must specify the database character set when you create the database. If clients using different character sets will access the database, then choose a superset that includes all client character sets. This ensures that the system will not waste time using replacement characters to facilitate conversions. You can also specify an alternate character set.	*Oracle9i Globalization and National Language Support Guide*
■ Select the standard database block size. This is specified at database creation by the `DB_BLOCK_SIZE` initialization parameter and cannot be changed after the database is created. The `SYSTEM` tablespace and most other tablespaces use the standard block size. Additionally, you can specify up to four non-standard block sizes when creating tablespaces.	"Specifying Database Block Sizes" on page 2-30
■ Use an undo tablespace to manage your undo records, rather than rollback segments.	Chapter 13, "Managing Undo Space"
■ Develop a backup and recovery strategy to protect the database from failure. It is important to protect the control file by multiplexing, to choose the appropriate backup mode, and to manage the online and archived redo logs.	Chapter 7, "Managing the Online Redo Log" Chapter 8, "Managing Archived Redo Logs" Chapter 6, "Managing Control Files" *Oracle9i Backup and Recovery Concepts*
■ Familiarize yourself with the principles and options of starting up and shutting down an instance and mounting and opening a database.	Chapter 4, "Starting Up and Shutting Down"

Meeting 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 start up and shut down an instance before the database is created or opened. This authentication is discussed in "Database Administrator Authentication" on page 1-12.
- There is sufficient memory 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 users 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 prepared scripts. 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).

  The Database Configuration Assistant can be launched by the Oracle Universal Installer, depending upon the type of install that you select, and provides a

graphical user interface (GUI) that guides you through the creation of a database. You can chose not to use the Database Configuration Assistant, or you can launch it as a standalone tool at any time in the future to create a database. See "The Oracle Database Configuration Assistant" on page 2-5.

- Create the database manually from a script.

  If you already have existing scripts for creating your database, you can still create your database manually. However, consider editing your existing script to take advantage of new Oracle features. 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 2-11.

- 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 or upgrade your existing Oracle database managed by a previous version or release of Oracle and use it with the new version of the Oracle software. Database migration and upgrade are not discussed in this book. The *Oracle9i Database Migration* manual contains information about migrating an existing database.

The Oracle Database Configuration Assistant

The Oracle Database Configuration Assistant (DBCA) is a graphical user interface (GUI) tool that interacts with the Oracle Universal Installer, or can be used standalone, to simplify the creation of a database. Online help is available to assist you in its use.

You can create or delete a database using the Database Configuration Assistant. You can configure database options so as to add options that have not been previously configured. Additionally, the Database Configuration Assistant enables you to create and manage database templates. You can create a template of a database definition and later modify that template, or you can modify templates supplied by Oracle. You can also create a template of an existing database and clone it.

The Oracle Database Configuration Assistant can be used to create single instance databases, or it can be used to create or add instances in an Oracle Real Application Clusters environment.

This section contains the following topics that introduce you to the Oracle Database Configuration Assistant:

Advantages of Using the Oracle Database Configuration Assistant

These are a few of the advantages of using the Oracle Database Configuration Assistant:

- Its wizards guides you through a selection of options providing an easy means of creating and tailoring your database. It allows you to provide varying levels of detail. You can provide a minimum of input and allow Oracle to make decisions for you, eliminating the need to spend time deciding how best to set parameters or structure the database. Optionally, it allows you to be very specific about parameter settings and file allocations.
- It builds efficient and effective databases that take advantage of Oracle's new features.
- It uses Optimal Flexible Architecture (OFA), whereby database files and administrative files, including initialization files, follow standard naming and placement practices.

Creating a Database

You can create a database from predefined templates provided by Oracle or from templates that you or others have created. When you select a template, you can choose either to include datafiles or not. If you select a template with datafiles, you will be able to save the database creation information as a template or script. You can run the script later to create a new database.

This section does not discuss all of the choices available to you when you use the Oracle Database Creation Assistant to create a database. Rather, it is intended to provide an introduction to its use. Wizards will guide you in making choices for defining the database that you want to create.

Using Templates for Creating a Databases

Oracle provides templates for the following environments:

Environment	Description of Environment
DSS (Data Warehousing)	Users perform numerous, complex queries that process large volumes of data. Response time, accuracy, and availability are key issues. 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.
OLTP (Online Transaction Processing)	Many concurrent users performing numerous transactions requiring rapid access to data. Availability, speed, concurrence, and recoverability are key issues. Transactions consist of reading (SELECT statements), writing (INSERT and UPDATE statements), and deleting (DELETE statements) data in database tables.
New Database	This template allows you maximum flexibility in defining a database.

You have the option of viewing details for a template. The "show details" page displays specific information about the database defined by a template including:

- Options included
- Initialization parameter settings
- Control files and locations
- Tablespaces
- Datafiles
- Rollback segments (if included)
- Redo log groups

You can save the details page as an HTML file.

Including Datafiles

When you select a template, you also specify whether the database definition is to include datafiles. The following types of databases are created accordingly:

Include Datafiles?	Database Structure
No	This type of template contains only the structure of the database and gives you full control to specify and change all database parameters. If you select a template without datafiles, database creation will take longer since all scripts must be run to create the schema.
Yes	This type of template contains both the structure and the physical datafiles of the existing database. In effect, this template copies a prebuilt seed, or starter, database. In the seed database, Oracle automatically includes features that result in a highly effective and easier to manage database. When you select a template that includes datafiles, the database is created faster since the schema is present in the datafiles. Also, all log files and control files are automatically created for the database. You can change only the following: ■ Name of the database ■ Destination of the datafiles ■ Control files ■ Redo log groups Other changes must be made using command line SQL statements or the Oracle Enterprise Manager after database creation. You can also use custom scripts for additional modification.

Specifying the Global Database Name and Parameters

You are guided thorough a series of pages that allow you to further define your database or to accept default parameter values and file locations as recommended by Oracle. You provide a global database name, specify database options to include, determine mode (dedicated server of shared server), and ultimately you can specify initialization parameter.

When specifying initialization parameters, the first page presented is the "memory parameters" page. It is used to determine the values of initialization parameters that size the initial System Global Area (SGA). You select one of the following options:

Type of Database	Memory Initialization Parameters
Typical	This creates a database with minimal user input. You do not specify specific initialization parameter values; instead, you specify the maximum number of concurrent users, the percentage of physical memory reserved for Oracle, and a database type (OLTP, Multipurpose or Data Warehousing). Oracle uses this information to create an efficient and effective database for your environment.
Custom	Custom allows you to specify initialization parameter values that affect the size of the System Global Area (SGA). It can be used by very experienced database administrators who have specific tuning needs. Other areas that you will be allowed to customize include: ■ Data, control, and redo log file settings ■ Tablespace sizes ■ Extent sizes ■ Archiving formats and destinations ■ Trace file destinations ■ Character set specifications

Completing Database Creation

After you have completed the specification of the parameters that define your database you can:

- Create the database

  Select to create the database now. For more information on the creation parameters, refer to the summary dialog that appears when you start the database creation process.

- Save the description as a database template

  Select to save the database creation parameters as a template. This template will be automatically added to the list of available database creation templates.

- Generate database creation scripts

  Select to generate the scripts used to create the database. The scripts are generated from the database parameters you specified in the previous pages. You can use the scripts as a checklist, or to create the database later without using the Database Creation Assistant.

Configuring Database Options

When you elect to configure database options, you can add Oracle options that have not previously been configured for use with your database

The following is a partial list of Oracle options or functionality that you can install in your database. Oracle provides a complete list from which you can select on the "configure database options" page. Some of the listed options might already be installed depending upon how you defined the database. Those options that are already installed are noted as such (grayed out).

- Oracle Spatial
- Oracle Text
- Oracle JServer
- Oracle Advanced Replication
- Oracle OLAP Services
- Oracle Label Security
- Oracle Sample Schemas

Deleting a Database

The Oracle Database Configuration Assistant enables you to delete a database. When you do so, you delete the database instance and its control file(s), redo log files, and data files. The initialization parameter file is not deleted.

Managing Templates

A template is a definition of a database. Oracle provides some basic templates for you to use, as discussed earlier in "Creating a Database" on page 2-6, or you have the option of saving database definitions that you create yourself. These saved definitions can then be used to create new databases in the future, without having to completely redefine them. Oracle saves templates in XML files.

The following are some of the advantages of using templates:

- They save you time. If you use a template you do not have to define the database.
- By creating a template containing your database settings, you can easily create a duplicate database without specifying parameters twice.
- You can quickly change database options from the template settings.

- Templates are easy to share. They can be copied from one machine to another.

A "template management" page provides you with several options that enable you to modify existing definitions or to create definitions based upon existing databases:

- Use an existing template

  From an existing template, create a new template based on the pre-defined template settings. You can add or change any template settings such as initialization parameters, storage parameters, or use custom scripts.

- Use an existing database

  From an existing database (structure only), create a new template whose structure is identical to the existing database. This includes tablespaces and storage. You can use an existing database that is either local or remote.

- Clone a database

  From an existing database (structure as well as data) create a template that has both the structure and data of an existing database. You can only use an existing database that is local.

You can view the "show details" page to see detail information about the templates you create or modify.

The "template management" page also allows you to delete existing templates.

Manually Creating an Oracle Database

This section presents the steps involved when you create a database manually. These steps should be followed in the order presented. You will previously have created your environment for creating your Oracle database, including most operating system dependent environmental variables, as part of the Oracle software installation process.

The examples shown in these steps are to create the database `mynewdb`.

Note: At this point, you may not be familiar with all of the initialization parameters and database structures discussed in this section. These steps contain many cross references to other parts of this book to allow you to learn about and understand these parameters and structures.

Step 1: Decide on Your Instance Identifier (SID)

Decide on a unique Oracle system identifier (SID) for your instance and set the ORACLE_SID environment variable accordingly. This identifier is used to avoid confusion with other Oracle instances that you may create later and run concurrently on your system.

The following examle sets the SID for the instance and database we are about to create:

```
% setenv ORACLE_SID mynewdb
```

The value of the `DB_NAME` initialization parameter should match the SID setting.

Step 2: Establish the Database Administrator Authentication Method

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

- "Database Administrator Security and Privileges" on page 1-9
- "Database Administrator Authentication" on page 1-12
- "Password File Administration" on page 1-18

Step 3: Create the Initialization Parameter File.

The instance (System Global Area and background processes) for any Oracle database is started using an initialization parameter file. One way getting started on your initialization parameter file is to edit a copy of the sample initialization parameter file that Oracle provides on the distribution media or the sample presented in this book.

For ease of operation, store your initialization parameter file in Oracle's default location, using the default name. That way, when you start your database, it is not necessary to specify the PFILE parameter because Oracle automatically looks in the default location for the initialization parameter file.

Default parameter file locations are shown in the following table:

Platform	Default Name	Default Location

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

NT	`init$ORACLE_SID.ora`	`$ORACLE_HOME\database`

The following is the initialization parameter file used to create the `mynewdb` database.

Sample Initialization Parameter File

```
# Cache and I/O
DB_BLOCK_SIZE=4096
DB_CACHE_SIZE=20971520

# Cursors and Library Cache
CURSOR_SHARING=SIMILAR
OPEN_CURSORS=300

# Diagnostics and Statistics
BACKGROUND_DUMP_DEST=/vobs/oracle/admin/mynewdb/bdump
CORE_DUMP_DEST=/vobs/oracle/admin/mynewdb/cdump
TIMED_STATISTICS=TRUE
USER_DUMP_DEST=/vobs/oracle/admin/mynewdb/udump

# Control File Configuration
```

```
CONTROL_FILES=("/vobs/oracle/oradata/mynewdb/control01.ctl",
               "/vobs/oracle/oradata/mynewdb/control02.ctl",
               "/vobs/oracle/oradata/mynewdb/control03.ctl")

# Archive
LOG_ARCHIVE_DEST_1='LOCATION=/vobs/oracle/oradata/mynewdb/archive'
LOG_ARCHIVE_FORMAT=%t_%s.dbf
LOG_ARCHIVE_START=TRUE

# Shared Server
# Uncomment and use first DISPATCHES parameter below when your listener is
# configured for SSL
# (listener.ora and sqlnet.ora)
# DISPATCHERS = "(PROTOCOL=TCPS)(SER=MODOSE)",
#               "(PROTOCOL=TCPS)(PRE=oracle.aurora.server.SGiopServer)"
DISPATCHERS="(PROTOCOL=TCP)(SER=MODOSE)",
            "(PROTOCOL=TCP)(PRE=oracle.aurora.server.SGiopServer)",
             (PROTOCOL=TCP)

# Miscellaneous
COMPATIBLE=9.0.0
DB_NAME=mynewdb

# Distributed, Replication and Snapshot
DB_DOMAIN=us.oracle.com
REMOTE_LOGIN_PASSWORDFILE=EXCLUSIVE

# Network Registration
INSTANCE_NAME=mynewdb

# Pools
JAVA_POOL_SIZE=31457280
LARGE_POOL_SIZE=1048576
SHARED_POOL_SIZE=52428800

# Processes and Sessions
PROCESSES=150

# Redo Log and Recovery
FAST_START_MTTR_TARGET=300

# Resource Manager
RESOURCE_MANAGER_PLAN=SYSTEM_PLAN

# Sort, Hash Joins, Bitmap Indexes
```

```
SORT_AREA_SIZE=524288

# System Managed Undo and Rollback Segments
UNDO_MANAGEMENT=AUTO
UNDO_TABLESPACE=undotbs
```

See Also:

- "Initialization Parameters and Database Creation" on page 2-28 for more information on some of these parameters and other intialization parameters that you decide to include

Step 4: Connect to the Instance

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

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

Step 5: Start the Instance.

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

```
STARTUP NOMOUNT
```

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

See Also:

- "Managing Initialization Parameters Using a Server Parameter File" on page 2-36
- Chapter 4, "Starting Up and Shutting Down" to learn how to use the STARTUP command

Step 6: Issue the CREATE DATABASE Statement

To create the new database, use the CREATE DATABASE statement. When you execute a CREATE DATABASE statement, Oracle performs (at least) the following operations. Other operations are performed depending upon the clauses that you specify in the CREATE DATABASE statement or initialization parameters that you have set.

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

The following statement creates database mynewdb:

```
CREATE DATABASE mynewdb
   MAXINSTANCES 1
   MAXLOGHISTORY 1
   MAXLOGFILES 5
   MAXLOGMEMBERS 5
   MAXDATAFILES 100
   DATAFILE '/vobs/oracle/oradata/mynewdb/system01.dbf' SIZE 325M REUSE
   UNDO TABLESPACE undotbs DATAFILE '/vobs/oracle/oradata/mynewdb/undotbs01.dbf'
      SIZE 200M REUSE AUTOEXTEND ON NEXT  5120K MAXSIZE UNLIMITED
   DEFAULT TEMPORARY TABLESPACE tempts1
   CHARACTER SET US7ASCII
   NATIONAL CHARACTER SET AL16UTF16
   LOGFILE GROUP 1 ('/vobs/oracle/oradata/mynewdb/redo01.log') SIZE 100M,
           GROUP 2 ('/vobs/oracle/oradata/mynewdb/redo02.log') SIZE 100M,
           GROUP 3 ('/vobs/oracle/oradata/mynewdb/redo03.log') SIZE 100M;
```

A database is created with the following characteristics:

- The database is named mynewdb. Its global database name is mynewdb.us.oracle.com. See "DB_NAME Initialization Parameter" and "DB_DOMAIN Initialization Parameter" on page 2-29.

- Three control files are created as specified by the CONTROL_FILES initialization parameter. See "Specifying Control Files" on page 2-29.
- MAXINSTANCES specified that only one instance can have this database mounted and open.
- MAXDATAFILES specifies the maximum number of datafiles that can be open in the database. This number affects the initial sizing of the control file.

Note: You can set several limits during database creation. Some of these limits are also subject to superseding limits of the operating system and can be affected by them. 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. However, because the maximum control file size is limited and operating system dependent, you might not be able to set all CREATE DATABASE parameters at their theoretical maximums.

For more information about setting limits during database creation, see the *Oracle9i SQL Reference* and your operating system specific Oracle documentation.

- The SYSTEM tablespace, consisting of the operating system file /vobs/oracle/oradata/mynewdb/system01.dbf is created as specified by the DATAFILE clause. If the file already exists, it is overwritten.
- The UNDO_TABLESPACE clause creates and names the undo tablespace to be used to store undo records for this database. See Chapter 13, "Managing Undo Space".
- The DEFAULT_TEMPORARY_TABLESPACE clause creates and names a default temporary tablespace for this database. See "Creating a Default Temporary Tablespace" on page 2-21.
- The US7ASCII character set is used to store data in this database.
- The AL16UTF16 character set is specified as the NATIONAL CHARACRTER SET used to store data in columns of specifically defined as NCHAR, NCLOB, or NVARCHAR2.
- The new database has three online redo log files as specified in the LOGFILE clause. MAXLOGHISTORY, MAXLOGFILES, and MAXLOGMEMBERS define limits for the redo log. See Chapter 7, "Managing the Online Redo Log".

- Because the ARCHIVELOG clause is not specified in this CREATE DATABASE statement, redo log files will not initially be archived. This is customary during database creation and an ALTER DATABASE statement can be used later to switch to ARCHIVELOG mode. The initialization parameters in the initialization parameter file for mynewdb affecting archiving are LOG_ARCHIVE_DEST_1, LOG_ARCHIVE_FORMAT, and LOG_ARCHIVE_START. See Chapter 8, "Managing Archived Redo Logs".
- The default database time zone is the same as the operating system's time zone. You set the database's default time zone by specifying the SET TIME_ZONE clause of the CREATE DATABASE statement. If omitted (as it is in this case), the default database time zone is the operating system time zone. The database time zone can be changed for a session with an ALTER SESSION statement. For information about the time zone files used by Oracle to obtain time zone data, see "Setting and Managing the Time Zone" on page 2-23.

> **See Also:** *Oracle9i SQL Reference* for more information about specifying the clauses and parameter values for the CREATE DATABASE statement

Step 7: Create Additional Tablespaces

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

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

For information about creating tablespaces, see Chapter 11, "Managing Tablespaces".

Step 8: Run Scripts to Build Data Dictionary Views

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

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

The following table contains descriptions of the scripts:

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

You may want to run other scripts. The scripts that you run are determined by the features and options you choose to use or install. Many of the scripts available to you are described in the *Oracle9i Database Reference*.

See your Oracle installation guide for your operating system for the location of these scripts.

Step 9: Run Scripts to Install Additional Options (Optional)

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

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

Step 10: Create a Server Parameter File (Recommended)

Oracle recommends you create a server parameter file as a dynamic means of maintaining initialization parameters. The server parameter file is discussed in "Managing Initialization Parameters Using a Server Parameter File" on page 2-36.

The following script creates a server parameter file from the text initialization parameter file and writes it to the default location. The instance is shut down, then restarted using the server parameter file (in the default location).

```
CONNECT SYS/password AS SYSDBA
-- create the server parameter file
CREATE SPFILE='/vobs/oracle/dbs/spfilemynewdb.ora' FROM
       PFILE='/vobs/oracle/admin/mynewdb/scripts/init.ora';
SHUTDOWN
-- this time you will start up using the server parameter file
CONNECT SYS/password AS SYSDBA
STARTUP
EXIT
```

Step 11: 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 *Oracle9i Backup and Recovery Concepts.*

Oracle9*i* Features that Simplify Database Creation and Management

In addition to using the Database Configuration Assistant for creating your database, Oracle9*i* offers you other options that can simplify the creation, operation, and management of your database. There are clauses, some shown in the above `CREATE DATABASE` statement, which are discussed in this section. Additionally, you can choose to use the Oracle Managed Files feature, which automatically creates and manages the underlying operating system files of your database.

Also discussed in this section is the management of the time zone files used to support the `SET TIME_ZONE` feature.

This section contains the following topics:

- Creating an Undo Tablespace
- Creating a Default Temporary Tablespace
- Using Oracle-Managed Files
- Setting and Managing the Time Zone

Creating an Undo Tablespace

Optionally, instead of using rollback segments in your database, you can use an undo tablespace. This requires the use of a different set of initialization parameters and, if creating the database for the first time, the `UNDO TABLESPACE` clause of the `CREATE DATABASE` statement. You also must include the following initialization parameter:

```
UNDO_MANAGEMENT=AUTO
```

This initialization parameter tells Oracle that you want to operate your database automatic undo management mode. In this mode rollback information, referred to as undo, is stored in an undo tablespace rather than rollback segments and is managed by Oracle.

> **See Also:** Chapter 13, "Managing Undo Space" for information about the creation and use of undo tablespaces

Creating a Default Temporary Tablespace

The DEFAULT TEMPORARY TABLESPACE clause of the CREATE DATABASE statement specifies that a temporary tablespace is to be created at database creation time. This tablespace is used as the default temporary tablespace for users who are not otherwise assigned a temporary tablespace.

Users can be explicitly assigned a default temporary tablespace in the CREATE USER statement. But, if no temporary tablespace is specified, they default to using the SYSTEM tablespace. It is not good practice to store temporary data in the SYSTEM tablespace. To avoid this problem, and to avoid the need to assign every user a default temporary tablespace at CREATE USER time, you can use the DEFAULT TEMPORARY TABLESPACE clause of CREATE DATABASE.

If you decide later to change the default temporary tablespace, or to create an initial one after database creation, you can do so. You do this by creating a new temporary tablespace (CREATE TEMPORARY TABLESPACE), then assign it as the temporary tablespace using the ALTER DATABASE DEFAULT TEMPORARY TABLESPACE statement. Users will automatically be switched (or assigned) to the new temporary default tablespace.

The following statement assigns a new default temporary tablespace:

```
ALTER TABLESPACE DEFAULT TEMPORARY TABLESPACE tempts2
```

The new default temporary tablespace must be an existing temporary tablespace.

You cannot drop a default temporary tablespace, but you can assign a new default temporary tablespace, then drop the former one. You are not allowed to change a default temporary tablespace to a permanent tablespace, nor can you take a default temporary tablespace offline.

Users can obtain the name of the current default temporary tablespace using the DATABASE_PROPERTIES view. The PROPERTY_NAME column contains the value

"DEFAULT_TEMP_TABLESPACE" and the PROPERTY_VALUE column contains the default temporary tablespace name.

See Also:

- *Oracle9i SQL Reference* for the syntax of the DEFAULT TEMPORARY TABLESPACE clause of CREATE DATABASE and ALTER DATABASE
- "Temporary Tablespaces" on page 11-11 for information about creating and using temporary tablespaces

Using Oracle-Managed Files

If you include the DB_CREATE_FILE_DEST or DB_CREATE_ONLINE_LOG_DEST_*n* initialization parameters in your initialization parameter file, you enable Oracle to create and manage the underlying operating system files of your database. Oracle will automatically create and manage the operating system files for the following database structures, dependent upon the initialization parameters you specify and how you specify clauses in your CREATE DATABASE statement:

- Tablespaces
- Temporary tablespaces
- Control files
- Online redo log files

Briefly, this is how the Oracle Managed Files feature works with the CREATE DATABASE statement presented earlier in this section and repeated here.

```
CREATE DATABASE rbdb1
     UNDO TABLESPACE undotbs
     DEFAULT TEMPORARY TABLESPACE tempts1;
```

- No DATAFILE clause is specified, therefore Oracle creates an Oracle-managed datafile for the SYSTEM tablespace.
- No LOGFILE clauses are included, therefore Oracle creates two online redo log file groups that are Oracle managed.
- No DATAFILE subclause is specified for the UNDO TABLESPACE clause, therefore Oracle creates an Oracle-managed datafile for the undo tablespace.
- No TEMPFILE subclause is specified for the DEFAULT TEMPORARY TABLESPACE clause, therefore Oracle creates an Oracle-managed tempfile.

- Additionally, if no CONTROL_FILES initialization parameter is specified in the initialization parameter file, Oracle creates an Oracle-managed control file.
- If using a server parameter file (see "Managing Initialization Parameters Using a Server Parameter File" on page 2-36) the initialization parameters are set accordingly and automatically.

Setting and Managing the Time Zone

Oracle9*i* enables you to set the time zone for your database using the SET TIME_ZONE clause of the CREATE DATABASE statement. This section provides information on the time zone files used to support this feature, specifically on Solaris platforms. Names of directories, filenames, and environment variables may differ for each platform but will probably be the same for all UNIX platforms.

The time zone files contain the valid time zone names and the following information is included for each zone (note that abbreviations are only used in conjunction with the zone names):

- Offset from UTC
- Transition times for daylight savings
- Abbreviation for standard time
- Abbreviation for daylight savings time

There are 2 time zone files under the Oracle installation directory:

- $ORACLE_HOME/oracore/zoneinfo/timezone.dat

  This is the default. It contains the most commonly used time zones and is smaller, thus enabling better database performance.

- $ORACLE_HOME/oracore/zoneinfo/timezlrg.dat

  This file contains the larger set of defined time zones and should be used by users who require zones that are not defined in the default timezone.dat file. Note that this larger set of zone information may affect performance.

To enable the use of the larger time zone data file, the DBA must do the following:

1. Shutdown the database.
2. Set the environment variable ORA_TZFILE to the full pathname of the location for the timezlrg.dat file.
3. Restart the database.

Once the larger `timezlrg.dat` is used, it must continue to be used unless the user is sure that none of the nondefault zones are used for data that is stored in the database. Also, all databases that share information must use the same time zone data file.

To view the time zone names, use the following query:

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

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, you must remove its datafiles, redo log files, and all other associated files (control files, initialization parameter files, archived log files). To view the names of the database's datafiles, redo log files, and control files, query the data dictionary views `V$DATAFILE`, `V$LOGFILE`, and `V$CONTROLFILE`, respectively.

If the database is in archive log mode, locate the archive log destinations by inspecting the initialization parameters `LOG_ARCHIVE_DEST_`*n*, or `LOG_ARCHIVE_DEST` and `LOG_ARCHIVE_DUPLEX_DEST`.

If you used the Database Configuration Assistant to create your database, you can use that tool to delete your database and clean up the files.

> **See Also:** *Oracle9i Database Reference* for more information about these views and initialization parameters

Considerations After Creating a Database

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

Some Security Considerations

A newly created database has least three users that are useful for administering your database: SYS, SYSTEM and OUTLN (owner of schema where stored outlines are stored).

> **Caution:** To prevent unauthorized access and protect the integrity of your database, the default passwords for SYS and SYSTEM should be changed immediately after the database is created.

Depending on the features and options installed, other users can also be present. Some of these users are:

- MDSYS (*inter*Media Spatial)
- ORDSYS (*inter*Media Audio)
- ORDPLUGINS (*inter*Media Audio)
- CTXSYS (Oracle Text)
- DBSNMP (Enterprise Manager Intelligent Agent)

To change the password for user DBSNMP refer to *Oracle Intelligent Agent User's Guide*.

Note Regarding Security Enhancements: In this release of Oracle9*i* and in subsequent releases, several enhancements are being made to ensure the security of default database user accounts.

- Beginning with this release, during initial installation with the Oracle Database Configuration Assistant (DCBA), all default database user accounts except SYS, SYSTEM, SCOTT, DBSNMP, OUTLN, AURORAJISUTILITY$, AURORA$ORB$UNAUTHENTICATED and OSE$HTTP$ADMIN will be locked and expired. To activate a locked account, the DBA must manually unlock it and reassign it a new password.
- In the next release of the database server, the Database Configuration Assistant will prompt for passwords for users SYS and SYSTEM during initial installation of the database rather than assigning default passwords to them. In addition, a CREATE DATABASE SQL statement issued manually will require you to specify passwords for these two users.
- Oracle9*i* will be the last major release to support the user SYSTEM as a default database user created during any type of installation or by the CREATE DATABASE SQL statement.

See Also:

- "A Security Checklist" on page 23-20
- "Database Administrator Usernames" on page 1-10 for more information about the users SYS and SYSTEM
- "Altering Users" on page 24-20 to learn how to add new users and change passwords
- *Oracle9i SQL Reference* for the syntax of the ALTER USER statement used for unlocking user accounts

Installing Oracle's Sample Schemas

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.

Starting with Oracle9*i*, Oracle provides sample schemas that enable you to become familiar with Oracle functionality. Some Oracle documents and books use these sample schemas for presenting examples. There is an ongoing effort for most Oracle books to convert to the use of Sample Schemas based examples.

The following table briefly describes the sample schemas:

Schema	Description
Human Resources	The Human Resources (HR) schema is a basic relational database schema. There are six tables in the HR schema: Employees, Departments, Locations, Countries, Jobs, and Job_ History. The Order Entry (OE) schema has links into HR schema
Order Entry	The Order Entry (OE) schema builds on the purely relational Human Relations (HR) schema with some object-relational and object-oriented features. The OE schema contains seven tables: Customers, Product_Descriptions, Product_Information, Order_ Items, Orders, Inventories, and Warehouses. The OE schema has links into the HR schema and PM schema. This schema also has synonyms defined on HR objects to make access transparent to users.
Product Media	Product Media (PM) schema includes two tables, online_media and print_media, one object type, adheader_typ, and one nested table, textdoc_typ. The PM schema includes interMedia and LOB column types. **Note:** To use interMedia Text you must create an interMedia Text index.
Sales History	The Sales History (SH) schema is an example of a relational star schema. It consists of one big range partitioned fact table sales and five dimension tables: times, promotions, channels, products and customers. The additional countries table linked to customers shows a simple snowflake.
Queued Shipping	The Queued Shipping (QS) schema is actually multiple schemas that contain message queues.

Sample Schemas can be installed automatically for you by the Oracle Database Configuration Assistant or you can install it manually. The schemas and installation instructions are described in detail in *Oracle9i Sample Schemas*.

Initialization Parameters and Database Creation

Oracle has attempted to provide appropriate values in the starter initialization parameter file provided with your database software. You can edit these Oracle-supplied initialization parameters and add others, depending upon your configuration and options and how you plan to tune the database. For any relevant initialization parameters not specifically included in the initialization parameter file, Oracle supplies defaults.

If you are creating an Oracle database for the first time, it is suggested that you minimize the number of parameter values that you alter. As you become more familiar with your database and environment, you can dynamically tune many initialization parameters for the current instance with the `ALTER SYSTEM` statement. Later, you can choose to permanently add or change parameter values by updating them manually in the traditional text initialization parameter file. Or, you can create a binary server parameter file that enables you to use the `ALTER SYSTEM` statement to make initialization parameter changes that can persist across shutdown and startup. Both of these options are discussed in "Managing Initialization Parameters Using a Server Parameter File" on page 2-36.

This section discusses some of the initialization parameters you may choose to add or edit before you create your new database.

The following topics are contained in this section:

- Determining the Global Database Name
- Specifying Control Files
- Specifying Database Block Sizes
- Setting Initialization Parameters that Affect the Size of the SGA
- Specifying the Maximum Number of Processes
- Specifying the Method of Undo Space Management
- Setting License Parameters

> **See Also:** *Oracle9i Database Reference* for descriptions of all initialization parameters including their default settings

Determining the Global Database Name

A database's global database name consists of the local database name that you assign and its location within a network structure. The `DB_NAME` initialization 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 must form a database name that is unique within a network.

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

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

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

DB_NAME Initialization Parameter

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

DB_DOMAIN Initialization Parameter

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

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

Specifying Control Files

Include the CONTROL_FILES initialization parameter in your new parameter file and set its value to a list of control filenames to use for the new database. When you execute the CREATE DATABASE statement, the control files listed in the CONTROL_FILES parameter will be created. If no filenames are listed for the CONTROL_FILES parameter, Oracle uses a default operating system dependent filename.

If you want Oracle to create new operating system files when creating your database's control files, the filenames listed in the CONTROL_FILES parameter must 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, ensure that the filenames listed in the CONTROL_FILES parameter match the filenames that are to be reused.

Caution: Use extreme caution when setting this 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.

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

See Also: Chapter 6, "Managing Control Files"

Specifying Database Block Sizes

The DB_BLOCK_SIZE initialization parameter specifies the standard block size for the database. This block size is used for the SYSTEM tablespace and by default in other tablespaces. Oracle can support up to 4 additional non-standard block sizes.

DB_BLOCK_SIZE Initialization Parameter

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

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 is valid:

```
DB_BLOCK_SIZE=4096
```

In some cases, you may want to specify a block size larger than your operating system block size. A larger data block size provides greater efficiency in disk and memory I/O (access and storage of data). Such cases include the following scenarios:

- 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 default 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.

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

Non-Standard Block Sizes

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

To use non-standard block sizes, you must configure sub-caches within the buffer cache area of the SGA memory for all of the non-standard block sizes that you intend to use. The initialization parameters used for configuring these sub-caches are described in the next section, "Setting Initialization Parameters that Affect the Size of the SGA".

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

See Also:

- "Creating Tablespaces" on page 11-4
- "Transporting Tablespaces Between Databases" on page 11-31

Setting Initialization Parameters that Affect the Size of the SGA

The initialization parameters discussed in this section affect the amount of memory that is allocated to the System Global Area. Except for the `SGA_MAX_SIZE` initialization parameter, they are dynamic parameters which values can be changed

by the ALTER SYSTEM statement. The size of the SGA is dynamic, and can grow or shrink by dynamically altering these parameters.

See Also:

- *Oracle9i Database Performance Guide and Reference* for more information about the initialization parameters affecting the SGA. It addresses the monitoring and tuning of the components of the SGA.
- *Oracle9i Database Concepts* for conceptual information about the SGA and its components

Setting the Buffer Cache Initialization Parameters

The buffer cache initialization parameters determine the size of the buffer cache component of the SGA. You use them to specify the sizes of caches for the various block sizes used by the database. These initialization parameters are all dynamic.

If you intend to use multiple block sizes in your database, you must have the DB_CACHE_SIZE and at least one DB_*n*K_CACHE_SIZE parameter set. Oracle assigns an appropriate default value to the DB_CACHE_SIZE parameter, but the DB_*n*K_CACHE_SIZE parameters default to 0, and no additional block size caches are configured.

The size of a buffer cache affects performance. Larger cache sizes generally reduce the number of disk reads and writes. However, a large cache may take up too much memory and induce memory paging or swapping.

DB_CACHE_SIZE Initialization Parameter The DB_CACHE_SIZE initialization parameter replaces the DB_BLOCK_BUFFERS initialization parameter that was used in previous releases. The DB_CACHE_SIZE parameter specifies the size of the cache of standard block size buffers, where the standard block size is specified by DB_BLOCK_SIZE.

For backward compatibility the DB_BLOCK_BUFFERS parameter will still work, but it remains a static parameter and cannot be combined with any of the dynamic sizing parameters.

DB_*n*K_CACHE_SIZE Initialization Parameters The sizes and numbers of non-standard block size buffers are specified by the following initialization parameters:

- DB_2K_CACHE_SIZE
- DB_4K_CACHE_SIZE

- DB_8K_CACHE_SIZE
- DB_16K_CACHE_SIZE
- DB_32K_CACHE_SIZE.

Each parameter specifies the size of the buffer cache for the corresponding block size. For example:

```
DB_BLOCK_SIZE=4096

DB_CACHE_SIZE=12M
DB_2K_CACHE_SIZE=8M
DB_8K_CACHE_SIZE=4M
```

In the above example, the parameters specify that the standard block size of the database will be 4K. The size of the cache of standard block size buffers will be 12M. Additionally, 2K and 8K caches will be configured with sizes of 8M and 4M respectively.

> **Note:** These parameters cannot be used to size the cache for the standard block size. For example, if the value of DB_BLOCK_SIZE is 2K, it is illegal to set DB_2K_CACHE_SIZE. The size of the cache for the standard block size is always determined from the value of DB_CACHE_SIZE.

Adjusting the Size of the Shared Pool

The SHARED_POOL_SIZE initialization parameter is a dynamic parameter (in previous releases it was not dynamic) that allows you to specify or adjust the size of the shared pool component of the SGA. Oracle selects an appropriate default value.

Adjusting the Size of the Large Pool

The LARGE_POOL_SIZE initialization parameter is a dynamic parameter (in previous releases it was not dynamic) that allows you to specify or adjust the size of the large pool component of the SGA. Oracle selects an appropriate default value.

Limiting the Size of the SGA

The SGA_MAX_SIZE initialization parameter specifies the maximum size of the System Global Area for the lifetime of the instance. You can dynamically alter the initialization parameters affecting the size of the buffer caches, shared pool, and large pool, but only to the extent that the sum of these sizes and the sizes of the

other components of the the SGA (fixed SGA, variable SGA, and redo log buffers) does not exceed the value specified by SGA_MAX_SIZE.

If you do not specify SGA_MAX_SIZE, then Oracle selects a default value that is the sum of all components specified or defaulted at initialization time.

Specifying the Maximum Number of Processes

The PROCESSES initialization parameter determines the maximum number of operating system processes that can be connected to Oracle concurrently. The value of this parameter must be 6 or greater (5 for the background processes plus 1 for each user process). For example, if you plan to have 50 concurrent users, set this parameter to at least 55.

Specifying the Method of Undo Space Management

Every Oracle database must have a method of maintaining information that is used to roll back, or undo, changes to the database. Such information consists of records of the actions of transactions, primarily before they are committed. Oracle refers to these records collectively as **undo**. Oracle allows you to store undo in an undo tablespace or in rollback segments.

See Also: Chapter 13, "Managing Undo Space"

UNDO_MANAGEMENT Initialization Parameter

The UNDO_MANAGEMENT initialization parameter determines whether an instance will start up in automatic undo management mode, where undo is stored in an undo tablespace, or rollback segment undo mode, where undo is stored in rollback segments. A value of AUTO enables automatic undo management mode, MANUAL enables rollback segment undo mode. For backward compatibility, the default is MANUAL.

UNDO_TABLESPACE Initialization Parameter

When the instance starts up in automatic undo management mode, it selects the first available undo tablespace in the instance for storing undo. A default undo tablespace named SYS_UNDOTBS is automatically created when you execute a CREATE DATABASE statement and the UNDO_MANAGEMENT initialization parameter is set to AUTO. This is the undo tablespace that Oracle will normally select whenever you start up the database.

Optionally, you can specify the UNDO_TABLESPACE initialization parameter. This causes the instance to use the undo tablespace specified by the parameter. The UNDO_TABLESPACE parameter can be used to assign a specific undo tablespace to an instance in an Oracle Real Application Clusters environment.

If there is no undo tablespace available, the instance will start, but uses the SYSTEM rollback segment. This is not recommended in normal circumstances, and an alert message is written to the alert file to warn that the system is running without an undo tablespace.

Oracle recommends using an undo tablespace rather than rollback segments. An undo tablespace is easier to administer and enables you to explicitly set an undo retention time.

ROLLBACK_SEGMENTS Initialization Parameter

The ROLLBACK_SEGMENTS parameter is a list of the non-system rollback segments an Oracle instance acquires at database startup if the database is to operate in rollback segment undo mode. List your rollback segments as the value of this parameter. If no rollback segments are specified, the system rollback segment is used.

The ROLLBACK_SEGMENTS initialization parameter is supported for backward compatibility. Oracle recommends using an undo tablespace rather than rollback segments.

Setting 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.

The licenses initialization parameters are introduced here, but are discussed in greater detail in "Session and User Licensing" on page 24-2.

LICENSE_MAX_SESSIONS and LICENSE_SESSIONS_WARNING Parameters

You can set a limit on the number of concurrent sessions that can connect to a database. To set the maximum number of concurrent sessions for an instance, set

the initialization parameter LICENSE_MAX_SESSIONS in the initialization 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 to 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 running with Oracle Real Application Cluster instances, 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.

LICENSE_MAX_USERS Initialization Parameter

You can set a limit on the number of users created in the database. Once this limit is reached, you cannot create more users.

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

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

```
LICENSE_MAX_USERS = 200
```

For Oracle Real Application Cluster instances, all instances connected to the same database should have the same named user limit.

Managing Initialization Parameters Using a Server Parameter File

Oracle has traditionally stored initialization parameters in a text initialization parameter file. Starting with Oracle9*i*, you can choose to maintain initialization parameters in a binary server parameter file.

This section introduces the server parameter file, and explains how to manage initialization parameters using either method of storing the parameters. The following topics are contained in this section.

What is a Server Parameter File?

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

A server parameter file is initially built from a traditional text initialization parameter file using the `CREATE SPFILE` statement. It is a binary file that cannot be browsed or edited using a text editor. Oracle provides other interfaces for viewing and modifying parameter settings.

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

At system startup, the default behavior of the `STARTUP` command is to read a server parameter file to obtain initialization parameter settings. The `STARTUP` command with no `PFILE` clause, reads the server parameter file from an operating

system specific location. If you choose to use the traditional text initialization parameter file, you must specify the PFILE clause when issuing the STARTUP command. Explicit instructions for starting an instance using a server parameter file are contained in Starting Up a Database on page 4-2.

Migrating to a Server Parameter File

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

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

   Note: If you are using Oracle9*i* Real Application Clusters, you must combine all of your instance specific initialization parameter files into a single initialization parameter file. Instructions for doing this, and other actions unique to using a server parameter file for Oracle Real Application Cluster instances, are discussed in:

   - *Oracle9i Real Application Clusters Installation and Configuration*
   - *Oracle9i Real Application Clusters Administration*

2. Create a server parameter file using the CREATE SPFILE statement. This statement reads the initialization parameter file to create a server parameter file. The database does not have to be started to issue a CREATE SPFILE statement.
3. Start up the instance using the newly created server parameter file.

Creating a Server Parameter File

The server parameter file must initially be created from a traditional text initialization parameter file. It must be created prior to its use in the STARTUP command. The CREATE SPFILE statement is used to create a server parameter file. You must have the SYSDBA or the SYSOPER system privilege to execute this statement.

The following example creates a server parameter file from initialization parameter file /u01/oracle/dbs/init.ora. In this example no SPFILE name is specified, so the file is created in a platform-specific default location and is named spfile$ORACLE_SID.ora.

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

Another example, below, illustrates creating a server parameter file and supplying a name.

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

The server parameter file is always created on the machine running the database server. If a server parameter file of the same name already exists on the server, it is overwritten with the new information.

Oracle recommends that you allow the database server to default the name and location of the server parameter file. This will ease administration of your database. For example, the STARTUP command assumes this default location to read the parameter file.

When the server parameter file is created from the initialization parameter file, comments specified on the same lines as a parameter setting in the initialization parameter file are maintained in the server parameter file. All other comments are ignored.

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

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

The SPFILE Initialization Parameter

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

The SPFILE parameter can also be set in a traditional parameter file to indicate the server parameter file to use. You use the SPFILE parameter to specify a server parameter file located in a nondefault location. *Do not* use an IFILE initialization parameter within a traditional initialization parameter file to point to a server

parameter file; instead, use the SPFILE parameter. See "Starting Up a Database" on page 4-2 for details about:

- Starting up a database that uses a server parameter file
- Using the SPFILE parameter to specify the name of a server parameter file to use at instance startup

Using ALTER SYSTEM to Change Initialization Parameter Values

The ALTER SYSTEM statement allows you to set, change, or delete (restore to default value) initialization parameter values. When the ALTER SYSTEM statement is used to alter a parameter setting in a traditional initialization parameter file, the change affects only the current instance, since there is no mechanism for automatically updating initialization parameters on disk. They must be manually updated in order to be passed to a future instance. Using a server parameter file overcomes this limitation.

Setting or Changing Initialization Parameter Values

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

SCOPE Clause	Description
SCOPE = SPFILE	The change is applied in the server parameter file only. The effect is as follows: ■ For dynamic parameters, the change is effective at the next startup and is persistent. ■ For static parameters, the behavior is the same as for dynamic parameters. This is the only SCOPE specification allowed for static parameters.
SCOPE = MEMORY	The change is applied in memory only. The effect is as follows: ■ For dynamic parameters, the effect is immediate, but it is not persistent because the server parameter file is not updated. ■ For static parameters, this specification is not allowed.

SCOPE Clause	Description
SCOPE = BOTH	The change is applied in both the server parameter file and memory. The effect is as follows: ■ For dynamic parameters, the effect is immediate and persistent. ■ For static parameters, this specification is not allowed.

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

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

A COMMENT clause allows a comment string to be associated with the parameter update. When you specify SCOPE as SPFILE or BOTH, the comment is written to the server parameter file.

The following statement changes the maximum number of job queue processes allowed for the instance. It also specifies a comment, and explicitly states that the change is to be made only in memory (that is, it is not persistent across instance shutdown and startup).

```
ALTER SYSTEM SET JOB_QUEUE_PROCESSES=50
                 COMMENT='temporary change on Nov 29'
                 SCOPE=MEMORY;
```

Another example illustrates setting a complex initialization parameter that takes a list of strings. Specifically, the parameter value being set is the LOG_ARCHIVE_DEST_n initialization parameter. The case could be that either the parameter is being changed to a new value or a new archive destination is being added.

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

Note that when a value consists of a list of strings, the syntax of the ALTER SYSTEM SET statement does not support editing each element of the list of values by the position or ordinal number. You must specify the complete list of values each time the parameter is updated and the new list completely replaces the old list.

Deleting Initialization Parameter Values

For initialization parameters whose values are string values you can restore a parameter to its default value (effectively deleting it), by using the following syntax:

```
ALTER SYSTEM SET parameter = '';
```

For numeric and boolean value parameters, you must specifically set the parameter back to its original default value.

Exporting the Server Parameter File

You can export a server parameter file to create a traditional text initialization parameter file. Reasons for doing this include:

- Creating backups of the server parameter file
- For diagnostic purposes, listing all of the parameter values currently used by an instance. This is analogous to the SQL*Plus SHOW PARAMETERS command or selecting from the V$PARAMETER or V$PARAMETER2 views.
- Modifying of the server parameter file by first exporting it, editing the output file, and then recreating it.

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

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

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

```
CREATE PFILE FROM SPFILE;
```

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

The following example creates a text initialization parameter file from a server parameter file where the names of the files are specified:

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

Errors and Recovery for the Server Parameter File

If an error occurs while reading the server parameter file (during startup or an export operation), or while writing the server parameter file during its creation, the operation terminates with an error reported to the user.

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

- Shutdown the instance, recover the server parameter file, then restart the instance
- Continue to run without caring that subsequent parameter updates will not be persistent

Viewing Parameters Settings

You have several options for viewing parameter settings.

Method	Description
`SHOW PARAMETERS`	This SQL*Plus command displays the currently in use parameter values.
`CREATE PFILE`	This SQL statement creates a text initialization parameter file from the binary server parameter file.
`V$PARAMETER`	This view displays the currently in effect parameter values.
`V$PARAMETER2`	This view displays the currently in effect parameter values. It is easier to distinguish list parameter values in this view because each list parameter value appears as a row.
`V$SPPARAMETER`	This view displays the current contents of the server parameter file. The view returns `NULL` values if a server parameter file is not being used by the instance.

See Also: *Oracle9i Database Reference* for a complete description of views

3
Using Oracle-Managed Files

This chapter discusses the use of the Oracle-managed files and contains the following topics:

What are Oracle-Managed Files?

Using Oracle-managed files simplifies the administration of an Oracle database. Oracle-managed files eliminate the need for you, the DBA, to directly manage the operating system files comprising an Oracle database. You specify operations in terms of database objects rather than filenames. Oracle internally uses standard file system interfaces to create and delete files as needed for the following database structures:

- Tablespaces
- Online redo log files
- Control files

Through initialization parameters, you specify the file system directory to be used for a particular type of file. Oracle then ensures that a unique file, an Oracle-managed file, is created and deleted when no longer needed.

This feature does not affect the creation or naming of administrative files such as trace files, audit files, alert files, and core files.

Who Can Use Oracle-Managed Files?

Oracle-managed files are most useful for the following types of databases:

- Low end or test databases
- Databases that are supported by the following:
  - A logical volume manager that supports striping/RAID and dynamically extensible logical volumes
  - A file system that provides large, extensible files

The Oracle Managed Files feature is not intended to ease administration of systems that use raw disks. This feature provides better integration with operating system functionality for disk space allocation. Since there is no operating system support for allocation of raw disks (it is done manually), this feature cannot help. On the other hand, because Oracle-managed files require that you use the operating system file system (unlike raw disks), you lose control over how files are laid out on the disks and thus, you lose some I/O tuning ability.

What is a Logical Volume Manager?

A logical volume manager (LVM) is a software package available with most operating systems. Sometimes it is called a logical disk manager (LDM). It allows

pieces of multiple physical disks to be combined into a single contiguous address space that appears as one disk to higher layers of software. An LVM can make the logical volume have better capacity, performance, reliability, and availability characteristics than any of the underlying physical disks. It uses techniques such as mirroring, striping, concatenation, and RAID 5 to implement these characteristics.

Some LVMs allow the characteristics of a logical volume to be changed after it is created, even while it is in use. The volume may be resized or mirrored, or it may be relocated to different physical disks.

What is a File System?

A file system is a data structure built inside a contiguous disk address space. A file manager (FM) is a software package that manipulates file systems, but it is sometimes called the file system. All operating systems have file managers. The primary task of a file manager is to allocate and deallocate disk space into files within a file system.

A file system allows the disk space to be allocated to a large number of files. Each file is made to appear as a contiguous address space to applications such as Oracle. The files may not actually be contiguous within the disk space of the file system. Files can be created, read, written, resized, and deleted. Each file has a name associated with it that is used to refer to the file.

A file system is commonly built on top of a logical volume constructed by an LVM. Thus all the files in a particular file system have the same performance, reliability, and availability characteristics inherited from the underlying logical volume. A file system is a single pool of storage that is shared by all the files in the file system. If a file system is out of space, then none of the files in that file system can grow. Space available in one file system does not affect space in another file system. However some LVM/FM combinations allow space to be added or removed from a file system.

An operating system can support multiple file systems. Multiple file systems are constructed to give different storage characteristics to different files as well as to divide the available disk space into pools that do not affect each other.

Benefits of Using Oracle-Managed Files

Consider the following benefits of using Oracle-managed files:

- They make the administration of the database easier.

There is no need to invent filenames and define specific storage requirements. A consistent set of rules is used to name all relevant files. The file system defines the characteristics of the storage and the pool where it is allocated.

- They reduce corruption caused by administrators specifying the wrong file.

  Each Oracle-managed file and filename is unique. Using the same file in two different databases is a common mistake that can cause very large down times and loss of committed transactions. Using two different names that refer to the same file is another mistake that causes major corruptions.

- They reduce wasted disk space consumed by obsolete files.

  Oracle automatically removes old Oracle-managed files when they are no longer needed. Much disk space is wasted in large systems simply because no one is sure if a particular file is still required. This also simplifies the administrative task of removing files that are no longer required on disk, and prevents the mistake of deleting the wrong file.

- They simplify creation of test and development databases.

  You can minimize the time spent making decisions regarding file structure and naming, and you have fewer file management tasks. You can focus better on meeting the actual requirements of your test or development database.

- Oracle-managed files make development of portable third-party tools easier.

  Oracle-managed files eliminate the need to put operating system specific file names in SQL scripts.

Oracle-Managed Files and Existing Functionality

Using Oracle-managed files does not eliminate any existing functionality. Existing databases are able to operate as they always have. New files can be created as managed files while old ones are administered in the old way. Thus, a database can have a mixture of Oracle-managed and unmanaged files.

Enabling the Creation and Use of Oracle-Managed Files

The following initialization parameters allow the database server to use the Oracle Managed Files feature:

Parameter	Description
DB_CREATE_FILE_DEST	Defines the location of the default file system directory where Oracle creates datafiles or tempfiles when no file specification is given in the creation operation. Also used as the default file system directory for online redo log and control files if DB_CREATE_ONLINE_LOG_DEST_*n* is not specified.
DB_CREATE_ONLINE_LOG_DEST_*n*	Defines the location of the default file system directory for online redo log files and control file creation when no file specification is given in the creation operation. You can use this initialization parameter multiple times, where *n* specifies a multiplexed copy of the online redo log or control file. You can specify up to five multiplexed copies.

The file system directory specified by either of these parameters must already exist: Oracle does not create it. The directory must also have permissions to allow Oracle to create the files in it.

The default location is used whenever a location is not explicitly specified for the operation creating the file. Oracle creates the filename, and a file thus created is an Oracle-managed file.

Both of these initialization parameters are dynamic, and can be set using the ALTER SYSTEM or ALTER SESSION statement.

See Also:

- *Oracle9i Database Reference* for additional information about initialization parameters.
- "How Oracle-Managed Files are Named" on page 3-7

Setting the DB_CREATE_FILE_DEST Initialization Parameter

Include the DB_CREATE_FILE_DEST initialization parameter in your initialization parameter file to identify the default location for the database server to create:

- Datafiles
- Tempfiles
- Online redo log files
- Control files

You specify the name of a file system directory that becomes the default location for the creation of the operating system files for these entities. The following example sets `/u01/oradata/payroll` as the default directory to use when creating Oracle-managed files.

```
DB_CREATE_FILE_DEST = '/u01/oradata/payroll'
```

Setting the DB_CREATE_ONLINE_LOG_DEST_*n* Initialization Parameter

Include the `DB_CREATE_ONLINE_LOG_DEST_n` initialization parameter in your initialization parameter file to identify the default location for the database server to create:

- Online redo log files
- Control files

You specify the name of a file system directory that becomes the default location for the creation of the operating system files for these entities. You can specify up to five multiplexed locations.

For the creation of online redo log files and control files only, this parameter overrides any default location specified in the `DB_CREATE_FILE_DEST` initialization parameter. If you do not specify a `DB_CREATE_FILE_DEST` parameter, but you do specify this parameter, then only online redo log files and control files can be created as Oracle-managed files.

It is recommended that you specify at least two parameters. For example:

```
DB_CREATE_ONLINE_LOG_DEST_1 = '/u02/oradata/payroll'
DB_CREATE_ONLINE_LOG_DEST_2 = '/u03/oradata/payroll'
```

This allows multiplexing, which provides greater fault-tolerance for the online redo log and control file if one of the destinations fails.

Creating Oracle-Managed Files

If you have met any of the following conditions, then Oracle creates Oracle-managed files for you, as appropriate, when no file specification is given in the creation operation:

- You have included either or both of the `DB_CREATE_FILE_DEST` and `DB_CREATE_ONLINE_LOG_DEST_n` initialization parameters in your initialization parameter file.

- You have issued the `ALTER SYSTEM` or `ALTER SESSION` statement to dynamically set either or both the `DB_CREATE_FILE_DEST` and `DB_CREATE_ONLINE_LOG_DEST_`*n* initialization parameters.

If a statement that creates an Oracle-managed file finds an error or does not complete due to some failure, then any Oracle-managed files created by the statement are automatically deleted as part of the recovery of the error or failure. However, because of the large number of potential errors that can occur with file systems and storage subsystems, there can be situations where you must manually remove the files using operating system commands. When an Oracle-managed file is created, its filename is written to the alert file. This information can be used to find the file if it is necessary to manually remove the file.

The following topics are discussed in this section:

See Also: *Oracle9i SQL Reference*

How Oracle-Managed Files are Named

The filenames of Oracle-managed files comply with the Oracle Flexible Architecture (OFA) standard for file naming. The assigned names are intended to meet the following requirements:

- Database files are easily distinguishable from all other files.
- Control files, online redo log files, and datafiles are identifiable as such.
- The association of datafile to tablespace is clearly indicated.

No two Oracle-managed files are given the same name. The name that is used for creation of an Oracle-managed file is constructed from three sources.

- The default file system directory location
- A port-specific file name template that is chosen based on the type of file

- A unique string created by the Oracle database server or the operating system. This ensures that file creation does not damage an existing file and that the file cannot be mistaken for some other file.

As a specific example, filenames for Oracle-managed files have the following format on Solaris:

File Type	Format	Example
Datafile	ora_%t_%u.dbf	/u01/oradata/payroll/ora_tbs1_2ixfh90q.dbf
Tempfile	ora_%t_%u.tmp	/u01/oradata/payroll/ora_temp1_6dygh80r.tmp
Redo log file	ora_%g_%u.log	/u01/oradata/payroll/ora_1_wo94n2xi.log
Control file	ora_%u.ctl	/u01/oradata/payroll/ora_cmr7t30p.ctl

where:

- %t is the tablespace name. At most, eight characters of the tablespace name are used. If eight characters causes the name to be too long, then the tablespace name is truncated. Placing the tablespace name before the uniqueness string means that all the datafiles for a tablespace appear next to each other in an alphabetic file listing.
- %u is an eight character string that guarantees uniqueness
- %g is the online redo log file group number

On other platforms the names are similar, subject to the constraints of the platform's naming rules.

Creating Oracle-Managed Files at Database Creation

The behavior of the `CREATE DATABASE` statement for creating database structures when using Oracle-managed files is discussed in this section.

Specifying Control Files at Database Creation

At database creation, the control file is created in the files specified by the `CONTROL_FILES` initialization parameter. If the `CONTROL_FILES` parameter is not set and at least one of the initialization parameters required for the creation of Oracle-managed files is set, then an Oracle-managed control file is created in the default control file destinations. In order of precedence, the default destination is defined as follows:

- If DB_CREATE_ONLINE_LOG_DEST_*n* initialization parameters are specified, then an Oracle-managed control file copy is created in each directory specified. The file in the first directory is the primary control file.
- If the DB_CREATE_FILE_DEST initialization parameter is specified, and no DB_CREATE_ONLINE_LOG_DEST_*n* initialization parameters are specified, then an Oracle-managed control file is created in the directory specified.

If the CONTROL_FILES parameter is not set and none of the above initialization parameters are set, then Oracle's default behavior is operating system dependent. At least one copy of a control file is created in an operating system dependent default location. Any copies of control files created in this fashion are not Oracle-managed files, and you must add a CONTROL_FILES initialization parameter to any initialization parameter file.

If Oracle creates an Oracle-managed control file, and if there is a server parameter file, Oracle creates a CONTROL_FILES initialization parameter entry the server parameter file. If there is no server parameter file, then you must create a CONTROL_FILES initialization parameter entry manually and include it in the text initialization parameter file.

See Also: Chapter 6, "Managing Control Files"

Specifying Online Redo Log Files at Database Creation

The LOGFILE clause is not required in the CREATE DATABASE statement, and omitting it provides a simple means of creating Oracle-managed online redo log files. If the LOGFILE clause is omitted, then online redo log files are created in the default online redo log file destinations. In order of precedence, the default destination is defined as follows:

- If DB_CREATE_ONLINE_LOG_DEST_*n* initialization parameters are specified, then Oracle creates two online redo files in each directory specified. More specifically, Oracle creates two online redo groups with corresponding members in each directory specified. These online redo log files are Oracle-managed files.
- If the DB_CREATE_FILE_DEST initialization parameter is specified, but no DB_CREATE_ONLINE_LOG_DEST_*n* parameters are specified, then two online redo log files (two groups with one member each) are created in the directory specified. These online redo log files are Oracle-managed files.
- If the LOGFILE clause is omitted and neither of the above initialization parameters are specified, then two online redo log files are created in operating system dependent default locations. Any online redo log files created in this fashion are not Oracle-managed files.

The default size of an Oracle-managed online redo log file is 100 (MB).

Optionally, you can create Oracle-managed online redo log files, and override default attributes, by including the LOGFILE clause but omitting a filename. Online redo log files are created as above, except for the following: if no filename is provided in the LOGFILE clause of CREATE DATABASE, and none of the initialization parameters required for creating Oracle-managed files are provided, then the CREATE DATABASE statement fails.

See Also: Chapter 7, "Managing the Online Redo Log"

Specifying the SYSTEM Tablespace Datafile at Database Creation

The DATAFILE clause is not required in the CREATE DATABASE statement, and omitting it provides a simple means of creating an Oracle-managed datafile for the SYSTEM tablespace. If the DATAFILE clause is omitted, then one of the following actions occurs:

- If DB_CREATE_FILE_DEST is set, then an Oracle-managed datafile for the SYSTEM tablespace is created in the DB_CREATE_FILE_DEST directory.
- If DB_CREATE_FILE_DEST is not set, then Oracle creates one SYSTEM tablespace datafile whose name and size are operating system dependent. Any SYSTEM tablespace datafile created in this manner is not an Oracle-managed file.

The default size for an Oracle-managed datafile is 100 MB and the file is autoextensible with an unlimited maximum size.

Optionally, you can create an Oracle-managed datafile for the SYSTEM tablespace, and override default attributes, by including the DATAFILE clause but omitting a filename. If a filename is not supplied and the DB_CREATE_FILE_DEST parameter is set, an Oracle-managed datafile for the SYSTEM tablespace is created in the DB_CREATE_FILE_DEST directory. If a filename is not supplied and the DB_CREATE_FILE_DEST parameter is not set, the CREATE DATABASE statement fails.

Specifying the Undo Tablespace Datafile at Database Creation

The DATAFILE subclause of the UNDO TABLESPACE clause is optional and a filename is not required in the file specification. If a filename is not supplied and the DB_CREATE_FILE_DEST parameter is set, then an Oracle-managed datafile is created in the DB_CREATE_FILE_DEST directory. If DB_CREATE_FILE_DEST is not set, then the statement fails with a syntax error.

The UNDO TABLESPACE clause itself is optional in CREATE DATABASE. If it is not supplied and automatic undo management mode is enabled, then a default undo tablespace named SYS_UNDOTBS is created and a 10 MB datafile that is autoextensible is allocated as follows:

- If DB_CREATE_FILE_DEST is set, then an Oracle-managed datafile is created in the indicated directory.
- If DB_CREATE_FILE_DEST is not set, then the datafile location is operating system specific.

See Also: Chapter 13, "Managing Undo Space"

Specifying the Default Temporary Tablespace Tempfile at Database Creation

The TEMPFILE subclause is optional for the DEFAULT TEMPORARY TABLESPACE clause and a filename is not required in the file specification. If a filename is not supplied and the DB_CREATE_FILE_DEST parameter set, then an Oracle-managed tempfile is created in the DB_CREATE_FILE_DEST directory. If DB_CREATE_FILE_DEST is not set, then the CREATE DATABASE statement fails with a syntax error.

The DEFAULT TEMPORARY TABLESPACE clause itself is optional, and if it is not specified, then no default temporary tablespace is created.

The default size for an Oracle-managed tempfile is 100 MB and the file is autoextensible with an unlimited maximum size.

CREATE DATABASE Statement Using Oracle-Managed Files: Examples

This section contains examples of the CREATE DATABASE statement when using the Oracle Managed Files feature.

CREATE DATABASE: Example 1

Included in the initialization parameter file:

```
DB_CREATE_FILE_DEST = '/u01/oradata/sample'
DB_CREATE_ONLINE_LOG_DEST_1 = '/u02/oradata/sample'
DB_CREATE_ONLINE_LOG_DEST_2 = '/u03/oradata/sample'
```

CREATE DATABASE statement:

```
SQL> CREATE DATABASE sample;
```

This example creates a database with the following Oracle-managed files:

- A SYSTEM tablespace datafile in directory /u01/oradata/sample that is 100 MB and autoextensible up to an unlimited size
- Two online log groups with two members of 100 MB each, one each in /u02/oradata/sample and /u03/oradata/sample
- If automatic undo management mode is enabled, then an undo tablespace datafile in directory /u01/oradata/sample2 that is 10 MB and autoextensible up to an unlimited size. An undo tablespace named SYS_UNDOTBS is created.
- If no CONTROL_FILES initialization parameter was specified, then two control files, one each in /u02/oradata/sample and /u03/oradata/sample. The control file in /u02/oradata/sample is the primary control file.

CREATE DATABASE: Example 2

In this example, it is assumed that:

- No DB_CREATE_ONLINE_LOG_DEST_*n* initialization parameters are specified in the initialization parameter file.
- No CONTROL_FILES initialization parameter was specified in the initialization parameter file.
- Automatic undo management mode is enabled.

```
SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/u01/oradata/sample2';
SQL> CREATE DATABASE sample2;
```

This example creates a database with the following Oracle-managed files:

- A 100 megabyte SYSTEM tablespace datafile in directory /u01/oradata/sample2
- Two online redo log files of 100 MB each in directory /u01/oradata/sample2. They are not multiplexed.
- An undo tablespace datafile in directory /u01/oradata/sample2 that is 10megabytes and autoextensible up to an unlimited size. An undo tablespace named SYS_UNDOTBS is created.
- A control file in /u01/oradata/sample2

This database configuration is not recommended, and should only be used for a very low-end database or simple test database. To better protect this database from failures, at least one more control file should be created and the online redo log should be multiplexed.

CREATE DATABASE: Example 3

Included in the initialization parameter file:

```
DB_CREATE_FILE_DEST = '/u01/oradata/sample3'
DB_CREATE_ONLINE_LOG_DEST_1 = '/u02/oradata/sample3'
DB_CREATE_ONLINE_LOG_DEST_2 = '/u03/oradata/sample3'
```

CREATE DATABASE statement:

```
SQL> CREATE DATABASE sample3 DATAFILE SIZE 400M
2>   DEFAULT TEMPORARY TABLESPACE dflt_ts TEMPFILE SIZE 10M
3>   UNDO TABLESPACE undo_ts DATAFILE SIZE 10M;
```

In this example, the file size for the Oracle-managed files for the default temporary tablespace and undo tablespace are specified. A database with the following characteristics is created:

This example creates a database with the following Oracle-managed files:

- A 400 megabyte SYSTEM tablespace datafile in directory /u01/oradata/sample3
- Two online redo log groups with two members of 100 MB each, one each in directories /u02/oradata/sample3 and /u03/oradata/sample3
- For the default temporary tablespace named dflt_ts, a 10 megabyte tempfile in directory /u01/oradata/sample3
- For the undo tablespace named undo_ts, a 10 megabyte datafile in directory /u01/oradata/sample3
- If no CONTROL_FILES initialization parameter was specified, then two control files, one each in directories /u02/oradata/sample3 and /u03/oradata/sample3. The control file in /u02/oradata/sample3 is the primary control file.

Creating Datafiles for Tablespaces

The following statements that can create datafiles are relevant to the discussion in this section:

- CREATE TABLESPACE
- CREATE UNDO TABLESPACE
- ALTER TABLESPACE ... ADD DATAFILE

When creating a tablespace, either a regular tablespace or an undo tablespace, the DATAFILE clause is optional. If you include the DATAFILE clause, then the filename is optional. If the DATAFILE clause or filename is not provided, then the following rules apply:

- If the DB_CREATE_FILE_DEST initialization parameter is specified, then an Oracle-managed datafile is created in the location specified by the parameter.
- If the DB_CREATE_FILE_DEST initialization parameter is not specified, then the statement creating the datafile fails.

If you add a datafile to a tablespace with the ALTER TABLESPACE ... ADD DATAFILE statement, then the filename is optional. If the filename is not specified, then the same rules apply as discussed in the previous paragraph.

By default, an Oracle-managed datafile for a regular tablespace is 100 MB and is autoextensible with an unlimited maximum size.

See Also:

- "Specifying the SYSTEM Tablespace Datafile at Database Creation" on page 3-10
- "Specifying the Undo Tablespace Datafile at Database Creation" on page 3-10
- Chapter 11, "Managing Tablespaces"

CREATE TABLESPACE: Examples

The following are some examples of creating tablespaces with Oracle-managed files.

CREATE TABLESPACE: Example 1

```
SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/u01/oradata/sample';
SQL> CREATE TABLESPACE tbs_1;
```

This example sets the default location for datafile creations to /u01/oradata/sample and then creates a tablespace tbs_1 with a datafile in that location. The datafile is 100 MB and is autoextensible with an unlimited maximum size.

CREATE TABLESPACE: Example 2

Included in initialization parameter file:

```
DB_CREATE_FILE_DEST = '/u01/oradata/sample2'
```

CREATE TABLESPACE statement:

```
SQL> CREATE TABLESPACE tbs_2 DATAFILE SIZE 400M AUTOEXTEND OFF;
```

This example creates a tablespace tbs_2 with a datafile in the directory /u01/oradata/sample2 that is not autoextensible and a size of 400 MB.

CREATE TABLESPACE: Example 3

Included in initialization parameter file:

```
DB_CREATE_FILE_DEST = '/u01/oradata/sample3'
```

CREATE TABLESPACE statement:

```
SQL> CREATE TABLESPACE tbs_3 DATAFILE AUTOEXTEND ON MAXSIZE 800M;
```

This example creates a tablespace tbs_3 with an autoextensible datafile in the directory /u01/oradata/sample3 with a maximum size of 800 MB and an initial size of 100 MB:

CREATE TABLESPACE: Example 4

```
SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/u01/oradata/sample4';
SQL> CREATE TABLESPACE tbs_4 DATAFILE SIZE 200M, SIZE 200M;
```

This example sets the default location for datafile creations to /u01/oradata/sample4 and then creates a tablespace tbs_4 in that directory with two autoextensible datafiles with an unlimited maximum size and an initial size of 200 MB.

CREATE UNDO TABLESPACE: Example

The following example creates an undo tablespace undotbs_1 with a datafile in the directory /u01/oradata/sample. The datafile for the undo tablespace is 100 MB and is autoextensible with an unlimited maximum size.

Included in initialization parameter file:

```
DB_CREATE_FILE_DEST = '/u01/oradata/sample'
```

CREATE UNDO TABLESPACE statement:

```
SQL> CREATE UNDO TABLESPACE undotbs_1;
```

ALTER TABLESPACE: Example

The following adds an Oracle-managed autoextensible datafile to tablespace `tbs_1` with an initial size of 100 MB and a maximum size of 800 MB.

Included in initialization parameter file:

```
DB_CREATE_FILE_DEST = '/u01/oradata/sample'
```

`ALTER TABLESPACE` statement:

```
SQL> ALTER TABLESPACE tbs_1 ADD DATAFILE AUTOEXTEND ON MAXSIZE 800M;
```

Creating Tempfiles for Temporary Tablespaces

The following statements that can create tempfiles are relevant to the discussion in this section:

- `CREATE TEMPORARY TABLESPACE`
- `ALTER TABLESPACE ... ADD TEMPFILE`

When creating a temporary tablespace the `TEMPFILE` clause is optional. If you include the `TEMPFILE` clause, then the filename is optional. If the `TEMPFILE` clause or filename is not provided, then the following rules apply:

- If the `DB_CREATE_FILE_DEST` initialization parameter is specified, then an Oracle-managed tempfile is created in the location specified by the parameter.
- If the `DB_CREATE_FILE_DEST` initialization parameter is not specified, then the statement creating the tempfile fails.

If you add a tempfile to a tablespace with the `ALTER TABLESPACE ... ADD TEMPFILE` statement, then the filename is optional. If the filename is not specified, then the same rules apply as discussed in the previous paragraph.

By default, an Oracle-managed tempfile for a tablespace is 100 MB and is autoextensible with an unlimited maximum size.

> **See Also:** "Specifying the Default Temporary Tablespace Tempfile at Database Creation" on page 3-11

CREATE TEMPORARY TABLESPACE: Example

The following example sets the default location for datafile creations to `/u01/oradata/sample` and then creates tablespace `temptbs_1` with a tempfile in that location. The tempfile is 100 MB and is autoextensible with an unlimited maximum size.

```
SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/u01/oradata/sample';
SQL> CREATE TEMPORARY TABLESPACE temptbs_1;
```

ALTER TABLESPACE ... ADD TEMPFILE: Example

The following example sets the default location for datafile creations to `/u03/oradata/sample` and then adds a tempfile in the default location to tablespace `temptbs_1`. The tempfile's initial size is 100 MB. It is autoextensible with an unlimited maximum size.

```
SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/u03/oradata/sample';
SQL> ALTER TABLESPACE TBS_1 ADD TEMPFILE;
```

Creating Control Files

When you issue the `CREATE CONTROLFILE` statement, a control file is created (or reused, if REUSE is specified) in the file(s) specified by the `CONTROL_FILES` initialization parameter. If the `CONTROL_FILES` parameter is not set, then the control file is created in the default control file destination(s). In order of precedence, the default destination is defined as follows:

- If `DB_CREATE_ONLINE_LOG_DEST_`*n* initialization parameters are specified, then an Oracle-managed control file copy is created in each directory specified. The file in the first directory is the primary control file.
- If the `DB_CREATE_FILE_DEST` initialization parameter is specified, and no `DB_CREATE_ONLINE_LOG_DEST_`*n* initialization parameters are specified, then an Oracle-managed control file is created in the directory specified.
- If neither `DB_CREATE_ONLINE_LOG_DEST_`*n* or `DB_CREATE_ONLINE_LOG_DEST_`*n* initialization parameters are specified, then a control file is created in an operating system specific default location. This control file is not an Oracle-managed file.

If Oracle creates an Oracle-managed control file, and there is a server parameter file, then Oracle creates a `CONTROL_FILES` initialization parameter for the server parameter file. If there is no server parameter file, then you must create a `CONTROL_FILES` initialization parameter manually and include it in the initialization parameter file.

If the datafiles in the database are Oracle-managed files, then the Oracle generated filenames for the files must be supplied in the `DATAFILE` clause of the statement.

If the online redo log files are Oracle-managed files, then the `[NO]RESETLOGS` keyword determines what can be supplied in the `LOGFILE` clause:

- NORESETLOGS: the Oracle generated filenames for the Oracle-managed online redo log files must be supplied in the LOGFILE clause.
- RESETLOGS: the online redo log file names can be supplied as with the CREATE DATABASE statement. See "Specifying Online Redo Log Files at Database Creation" on page 3-9.

The following sections contain examples of using the CREATE CONTROLFILE statement with Oracle-managed files.

> **See Also:** "Specifying Control Files at Database Creation" on page 3-8

CREATE CONTROLFILE Using NORESETLOGS Keyword: Example

The following CREATE CONTROLFILE statement is generated by an ALTER DATABASE BACKUP CONTROLFILE TO TRACE statement for a database with Oracle-managed datafiles and online redo log files:

```
CREATE CONTROLFILE
     DATABASE sample
     LOGFILE GROUP 1 ('/u01/oradata/sample/ora_1_o220rtt9.log',
                      '/u02/oradata/sample/ora_1_v2o0b2i3.log') SIZE 100M,
             GROUP 2 ('/u01/oradata/sample/ora_2_p22056iw.log',
                      '/u02/oradata/sample/ora_2_p02rcyg3.log') SIZE 100M
     NORESETLOGS
     DATAFILE '/u01/oradata/sample/ora_system_xu34ybm2.dbf' SIZE 100M
     MAXLOGFILES 5
     MAXLOGHISTORY 100
     MAXDATAFILES 10
     MAXINSTANCES 2
     ARCHIVELOG;
```

CREATE CONTROLFILE Using RESETLOGS Keyword: Example

The following is an example of a CREATE CONTROLFILE statement with the RESETLOGS option. DB_CREATE_ONLINE_LOG_DEST_*n* or DB_CREATE_FILE_DEST must be set.

```
CREATE CONTROLFILE
     DATABASE sample
     RESETLOGS
     DATAFILE '/u01/oradata/sample/ora_system_aawbmz51.dbf' SIZE 100M
     MAXLOGFILES 5
     MAXLOGHISTORY 100
     MAXDATAFILES 10
```

```
MAXINSTANCES 2
ARCHIVELOG;
```

Later, you must issue the ALTER DATABASE OPEN RESETLOGS statement to recreate the online redo log files. This is discussed in the next section. If the previous log files were Oracle-managed files, then they are not deleted.

Creating Online Redo Log Files

Online redo log files are created at database creation time. They can also be created when you issue either of the following statements:

- ALTER DATABASE ADD LOGFILE
- ALTER DATABASE OPEN RESETLOGS

Using the ALTER DATABASE ADD LOGFILE Statement

The ALTER DATABASE ADD LOGFILE statement allows you to later add a new group to your current online redo log. The filename in the ADD LOGFILE clause is optional if you are using Oracle-managed files. If a filename is not provided, then a redo log file is created in the default log file destination. In order of precedence, the default destination is defined as follows:

- If DB_CREATE_ONLINE_LOG_DEST_*n* initialization parameters are specified, then an Oracle-managed log file member is created in each directory specified in the parameters (up to MAXLOGMEMBERS for the database).
- If the DB_CREATE_FILE_DEST initialization parameters specified, and no DB_CREATE_ONLINE_LOG_DEST_*n* initialization parameters are specified, then an Oracle-managed log file member is created in the directory specified in the parameter.

If a filename is not provided and you have not provided one of the initialization parameters required for creating Oracle-managed files, then the statement returns an error.

The default size for an Oracle-managed log file is 100 MB.

Online redo log file members continue to be added and dropped by specifying complete filenames.

See Also:

- "Specifying Online Redo Log Files at Database Creation" on page 3-9
- "Creating Control Files" on page 3-17

Adding New Online Redo Log Files: Example

The following example creates a log file with a member in `/u01/oradata/sample` and another member in `/u02/oradata/sample`. The size of the log file is 100 MB.

Included in the initialization parameter file:

```
DB_CREATE_ONLINE_LOG_DEST_1 = '/u01/oradata/sample'
DB_CREATE_ONLINE_LOG_DEST_2 = '/u02/oradata/sample'
```

The `ALTER DATABASE` statement:

```
SQL> ALTER DATABASE ADD LOGFILE;
```

Using the ALTER DATABASE OPEN RESETLOGS Statement

If you previously created a control file specifying `RESETLOGS`, and either did not specify filenames, or specified non-existent filenames, then Oracle creates online redo log files for you when you issue the `ALTER DATABASE OPEN RESETLOGS` statement. The rules for determining the directories in which to store redo log files, when none are specified in the control file, are the same as those discussed in "Specifying Online Redo Log Files at Database Creation" on page 3-9.

Behavior of Oracle-Managed Files

The filenames of Oracle-managed files are accepted in SQL statements wherever a filename is used to identify an existing file. These filenames, like other filenames, are stored in the control file, and, if using Recovery Manager (RMAN) for backup and recovery, in the RMAN catalog. They are visible in all of the usual fixed and dynamic performance views that are available for monitoring datafiles and tempfiles (for example, `V$DATAFILE` or `DBA_DATA_FILES`).

Some examples of statements using Oracle generated filenames are:

```
SQL> ALTER DATABASE RENAME FILE 'ora_tbs01_ziw3bopb.dbf'
  2> TO 'tbs0101.dbf';

SQL> ALTER DATABASE DROP LOGFILE 'ora_1_wo94n2xi.log';
```

```
SQL> ALTER TABLE emp ALLOCATE EXTENT ( DATAFILE 'ora_tbs1_2ixfh90q.dbf' );
```

You can backup and restore Oracle-managed datafiles, tempfiles, and control files as you would corresponding non Oracle-managed files. Using Oracle generated filenames does not impact the use of logical backup files such as export files. This is particularly important for tablespace point-in-time recovery (TSPITR) and transportable tablespace export files.

There are some cases where Oracle-managed files behave differently. These are discussed in the sections that follow.

Dropping Datafiles and Tempfiles

Unlike files that are not Oracle managed, when an Oracle-managed datafile or tempfile is dropped, the filename is removed from the control file and the file is automatically deleted from the file system. The statements that delete Oracle-managed files when they are dropped are:

- `DROP TABLESPACE`
- `ALTER DATABASE TEMPFILE ... DROP`

Dropping Online Redo Log Files

When an Oracle-managed online redo log file is dropped its Oracle-managed files are deleted. You specify the group or members to be dropped. The following statements drop and delete online redo log files:

- `ALTER DATABASE DROP LOGFILE`
- `ALTER DATABASE DROP LOGFILE MEMBER`

Renaming Files

The following statements are used to rename files:

- `ALTER DATABASE RENAME FILE`
- `ALTER TABLESPACE ... RENAME DATAFILE`

These statements do not actually rename the files on the operating system, but rather, the names in the control file are changed. If the old file is an Oracle-managed file and it exists, then it is deleted. You must specify each filename using the conventions for filenames on your operating system when you issue this statement.

Managing Standby Databases

The datafiles, control files, and online redo log files in a standby database can be Oracle managed. This is independent of whether Oracle-managed files are used on the primary database.

When recovery of a standby database encounters redo for the creation of a datafile, if the datafile is an Oracle-managed file then the recovery process creates an empty file in the local default file system location. This allows the redo for the new file to be applied immediately without any human intervention.

When recovery of a standby database encounters redo for the deletion of a tablespace, it deletes any Oracle-managed datafiles in the local file system. Note that this is independent of the `INCLUDING DATAFILES` option issued at the primary database.

> **See Also:** *Oracle9i Data Guard Concepts and Administration* for information about using Oracle-managed files with standby databases

Scenarios for Using Oracle-Managed Files

This section further demonstrates the use of Oracle-managed files by presenting scenarios of their use.

Scenario 1: Create and Manage a Database with Multiplexed Online Redo Logs

In this scenario, a DBA creates a database where the datafiles and online redo log files are created in separate directories. The online redo log files and control files are multiplexed. The database uses an undo tablespace, and has a default temporary tablespace. The following are tasks involved with creating and maintaining this database.

1. Setting the initialization parameters

   The DBA includes three generic file creation defaults in the initialization parameter file before creating the database. Automatic undo management mode is also specified.

   ```
   DB_CREATE_FILE_DEST = '/u01/oradata/sample'
   DB_CREATE_ONLINE_LOG_DEST_1 = '/u02/oradata/sample'
   DB_CREATE_ONLINE_LOG_DEST_2 = '/u03/oradata/sample'
   UNDO_MANAGEMENT = AUTO
   ```

The DB_CREATE_FILE_DEST parameter sets the default file system directory for the datafiles and tempfiles.

DB_CREATE_ONLINE_LOG_DEST_1 and DB_CREATE_ONLINE_LOG_DEST_2 set the default file system directories for online redo log file and control file creation. Each online redo log file and control file is multiplexed across the two directories.

2. Creating a database

Once the initialization parameters are set, the database can be created:

```
SQL> CREATE DATABASE sample
2>   DEFAULT TEMPORARY TABLESPACE dflt_tmp;
```

Because a DATAFILE clause is not present and the DB_CREATE_FILE_DEST initialization parameter is set, the SYSTEM tablespace datafile is created in the default file system (/u01/oradata/sample in this scenario). The filename is uniquely generated by Oracle. The file is autoextensible with an initial size of 100 MB and an unlimited maximum size. The file is an Oracle-managed file.

Because a LOGFILE clause is not present, two online redo log groups are created. Each log group has two members, with one member in the DB_CREATE_ONLINE_LOG_DEST_1 location and the other member in the DB_CREATE_ONLINE_LOG_DEST_2 location. The filenames are uniquely generated by Oracle. The log files are created with a size of 100 MB. The log file members are Oracle-managed files.

Similarly, because the CONTROL_FILES initialization parameter is not present, and two DB_CREATE_ONLINE_LOG_DEST_*n* initialization parameters are specified, two control files are created. The control file located in the DB_CREATE_ONLINE_LOG_DEST_1 location is the primary control file; the control file located in the DB_CREATE_ONLINE_LOG_DEST_2 location is a multiplexed copy. The filenames are uniquely generated by Oracle. They are Oracle-managed files. Assuming there is a server parameter file, a CONTROL_FILES initialization parameter in generated.

Automatic undo management mode is specified, but because an undo tablespace is not specified and the DB_CREATE_FILE_DEST initialization parameter is set, a default undo tablespace named SYS_UNDOTBS is created in the directory specified by DB_CREATE_FILE_DEST. The datafile is a 10 megabyte datafile that is autoextensible. It is an Oracle-managed file.

Lastly, a default temporary tablespace named dflt_tmp is specified. Because DB_CREATE_FILE_DEST is included in the parameter file, the tempfile for

dflt_tmp is created in the directory specified by that parameter. The tempfile is 100 MB and is autoextensible with an unlimited maximum size. It is an Oracle-managed file.

The resultant file tree, with generated filenames, is as follows:

```
/u01
     /oradata
          /sample
               /ora_system_cmr7t30p.dbf
               /ora_sys_undo_2ixfh90q.dbf
               /ora_dflt_tmp_157se6ff.tmp
/u02
     /oradata
          /sample
               /ora_1_0orrm31z.log
               /ora_2_2xyz16am.log
               /ora_cmr7t30p.ctl
/u03
     /oradata
          /sample
               /ora_1_ixfvm8w9.log
               /ora_2_q89tmp28.log
               /ora_x1sr8t36.ctl
```

The internally generated filenames can be seen when selecting from the usual views. For example:

```
SQL> SELECT NAME FROM V$DATAFILE;

NAME
--------------------------------------------------
/u01/oradata/sample/ora_system_cmr7t30p.dbf
/u01/oradata/sample/ora_sys_undo_2ixfh90q.dbf

2 rows selected
```

The name is also printed to the alert file when the file is created.

3. Managing control files

   The control file was created when generating the database, and a CONTROL_FILES initialization parameter was added to the parameter file. If needed, the DBA can recreate the control file or build a new one for the database using the CREATE CONTROLFILE statement.

The correct Oracle-managed filenames must be used in the DATAFILE and LOGFILE clauses. The ALTER DATABASE BACKUP CONTROLFILE TO TRACE statement generates a script with the correct filenames. Alternatively, the filenames can be found by selecting from the V$DATAFILE, V$TEMPFILE, and V$LOGFILE views. The following example recreates the control file for the sample database:

```
SQL> CREATE CONTROLFILE REUSE
2>       DATABASE sample
3>       LOGFILE GROUP 1('/u02/oradata/sample/ora_1_0orrm31z.log',
4>                       '/u03/oradata/sample/ora_1_ixfvm8w9.log'),
5>               GROUP 2('/u02/oradata/sample/ora_2_2xyz16am.log',
6>                       '/u03/oradata/sample/ora_2_q89tmp28.log')
7>       NORESETLOGS
8>       DATAFILE '/u01/oradata/sample/ora_system_cmr7t30p.dbf',
9>                '/u01/oradata/sample/ora_sys_undo_2ixfh90q.dbf',
10>               '/u01/oradata/sample/ora_dflt_tmp_157se6ff.tmp'
11>      MAXLOGFILES 5
12>      MAXLOGHISTORY 100
13>      MAXDATAFILES 10
14>      MAXINSTANCES 2
15>      ARCHIVELOG;
```

The control file created by this statement is located as specified by the CONTROL_FILES initialization parameter that was generated when the database was created. The REUSE clause causes any existing file(s) to be overwritten.

4. Managing the online redo log

   To create a new group of online redo log files, the DBA can use the ALTER DATABASE ADD LOGFILE statement. The following statement adds a log file with a member in the DB_CREATE_ONLINE_LOG_DEST_1 location and a member in the DB_CREATE_ONLINE_LOG_DEST_2 location. These files are Oracle-managed files.

   ```
   SQL> ALTER DATABASE ADD LOGFILE;
   ```

   Log file members continue to be added and dropped by specifying complete filenames.

   The GROUP clause can be used to drop a log file. In the following example the operating system file associated with each Oracle-managed log file member is automatically deleted.

   ```
   SQL> ALTER DATABASE DROP LOGFILE GROUP 3;
   ```

5. Managing tablespaces

   The default storage for all datafiles for future tablespace creations in the sample database is the location specified by the DB_CREATE_FILE_DEST initialization parameter (/u01/oradata/sample in this scenario). Any datafiles for which no filename is specified, are created in the file system specified by the initialization parameter DB_CREATE_FILE_DEST. For example:

   ```
   SQL> CREATE TABLESPACE tbs_1;
   ```

   The preceding statement creates a tablespace whose storage is in /u01/oradata/sample. A datafile is created with an initial size of 100 MB and it is autoextensible with an unlimited maximum size. The datafile is an Oracle-managed file.

   When the tablespace is dropped, the Oracle-managed files for the tablespace are automatically removed. The following statement drops the tablespace and all the Oracle-managed files used for its storage:

   ```
   SQL> DROP TABLESPACE tbs_1;
   ```

   Once the first datafile is full, Oracle does not automatically create a new datafile. More space can be added to the tablespace by adding another Oracle-managed datafile. The following statement adds another datafile in the location specified by DB_CREATE_FILE_DEST:

   ```
   SQL> ALTER TABLESPACE tbs_1 ADD DATAFILE;
   ```

   The default file system can be changed by changing the initialization parameter. This does not change any existing datafiles. It only effects future creations. This can be done dynamically using the following statement:

   ```
   SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST='/u04/oradata/sample';
   ```

6. Archiving redo information

   Archiving of online redo log files is no different for Oracle-managed files, than it is for unmanaged files. A file system location for the archived log files can be specified using the LOG_ARCHIVE_DEST_*n* initialization parameters. The filenames are formed based on the LOG_ARCHIVE_FORMAT parameter or its default.

   The archived logs are not Oracle-managed files

7. Backup, restore, and recover.

Since an Oracle-managed file is compatible with standard operating system files, you can use operating system utilities to backup or restore Oracle-managed files. All existing methods for backing up, restoring, and recovering the database work for Oracle-managed files.

Scenario 2: Add Oracle-Managed Files to an Existing Database

Assume in this case that an existing database does not have any Oracle-managed files, but the DBA would like to create new tablespaces with Oracle-managed files and locate them in directory `/u03/oradata/sample2`.

1. Setting the initialization parameters

   To allow automatic datafile creation, set the `DB_CREATE_FILE_DEST` initialization parameter to the file system directory in which to create the datafiles. This can be done dynamically as follows:

   ```
   SQL> ALTER SYSTEM SET DB_CREATE_FILE_DEST = '/u03/oradata/sample2';
   ```

2. Creating tablespaces

   Once `DB_CREATE_FILE_DEST` is set, the `DATAFILE` clause can be omitted from a `CREATE TABLESPACE` statement. The datafile is created in the location specified by `DB_CREATE_FILE_DEST` by default. For example:

   ```
   SQL> CREATE TABLESPACE tbs_2;
   ```

   When tablespace `tbs_2` is dropped, its datafiles are automatically deleted.

4

Starting Up and Shutting Down

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

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

> **See Also:** For additional information specific to an Oracle Real Application Clusters environment:
>
> - *Oracle9i Real Application Clusters Administration*
> - *Oracle9i Real Application Clusters Installation and Configuration*

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 and perform typical data access operations. However, there are other options and these are also discussed in this section.

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

Options for Starting Up a Database

There are options as to the method you use for starting up (and administering) an instance of your database.

Using SQL*Plus

To start up a database use SQL*Plus to connect to Oracle with administrator privileges and then issue the `STARTUP` command. While three methods are presented, using SQL*Plus is the only method that is within the scope of this book.

Using Recovery Manager

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

See Also: *Oracle9i 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 it up and shutting it 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 enables you to perform the functions discussed in this book using a GUI interface, rather than command lines.

See Also:

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

Preparing to Start an Instance

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

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

   ```
   SQLPLUS /NOLOG
   ```

2. Connect to Oracle as SYSDBA:

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

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

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

Using SQL*Plus to Start Up a Database

You use the STARTUP command to start up a database instance. To start an instance, Oracle must read instance configuration parameters (the initialization parameters) from either a server parameter file or a traditional text initialization parameter file.

When you issue the STARTUP command with no PFILE clause, Oracle reads the initialization parameters from a server parameter file (SPFILE) in a platform-specific default location.

Note: For UNIX, the platform-specific default location (directory) for the server parameter file (or text initialization parameter file) is:

```
$ORACLE_HOME/dbs
```

For Windows NT and Windows 2000 the location is:

```
$ORACLE_HOME\database
```

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

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

You can direct Oracle to read initialization parameters from a traditional text initialization parameter file, by using the PFILE clause of the STARTUP command. For example:

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

Further, you can use this PFILE clause to start an instance with a nondefault server parameter file as follows:

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

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

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

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

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

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

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

You can start an instance in various modes:

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

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

In addition, you can force the instance to start, or start the instance and have complete media recovery begin immediately. The STARTUP command options that you specify to achieve these states are illustrated in the following section.

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

Starting an Instance: Scenarios

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

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

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

Starting an Instance, and Mounting and Opening a Database

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

Start an instance, read the initialization parameters from the default server parameter file location, and then mount and open the database by using the STARTUP command by itself (you can, of course, optionally specify a PFILE or SPFILE clause):

```
STARTUP
```

Starting an Instance Without Mounting a Database

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

Task	For more information...
Renaming datafiles	Chapter 12, "Managing Datafiles"
Adding, dropping, or renaming redo log files	Chapter 7, "Managing the Online Redo Log"
Enabling and disabling redo log archiving options	Chapter 8, "Managing Archived Redo Logs"
Performing full database recovery	*Oracle9i User-Managed Backup and Recovery Guide* *Oracle9i 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
```

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 an export or import of database data
- Perform a data load (with SQL*Loader)
- Temporarily prevent typical users from using data
- During certain migration and upgrade operations

Typically, all users with the CREATE SESSION system privilege can connect to an open database. Opening a database in restricted mode allows database access only to users with both the CREATE SESSION and RESTRICTED SESSION system privilege. Only database administrators should have the RESTRICTED SESSION system privilege.

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:

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

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 4-10.

> **See Also:** *Oracle9i SQL Reference* for more information on the ALTER SYSTEM statement

Forcing an Instance to Start

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

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

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

```
STARTUP FORCE
```

If an instance is running, STARTUP FORCE shuts it down with mode ABORT before restarting it.

> **See Also:** "Shutting Down with the ABORT Option" on page 4-13 to understand the side effects of aborting the current instance

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

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

```
STARTUP OPEN RECOVER
```

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

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, see your operating system specific Oracle documentation.

Starting Remote Instances

If your local Oracle server is part of a distributed database, you might want to start a remote instance and database. Procedures for starting and stopping remote

instances vary widely depending on communication protocol and operating system.

Altering Database Availability

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

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

```
ALTER DATABASE MOUNT
```

> **See Also:** "Starting an Instance and Mounting a Database" on page 4-6 for a list of operations that require the database to be mounted and closed (and procedures to start an instance and mount a database in one step)

Opening a Closed Database

You can make a mounted but closed database available for general use by opening the database. To open a mounted database, use the `ALTER DATABASE` statement with the `OPEN` 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 operations that change the state of the database without generating redo. For example, you can take datafiles offline or bring them online since these operations do not effect data content.

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

Ideally, you open a database in read-only mode when you alternate a standby database between read-only and recovery mode. Be aware 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;
```

However, read-write is the default mode.

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

See Also: *Oracle9i SQL Reference* for more information about the `ALTER DATABASE` statement

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 should consider killing all current user sessions before performing any administrative tasks. To lift an instance from restricted mode, use `ALTER SYSTEM` with the `DISABLE RESTRICTED SESSION` option.

See Also: "Restricting Access to a Database at Startup" on page 4-7 to learn some reasons for placing an instance in restricted mode

Shutting Down a Database

To initiate database shutdown, use the SQL*Plus SHUTDOWN command. Control is not returned to the session that initiates a database shutdown until shutdown is complete. Users who attempt connections while a shutdown is in progress receive a message like the following:

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

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

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

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

Shutting Down with the NORMAL Option

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

```
SHUTDOWN NORMAL
```

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.

Shutting Down with the IMMEDIATE Option

Use immediate database shutdown only in the following situations:

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

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

```
SHUTDOWN IMMEDIATE
```

Immediate database shutdown proceeds with the following conditions:

- No new connections are allowed, nor are new transactions allowed to be started, after the statement is issued.
- Any uncommitted transactions are rolled back. (If long uncommitted transactions exist, this method of shutdown might not complete quickly, despite its name.)
- Oracle 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.

Shutting Down with the TRANSACTIONAL Option

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

```
SHUTDOWN TRANSACTIONAL
```

Transactional database shutdown proceeds with the following conditions:

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

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

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

Shutting Down with the ABORT 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* none of the other types of shutdown works.
- You need to shut down the database instantaneously (for example, if you know a power shutdown is going to occur in one minute).
- You experience problems when starting a database instance.

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

```
SHUTDOWN ABORT
```

An aborted database shutdown proceeds with the following conditions:

- No new connections are allowed, nor are new transactions allowed to be started, after the statement is issued.
- Current client SQL statements being processed by Oracle 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.

Quiescing a Database

There are times when there is a need to put a database into a state where only DBA transactions, queries, fetches, or PL/SQL statements are allowed. This is called a quiesced state, in the sense that there are no ongoing non-DBA transactions, queries, fetches, or PL/SQL statements in the system. This quiesced state allows you or other administrators to perform actions that cannot safely be done otherwise. These actions are categorized as follows:

- Actions that can fail if concurrent user transactions access the same object. For example, changing the schema of a database table or adding a column to an existing table where a no-wait lock is required.
- Actions whose undesirable intermediate effect can be seen by concurrent user transactions. For example, a multistep procedure for reorganizing a table where the table is first exported, then dropped, and finally imported. A concurrent user who attempted to access the table after it was dropped, but before import, would see disturbing results.

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

Note: For this release of Oracle9i, in the quiesce database context a DBA is defined as user SYS or SYSTEM. Other users, including those with the SYSDBA system privilege or DBA role are not allowed to issue the ALTER SYSTEM QUIESCE DATABASE statement or proceed after the database is quiesced.

Placing a Database into a Quiesced State

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

```
ALTER SYSTEM QUIESCE RESTRICTED
```

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

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

Note: You must have the Database Resource Manager feature activated, and it must have been activated since instance startup (all instances in an Oracle Real Application Clusters environment) to successfully issue the `ALTER SYSTEM QUIESCE RESTRICTED` statement. It is through the facilities of the Database Resource Manager that non-DBA sessions are prevented from becoming active. Also, while this statement is in effect, any attempt to change the current resource plan will be queued until after the system is unquiesced.

For information about the Database Resource Manager, see Chapter 27, "Using the Database Resource Manager".

The `ALTER SYSTEM QUIESCE RESTRICTED` statement may wait a long time for active sessions to become inactive. If you interrupt the request, or if your session abnormally terminates for some reason before all active sessions are quiesced, Oracle will automatically undo any partial effects of the statement.

If a query is carried out by successive multiple Oracle Call Interface (OCI) fetches, the `ALTER SYSTEM QUIESCE RESTRICTED` statement does not wait for all fetches to finish; it only waits for the current fetch to finish.

For dedicated server connections, the `ALTER SYSTEM QUIESCE RESTRICTED` statement does not impose any restrictions to user logins. However, for shared server connections, all non-DBA logins after this statement is issued are queued by the Database Resource Manager, and are not allowed to proceed. To the user, it will appear as if the login is hung. The login will resume when the database is unquiesced.

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

While in the quiesced state, you cannot use file system copy to backup the database's datafiles as cold backups, even if you do a checkpoint on every instance. The reason for this is that in the quiesced state the file headers of online datafiles continue to look like they are being accessed. They do not look the same as if a clean shutdown were done. Similarly, to perform a hot backup of the datafiles of any online tablespace while the database is in a quiesced state, you are still required to first place the tablespace into backup mode using the `ALTER TABLESPACE... BEGIN BACKUP` statement.

Restoring the System to Normal Operation

The following statement restores the database to normal operation:

```
ALTER SYSTEM UNQUIESCE
```

All non-DBA activity is allowed to proceed. In an Oracle Real Application Clusters environment, this statement is not required to be issued from the same session, or even the same instance, as that which imposed the quiesce state. If the session issuing the ALTER SYSTEM UNQUIESCE statement should terminate abnormally, the Oracle database server ensures that the unquiesce operation finishes.

Viewing the Quiesce State of an Instance

The V$INSTANCE view can be queried to see the current state of an instance. It contains a column named ACTIVE_STATE, whose values are shown in the following table:

ACTIVE_STATE	**Description**
NORMAL	Normal unquiesced state
QUIESCING	Being quiesced, but there are still active non-DBA sessions running
QUIESCED	Quiesced, no active non-DBA sessions are active or allowed

Suspending and Resuming a Database

The ALTER SYSTEM SUSPEND statement suspends a database by halting all input and output (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 is suspended all preexisting I/O operations are allowed to complete and any new database accesses are placed in a queued state.

The suspend command suspends the database, and is not specific to an instance. Therefore, in an Oracle Real Application Clusters 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. 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.

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

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

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

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

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

See Also: *Oracle9i User-Managed Backup and Recovery Guide* for details about backing up a database using the database suspend/resume feature

Part II

Oracle Server Processes and Storage Structure

Part II presents the Oracle database server processes and underlying database storage structures that support its operation. It contains the following chapters:

5

Managing Oracle Processes

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

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 if your database server is configured for **shared server**, it can be a **shared server process**, where a server process can service multiple user processes.

> **See Also:** *Oracle9i Database Concepts*

Dedicated Server Processes

Figure 5–1, "Oracle Dedicated Server Processes" illustrates how dedicated server processes work. In this diagram two user processes are connected to Oracle through dedicated server processes.

In general, it is better to be connected through a dispatcher and use a shared server process. This is illustrated in Figure 5–2, "Oracle Shared Server Processes". A shared server process can be more efficient because it keeps the number of processes required for the running instance low.

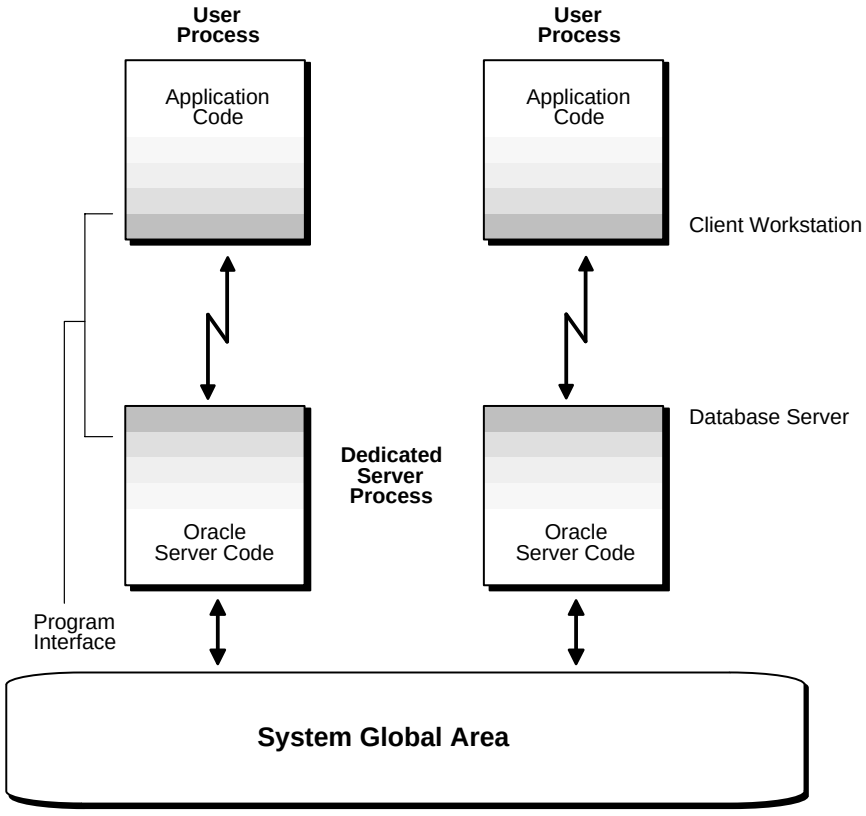
In the following situations, however, users and administrators should explicitly connect to an instance using a dedicated server process:

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

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

> **See Also:** For a complete description of the net service name, see the *Oracle Net Services Administrator's Guide* and your operating system specific Oracle documentation.

Figure 5–1 Oracle Dedicated Server Processes

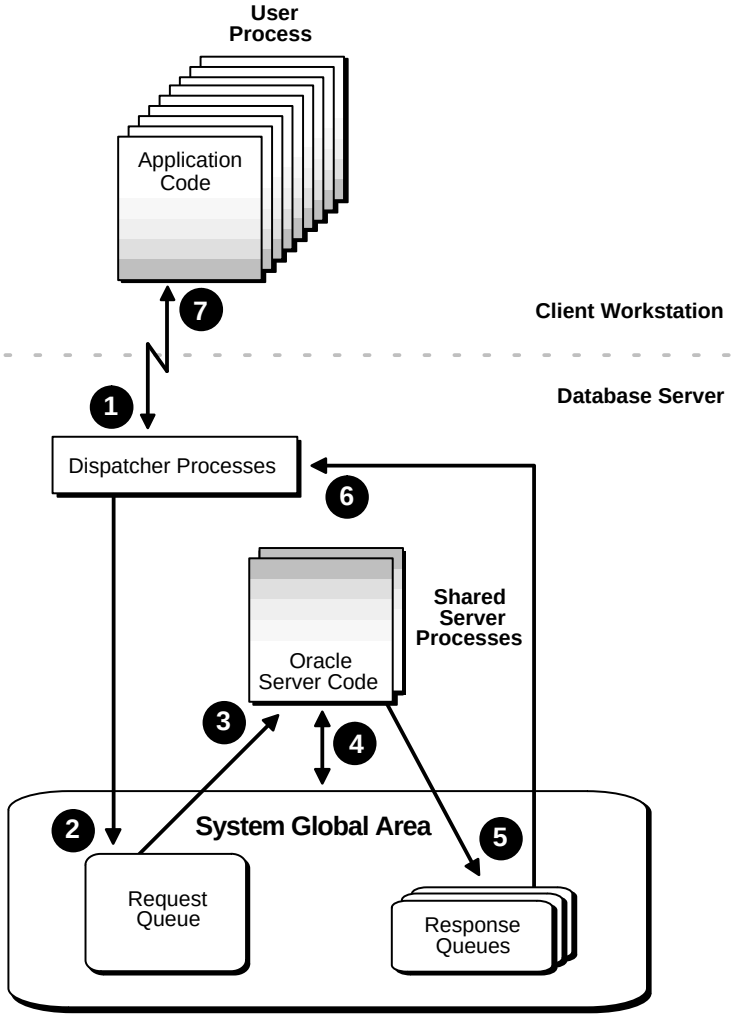


Shared Server Processes

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 shared server architecture eliminates the need for a dedicated server process for each connection (see Figure 5–2).

Figure 5–2 Oracle Shared Server Processes



In a shared server 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 shared server architecture over the dedicated server model is the reduction of system resources, enabling the support of an increased number of users.

The shared server architecture requires Oracle Net Services. User processes targeting the shared server must connect through Oracle Net Services, even if they are on the same machine as the Oracle instance.

There are several things that must be done to configure your system for shared server. These are discussed in the next section.

> **See Also:** *Oracle Net Services Administrator's Guide* to learn more about shared server, including additional features such as connection pooling

Configuring Oracle for the Shared Server

You activate shared server by setting database initialization parameters. Shared server requires that an Oracle Net Services listener process be active. This section discusses setting shared server initialization parameters and how to alter them. For specifics relating to Oracle Net Services, see the *Oracle Net Services Administrator's Guide*.

This section contains the following topics:

- Initialization Parameters for Shared Server
- Setting the Initial Number of Dispatchers (DISPATCHERS)
- Setting the Initial Number of Shared Servers (SHARED_SERVERS)
- Modifying Dispatcher and Server Processes
- Monitoring Shared Server

Initialization Parameters for Shared Server

The initialization parameters controlling shared server are:

Parameter	Description
Required	

Parameter	Description
DISPATCHERS	Configures dispatcher processes in the shared server architecture.
Optional. If you do not specify the following parameters, Oracle selects appropriate defaults.	
MAX_DISPATCHERS	Specifies the maximum number of dispatcher processes that can run simultaneously.
SHARED_SERVERS	Specifies the number of shared server processes created when an instance is started up.
MAX_SHARED_SERVERS	Specifies the maximum number of shared server processes that can run simultaneously.
CIRCUITS	Specifies the total number of virtual circuits that are available for inbound and outbound network sessions.
SHARED_SERVER__SESSIONS	Specifies the total number of shared server user sessions to allow. Setting this parameter enables you to reserve user sessions for dedicated servers.
Other initialization parameters affected by shared server that may require adjustment.	
LARGE_POOL_SIZE	Specifies the size in bytes of the large pool allocation heap. Shared server may force the default value to be set too high, causing performance problems or problems starting the database.
SESSIONS	Specifies the maximum number of sessions that can be created in the system. May need to be adjusted for shared server.

See Also:

- *Oracle Net Services Reference Guide*
- *Oracle9i Database Reference*

Setting the Initial Number of Dispatchers (DISPATCHERS)

The number of dispatcher processes started at instance startup is controlled by the DISPATCHERS initialization parameter. You can specify multiple DISPATCHERS parameters in the initialization file, but they must be adjacent to each other. Internally, Oracle will assign an INDEX value to each DISPATCHERS parameter, so that you can later specifically refer to that 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 for each process (which is operating system dependent), and the number of connections required for each 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 5-8.

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 DISPATCHERS initialization parameter.

Example: Typical

This is a typical example of setting the DISPATCHERS initialization parameter.

```
DISPATCHERS="(PROTOCOL=TCP)"
```

Example: Forcing the IP Address Used for Dispatchers

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

```
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.

Example: Forcing the Port Used by Dispatchers

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

```
DISPATCHERS="(ADDRESS=(PROTOCOL=TCP)(PORT=5000))"
DISPATCHERS="(ADDRESS=(PROTOCOL=TCP)(PORT=5001))"
```

Setting the Initial Number of Shared Servers (SHARED_SERVERS)

The SHARED_SERVERS initialization parameter specifies the number of shared 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 SHARED_SERVERS and MAX_SHARED_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. This could happen when the rate of requests is low, or when the ratio of server usage to request is low. On the other hand, 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 MAX_SHARED_SERVERS to a reasonable value based on your application. Oracle provides good defaults for SHARED_SERVERS and MAX_SHARED_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 MAX_SHARED_SERVERS to a high value because each server is a thread in a common process.

MAX_SHARED_SERVERS is a static initialization parameter, so you cannot change it without shutting down your database. However, SHARED_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 DISPATCHERS and SHARED_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:** *Oracle9i SQL Reference* for information about the ALTER SYSTEM statement

Adding and Removing Dispatcher Processes

You can control the number of dispatcher processes in the instance. If monitoring the V$QUEUE, V$DISPATCHER and V$DISPATCHER_RATE views indicates 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 DISPATCHERS value, or you can add new DISPATCHERS values. Dispatchers can be added up to the limit specified by MAX_DISPATCHERS.

If you reduce the number of dispatchers for a particular shared server 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 DISPATCHERS.

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

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

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

Note: The INDEX keyword can be used to identify which DISPATCHERS parameter to modify. The INDEX value can range from 0 to *n*, where *n* is one less than the defined number of DISPATCHERS parameters. If your ALTER SYSTEM statement specifies an INDEX value equal to *n+1*, where *n* is the current number of dispatchers, a new DISPATCHERS parameter is added. To identify the index number assigned to an 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 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 D*nnn*.

To shut down dispatcher D002, issue the following statement:

```
ALTER SYSTEM SHUTDOWN IMMEDIATE 'D002';
```

The IMMEDIATE keyword stops the dispatcher from accepting new connections and 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 connections terminated before shutting down.

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 SHARED_SERVERS to 0, Oracle terminates all current servers when they become idle and does not start any new servers until you increase SHARED_SERVERS. Thus, setting SHARED_SERVERS to 0 may be used to effectively disable shared server.

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

```
ALTER SYSTEM SET SHARED_SERVERS = 2;
```

Monitoring Shared Server

The following are useful views for obtaining information about your shared server configuration and for monitoring performance.

View	Description
V$DISPATCHER	Provides information on the dispatcher processes, including name, network address, status, various usage statistics, and index number.
V$DISPATCHER_RATE	Provides rate statistics for the dispatcher processes.
V$QUEUE	Contains information on the shared server message queues.
V$SHARED_SERVER	Contains information on the shared server processes.
V$CIRCUIT	Contains information about virtual circuits, which are user connections to the database through dispatchers and servers.
V$SHARED_SERVER_MONITOR	Contains information for tuning shared server.
V$SGA	Contains size information about various system global area (SGA) groups. May be useful when tuning shared server.
V$SGASTAT	Detailed statistical information about the SGA, useful for tuning.
V$SHARED_POOL_RESERVED	Lists statistics to help tune the reserved pool and space within the shared pool.

See Also:

- *Oracle9i Database Reference* for a detailed description of these views
- *Oracle9i Database Performance Guide and Reference* for specific information about monitoring and tuning shared server

About Oracle Background Processes

To maximize performance and accommodate many users, a multiprocess 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.

The following are some basic Oracle background processes, many of which are discussed in more detail elsewhere in this book. The use of additional Oracle database server features or options can cause more background processes to be present. For example, if you use Advanced Queuing, the queue monitor (QMN*n*) background process is present

Process Name	Description
Database writer (DBW*n*)	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 DBW*n* 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 7, "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 DBW*n*. This event is called a checkpoint. The checkpoint process is responsible for signalling DBW*n* at checkpoints and updating all the datafiles and control files of the database to indicate the most recent checkpoint.
System monitor (SMON)	The system monitor performs crash recovery when a failed instance starts up again. In a multiple instance system (Oracle9*i* Real Application Clusters), 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 11-16).
Process monitor (PMON)	The process monitor performs process recovery when a user process fails. PMON is responsible for cleaning up the cache and freeing resources that the process was using. PMON also checks on the dispatcher processes (see below) and server processes and restarts them if they have failed.

Process Name	Description
Archiver (ARC*n*)	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 8, "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 Chapter 32, "Managing Distributed Transactions".
Dispatcher (D*nnn*)	Dispatchers are optional background processes, present only when the shared server configuration is used. Shared server was discussed previously in "Configuring Oracle for the Shared Server" on page 5-5.
Global Cache Service (LMS)	In an Oracle Real Application Clusters environment, this process manages resources and provides inter-instance resource control. See: ■ *Oracle9i Real Application Clusters Concepts* ■ *Oracle9i Real Application Clusters Installation and Configuration.*
Coordinator job queue process (CJQ0)	This is the coordinator of job queue processes for an instance. It monitors the JOB$ table (table of jobs in the job queue) and starts job queue processes (J*nnn*) as needed to execute jobs The J*nnn* processes execute job requests created by the DBMS_JOBS package. This is the subject of Chapter 10, "Managing Job Queues" Additionally, up to 1000 J*nnn* processes can automatically refresh materialized views. They wake up periodically and refresh any materialized views that are scheduled to be refreshed. For information about creating and refreshing materialized views, see: ■ *Oracle9i Replication* ■ *Oracle9i Replication Management API Reference.* Yet another function of the J*nnn* processes is to propagate queued messages to queues on other databases. See *Oracle9i Application Developer's Guide - Advanced Queuing* for information on propagating queued messages. Unlike many Oracle background processes, if a job queue process or the coordinator (CJQ0) fails, it does not cause instance failure.

See Also: *Oracle9i Database Concepts* for more information about Oracle's background processes

Monitoring the Processes of an Oracle Instance

This section lists some of the data dictionary views that 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, that are discussed in the section of this book where the process is described. Also presented are scripts and a view for monitoring the status of locks.

See Also:

- *Oracle9i Database Reference* contains detailed descriptions of these views.
- *Oracle9i Database Performance Guide and Reference* provides information for resolving performance problems and conflicts that 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. 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 for each 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, in tree-structured fashion, the sessions in the system that are waiting for locks and the locks that they are waiting for. Using an ad hot 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 and the Alert File

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 Support Services. Trace file information is also used to tune applications and instances.

The **alert file**, or **alert log**, is a special trace file. The alert file 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, and DROP statements and STARTUP, SHUTDOWN, and ARCHIVELOG statements
- Several messages and errors relating to the functions of shared server and dispatcher processes
- Errors occurring during the automatic refresh of a materialized view
- The values of all initialization parameters at the time the database and instance start

Oracle uses the alert file 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 file, along with a timestamp.

Initialization parameters controlling the location and size of trace files are:

- BACKGROUND_DUMP_DEST
- USER_DUMP_DEST
- MAX_DUMP_FILE_SIZE

These parameters are discussed in the following sections.

> **See Also:** *Oracle9i Database Reference* for information about initialization parameters that control the writing to trace files

Using the Trace Files

You should periodically check the alert file 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 file. 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 file, 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 file. 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 file are written to the destination directory specified by the initialization parameter BACKGROUND_DUMP_DEST. All trace files for server processes are written to the destination directory specified by the initialization parameter USER_DUMP_DEST. The names of trace files are operating system specific, but each file usually includes the name of the process writing the file (such as LGWR and RECO).

> **See Also:** Your operating system specific Oracle documentation for information about the names of trace files

Controlling the Size of Trace Files

You can control the maximum size of all trace files (excluding the alert file) 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 file, 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 file 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 ARC*n* 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 8-21. Other background processes do not have this flexibility.

Trace files are written on behalf of server processes whenever internal errors occur. Additionally, setting the initialization parameter SQL_TRACE = TRUE causes the SQL trace facility to generate performance statistics for the processing of all SQL statements for an *instance* and write them to the USER_DUMP_DEST directory.

Optionally, trace files can be generated for server processes at user request. Regardless of the current value of the SQL_TRACE initialization parameter, each session can enable or disable trace logging on behalf of the associated server process by using the SQL statement ALTER SESSION SET SQL_TRACE. This example enables the SQL trace facility for a specific session:

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

> **Caution:** Because the SQL trace facility for server processes can cause significant system overhead resulting in severe performance impact, enable this feature only when collecting statistics.

For shared 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.

The DBMS_SESSION and DBMS_SYSTEM packages can also be used to control SQL tracing for a session.

> **See Also:** *Oracle9i Database Performance Guide and Reference* contains information about using the SQL trace facility and using TKPROF to interpret the generated trace files.

Managing Processes for Parallel Execution

This section describes how to manage parallel processing of SQL statements. In this configuration Oracle can divide the work of processing an SQL statement among multiple parallel processes.

The execution of many SQL statements can be parallelized. The **degree of parallelism** is the number of parallel execution servers that can be associated with a single operation. The degree of parallelism is determined by any of the following:

- A PARALLEL clause in a statement
- For objects referred to in a query, the PARALLEL clause that was used when the object was created or altered
- A parallel hint inserted into the statement
- A default determined by Oracle

An example of using parallel execution is contained in "Parallelizing Table Creation" on page 15-8.

The following topics are contained in this section:

Note: The parallel execution feature described in this section is available with the Oracle9*i* Enterprise Edition and Oracle9*i* Personal Edition.

See Also:

- *Oracle9i Database Concepts* and *Oracle9i Data Warehousing Guide* for additional information about parallel execution
- *Oracle9i Database Performance Guide and Reference* for information about using parallel hints

Managing the Parallel Execution Servers

With the parallel execution feature, a process known as the **parallel execution coordinator** dispatches the execution of a pool of **parallel execution servers** and coordinates the sending of results from all of these parallel execution servers back to the user. Parallel execution server processes remain associated with a statement

throughout its execution phase. When the statement is completely processed, these processes become available to process other statements.

Parallel execution can be tuned for you automatically by setting the initialization parameter PARALLEL_AUTOMATIC_TUNING = TRUE. With this setting, Oracle determines the default values for other initialization parameters that affect the performance of parallel execution.

Altering Parallel Execution for a Session

The ALTER SESSION statement can be used to control parallel execution for a session.

Disabling Parallel Execution

All subsequent DML (INSERT, UPDATE, DELETE), DDL (CREATE, ALTER), or query (SELECT) statements will not be parallelized after an ALTER SESSION DISABLE PARALLEL DML|DDL|QUERY statement is issued. They will be executed serially, regardless of any PARALLEL clause or parallel hints associated with the statement.

The following statement disables parallel DDL:

```
ALTER SESSION DISABLE PARALLEL DDL;
```

Enabling Parallel Execution

Where a PARALLEL clause or parallel hint is associated with a statement, those DML, DDL, or query statements will execute in parallel after an ALTER SESSION ENABLE PARALLEL DML|DDL|QUERY statement is issued. This is the default for DDL and query statements.

A DML statement can be parallelized *only* if you specifically issue this statement. The following statement enables parallel processing of DML statements:

```
ALTER SESSION ENABLE PARALLEL DML;
```

Note: Parallel DML is available only if you have installed Oracle's Partitioning Option.

Forcing Parallel Execution

You can force parallel execution of all subsequent DML, DDL, or query statements for which parallelization is possible with the ALTER SESSION FORCE PARALLEL

DML|DDL|QUERY statement. Additionally you can force a specific degree of parallelism to be in effect, overriding any PARALLEL clause associated with subsequent statements. If you do not specify a degree of parallelism in this statement, the default degree of parallelism is used. However, a degree of parallelism specified in a statement through a hint will override the degree being forced.

The following statement forces parallel execution of subsequent statements and sets the overriding degree of parallelism to 5:

```
ALTER SESSION FORCE PARALLEL DDL PARALLEL 5;
```

To force the parallelization of DML, it must also be enabled as shown in "Enabling Parallel Execution".

Managing Processes for External Procedures

External procedures, are procedures that are called from another program, but are written in a different language. An example would be a PL/SQL program calling one or more C routines that are required to perform special-purpose processing.

These callable routines are stored in a dynamic link library (DLL), or libunit in the case of a Java class method, and are registered with the base language. Oracle provides a special-purpose interface, the call specification (call spec), that enables users to call external procedures from other languages.

Very briefly, to call an external procedure, the application must know the DLL or shared library in which the external procedure resides. It alerts a network listener process, which in turn starts an external procedure agent, which by default is named `extproc`. Using the network connection established by the listener, the application passes to the external procedure agent the name of the DLL, the name of the external procedure, and any parameters passed in by the application. Then, the external procedure agent loads the DLL and runs the external procedure and passes back to the application any values returned by the external procedure.

To control access to DLLs, the database administrator grants execute privileges for the appropriate DLLs to application developers. The application developers write the external procedures and grant execute privilege on specific external procedures to other users.

The agent can reside on the same computer as the database server or on a remote computer with a listener.

This section discusses how to set up the environment to allow for calling external procedures.

Note: Although not required, it is recommended that you perform these setup tasks during installation of your Oracle database.

See Also: The following books contain information about call specifications and implementing external procedures.

- *PL/SQL User's Guide and Reference*
- *Oracle9i Application Developer's Guide - Fundamentals*
- *Oracle9i Java Stored Procedures Developer's Guide*

Setting up an Environment for Calling External Procedures

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

1. Edit the `tnsnames.ora` file by adding an entry that enables you to connect to the listener process (and subsequently, the external procedure agent). Or, you can use the Oracle Net Configuration Assistant to set up your `tnsnames.ora` file for you.
2. Edit the `listener.ora` file by adding an entry for the "external procedure listener." Or, you can use the Oracle Net Configuration Assistant to set up your `listener.ora` file for you.
3. Start a separate listener process to exclusively handle external procedures.
4. The external procedure agent 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 to 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 the external procedure agent is on a remote computer, place the external procedure agent 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.

See Also: *Oracle Net Services Administrator's Guide* for more information about external procedure agents and run time libraries

Example of tnsnames.ora Entry for External Procedure Listener

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)))
```

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.

Example of listener.ora Entry for External Procedures

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

```
LISTENER=
 (DESCRIPTION=
  (ADDRESS=
     (PROTOCOL=ipc)(KEY=extproc_key)))
SID_LIST_LISTENER=
  (SID_LIST=
    (SID_DESC=
     (SID_NAME=extproc_agent)
     (ORACLE_HOME=/u1/app/oracle/9.0)
     (PROGRAM=extproc)))
```

In this example, the `PROGRAM` parameter is set to `extproc` to match the name of the default external procedure agent. The `SID_NAME` is a system identifier for the external procedure agent and can be any name. The `external procedure agent` executable must reside in `$ORACLE_HOME/bin`.

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 contains 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 system identifier is 7 and serial number is 15:

```
ALTER SYSTEM KILL SESSION '7,15';
```

Identifying Which Session to Terminate

To identify which session to terminate, specify the session's index number and serial number. To identify the system identifier (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#, STATUS
  FROM V$SESSION
  WHERE USERNAME = 'JWARD';

SID    SERIAL#    STATUS
-----  ---------  --------
    7         15  ACTIVE
   12         63  INACTIVE
```

A session is `ACTIVE` when it is making a SQL call to Oracle. A session is `INACTIVE` if it is not making a SQL call to Oracle.

> **See Also:** *Oracle9i Database Reference* for a description of the status values for a session

Terminating an Active Session

If a user session is processing a transaction (ACTIVE status) when 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.
```

6

Managing Control Files

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

- What Is a Control File?
- Guidelines for Control Files
- Creating Control Files
- Troubleshooting After Creating Control Files
- Backing Up Control Files
- Recovering a Control File Using a Current Copy
- Dropping Control Files
- Displaying Control File Information

> **See Also:** Chapter 3, "Using Oracle-Managed Files" for information about creating control files that are both created and managed by the Oracle database server

What Is a Control File?

Every Oracle database has a **control file**. A control file is a small binary file that records the physical structure of the database and includes:

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

The control file must be available for writing by the Oracle database server whenever the database is open. Without the control file, the database cannot be mounted and recovery is difficult.

The control file of an Oracle database is created at the same time as the database. By default, at least one copy of the control file is created during database creation. On some operating systems the default is to create multiple copies. You should create two or more copies of the control file during database creation. You 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 contains the following topics:

- Provide Filenames for the Control Files
- Multiplex Control Files on Different Disks
- Place Control Files Appropriately
- Back Up Control Files
- Manage the Size of Control Files

Provide Filenames for the Control Files

You specify control file names using the `CONTROL_FILES` initialization parameter in the database's initialization parameter file (see "Creating Initial Control Files" on page 6-4). The instance startup procedure recognizes and opens all the listed files.

The instance writes to and maintains all listed control files during database operation.

If you do not specify files for CONTROL_FILES before database creation, *and you are not using the Oracle Managed Files* feature, Oracle creates a control file and uses a default filename. The default name is operating system specific.

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 the intact copy of the control file from the other disk and the instance can be restarted. In this case, no media recovery is required.

The following describes the behavior of multiplexed control files:

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

Note: Oracle strongly recommends that your database has a minimum of two control files and that they are located on separate disks.

Place Control Files Appropriately

As already suggested, each copy of a control file should be stored on a different disk drive. One practice is to store a control file copy 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.

Back Up Control Files

It is very important that you back up your control files. This is true initially, and at any time after you change the physical structure of your database. Such structural changes include:

- Adding, dropping, or renaming datafiles
- Adding or dropping a tablespace, or altering the read-write state of the tablespace
- Adding or dropping redo log files or groups

The methods for backing up control files are discussed in "Backing Up Control Files" on page 6-10.

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:

- Your operating system specific Oracle documentation contains more information about the maximum control file size.
- *Oracle9i SQL Reference* for a description of the CREATE DATABASE statement

Creating Control Files

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

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

Creating Initial Control Files

The initial control files of an Oracle database are created when you issue the CREATE DATABASE statement. The names of the control files are specified by the CONTROL_FILES parameter in the initialization parameter file used during database creation. The filenames specified in CONTROL_FILES should be fully specified and are operating system specific. The following is an example of a CONTROL_FILES initialization parameter:

```
CONTROL_FILES = (/u01/oracle/prod/control01.ctl,
```

```
/u02/oracle/prod/control02.ctl,
/u03/oracle/prod/control03.ctl)
```

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

You can subsequently change the value of the CONTROL_FILES initialization parameter to add more control files or to change the names or locations of existing control files.

> **See Also:** Your operating system specific Oracle documentation contains more information about specifying control files.

Creating Additional Copies, Renaming, and Relocating Control Files

You 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.

Creating New Control Files

This section discusses when and how to create new control files.

When to Create New Control Files

It is necessary for you to create new control files in the following situations:

- All control files for the database have been permanently damaged and you do not have a control file backup.
- You want to change one of the permanent database parameter settings originally specified in the CREATE DATABASE statement. These settings include the database's name and the following parameters: MAXLOGFILES, MAXLOGMEMBERS, MAXLOGHISTORY, MAXDATAFILES, and MAXINSTANCES.

  For example, you would change a database's name if it conflicted with another database's name in a distributed environment. Or, as another example, you can change the value of MAXLOGFILES if the original setting is too low.

The CREATE CONTROLFILE Statement

You can create a new control file for a database using the CREATE CONTROLFILE statement. The following statement creates a new control file for the prod database (formerly a database that used a different database name):

```
CREATE CONTROLFILE
   SET DATABASE prod
   LOGFILE GROUP 1 ('/u01/oracle/prod/redo01_01.log',
                    '/u01/oracle/prod/redo01_02.log'),
           GROUP 2 ('/u01/oracle/prod/redo02_01.log',
                    '/u01/oracle/prod/redo02_02.log'),
           GROUP 3 ('/u01/oracle/prod/redo03_01.log',
                    '/u01/oracle/prod/redo03_02.log')
   NORESETLOGS
   DATAFILE '/u01/oracle/prod/system01.dbf' SIZE 3M,
            '/u01/oracle/prod/rbs01.dbs' SIZE 5M,
            '/u01/oracle/prod/users01.dbs' SIZE 5M,
            '/u01/oracle/prod/temp01.dbs' SIZE 5M
   MAXLOGFILES 50
   MAXLOGMEMBERS 3
   MAXDATAFILES 200
   MAXINSTANCES 6
   ARCHIVELOG;
```

Caution: 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 instructions in "Steps for Creating New Control Files".

See Also: *Oracle9i SQL Reference* describes the complete syntax of the `CREATE CONTROLFILE` statement

Steps for Creating New Control Files

Complete the following steps to create a new control file.

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

   If you follow recommendations for control file backups as discussed in "Backing Up Control Files" on page 6-10, you will already have a list of datafiles and online redo log files that reflect the current structure of the database. However, if you have no such list, executing the following statements will produce one.

   ```
   SELECT MEMBER FROM V$LOGFILE;
   SELECT NAME FROM V$DATAFILE;
   SELECT VALUE FROM V$PARAMETER WHERE NAME = 'CONTROL_FILES';
   ```

   If you have no such lists and your control file has been damaged so that the database cannot be opened, try to locate all of the datafiles and 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 normally 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 a new instance, but do not mount or open the database:

   ```
   STARTUP NOMOUNT;
   ```

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

   When creating a new control file, select the RESETLOGS option if you have lost any online redo log groups in addition to control files. In this case, you will need to recover from the loss of the redo logs (Step 8). You must 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. See "Backing Up Control Files" on page 6-10 for instructions for creating a backup.

7. Edit the CONTROL_FILES initialization parameter for the database to indicate all of the control files now part of your database as created in Step 5 (not including the backup control file). If you are renaming the database, edit the DB_NAME parameter 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 using one of the following methods:

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

     ```
     ALTER DATABASE OPEN;
     ```

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

     ```
     ALTER DATABASE OPEN RESETLOGS;
     ```

The database is now open and available for use.

See Also: *Oracle9i User-Managed Backup and Recovery Guide* contains additional information about:

- Listing database files
- Backing up all datafiles and online redo log files of the database
- Recovering online or archived redo log files
- Performing 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 contains the following topics:

- Checking for Missing or Extra Files
- Handling Errors During CREATE CONTROLFILE

Checking for Missing or Extra Files

After creating a new control file and using it to open the database, check the alert file 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.

The actual datafile corresponding to `MISSING`*nnnn* can be made accessible by renaming `MISSING`*nnnn* so that it points to the datafile only if the datafile was read-only or offline normal. If, on the other hand, `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, because the datafile requires media recovery that is precluded by the results of `RESETLOGS`. In this case, you must drop the tablespace containing the datafile.

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 file to let you know what was 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 on page 6-7 and repeat the procedure from Step 4, using the correct filenames.

Backing Up Control Files

Use the ALTER DATABASE BACKUP CONTROLFILE statement to back up your control files. You have two options:

1. Back up the control file to a binary file (duplicate of existing control file) using the following statement:

   ```
   ALTER DATABASE BACKUP CONTROLFILE TO '/oracle/backup/control.bkp';
   ```

2. Produce SQL statements that can later be used to recreate your control file:

   ```
   ALTER DATABASE BACKUP CONTROLFILE TO TRACE;
   ```

   This command writes a SQL script to the databases's trace file where it can be captured and edited to reproduce the control file.

   See Also: *Oracle9i User-Managed Backup and Recovery Guide* for more information on backing up your control files and how this fits into your overall backup and recovery strategy

Recovering a Control File Using a Current Copy

This section presents ways that you can recover your control file from a current backup or from a multiplexed copy.

Recovering from Control File Corruption Using a Control File Copy

This procedure assumes that one of the control files specified in the CONTROL_FILES parameter is corrupted, the control file directory is still accessible, and you have a multiplexed copy of the control file.

1. With the instance shut down, use an operating system command to overwrite the bad control file with a good copy:

```
% cp /u01/oracle/prod/control03.ctl  /u01/oracle/prod/control02.ctl;
```

2. Start SQL*Plus and open the database:

```
SQL> STARTUP
```

Recovering from Permanent Media Failure Using a Control File Copy

This procedure assumes that one of the control files specified in the CONTROL_FILES parameter is inaccessible due to a permanent media failure, and you have a multiplexed copy of the control file.

1. With the instance shut down, use an operating system command to copy the current copy of the control file to a new, accessible location:

```
% cp /u01/oracle/prod/control01.ctl  /u04/oracle/prod/control03.ctl;
```

2. Edit the CONTROL_FILES parameter in the initialization parameter file to replace the bad location with the new location:

```
CONTROL_FILES = (/u01/oracle/prod/control01.ctl,
                 /u02/oracle/prod/control02.ctl,
                 /u04/oracle/prod/control03.ctl)
```

3. Start SQL*Plus and open the database:

```
SQL> STARTUP
```

In any case where you have multiplexed control files, and you must get the database up in minimum time, you can do so by editing the CONTROL_FILES initialization parameter to remove the bad control file and restarting the database immediately. Then you can perform the reconstruction of the bad control file and at some later time shutdown and restart the database after editing the CONTROL_FILES initialization parameter to include the recovered control file.

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 no longer appropriate. 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.

> **Note:** This operation does not physically delete the unwanted control file from the disk. Use operating system commands to delete the unnecessary file after you have dropped the control file from the database.

Displaying Control File Information

The following views display information about control files:

View	Description
V$CONTROLFILE	Lists the names of control files
V$CONTROLFILE_RECORD_SECTION	Displays information about control file record sections
V$PARAMETER	Can be used to display the names of control files as specified in the CONTROL_FILES initialization parameter

This example lists the names of the control files.

```
SQL> SELECT NAME FROM V$CONTROLFILE;

NAME
------------------------------------
/u01/oracle/prod/control01.ctl
/u02/oracle/prod/control02.ctl
/u03/oracle/prod/control03.ctl
```

7

Managing the Online Redo Log

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

- What Is the Online Redo Log?
- Planning the Online Redo Log
- Creating Online Redo Log Groups and Members
- Relocating and Renaming 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
- Viewing Online Redo Log Information

See Also:

- Chapter 3, "Using Oracle-Managed Files" for information about creating online redo log files that are both created and managed by the Oracle database server
- *Oracle9i Real Application Clusters Administration* for more information about managing the online redo logs of instances when using Oracle Real Application Clusters
- *Oracle9i Database Performance Guide and Reference* to learn how checkpoints and the redo log impact instance recovery

What Is the Online Redo Log?

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

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 Oracle Real Application Clusters, however, two or more instances concurrently access a single database and each instance has its own thread.

This chapter describes how to configure and manage the online redo log when the Oracle9i Real Application Clusters feature 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 (see "How Oracle Writes to the Online Redo Log") 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 when all redo records associated with a given transaction are safely on disk in the online logs is the user process notified that the transaction has been committed.

Redo records can also be written to 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

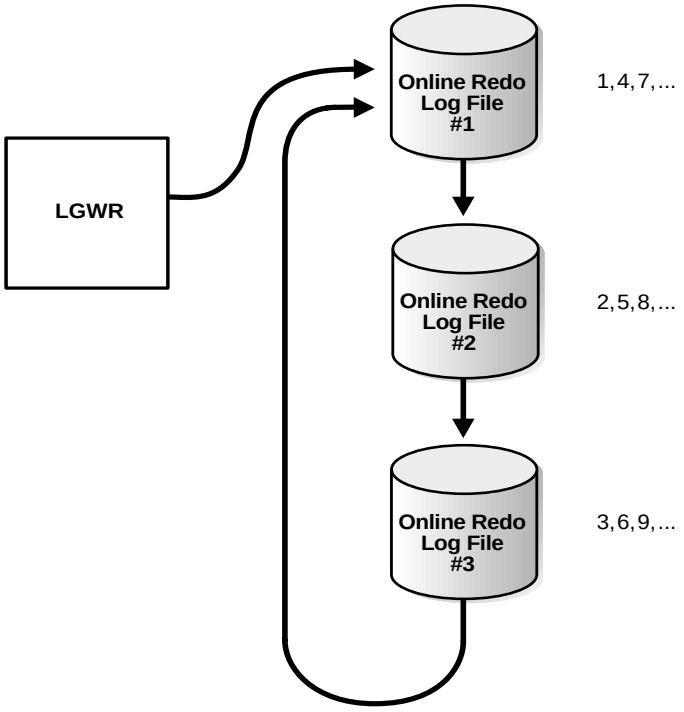
The online redo log of a database consists of two or more online redo log files. Oracle requires a minimum of two files to guarantee that one is always available for writing while the other is being archived (if in `ARCHIVELOG` mode).

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 7–1 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 reuse 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 7–1 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 to 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 (`ARCHIVELOG` mode), Oracle cannot reuse or overwrite an active online log file until ARC*n* has archived its contents. If archiving is disabled (`NOARCHIVELOG` mode), 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. Normally, a log switch occurs when the current online redo log file is completely filled and writing must continue to the next online redo log file. However, you can specify that a log switch occurs in a time-based manner, regardless of whether the current online redo log file is completely filled. 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 contains the following topics:

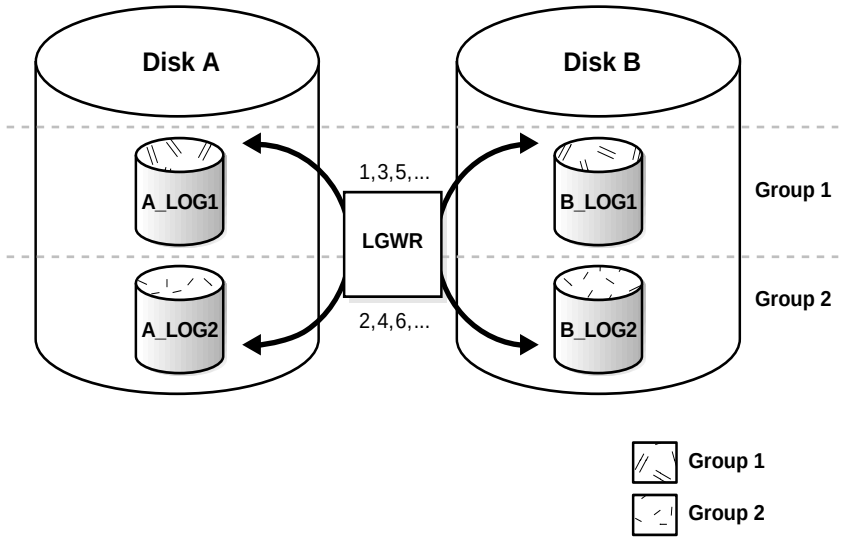
- Multiplexing Online Redo Log Files
- Placing Online Redo Log Members on Different Disks
- Setting the Size of Online Redo Log Members
- Choosing the Number of Online Redo Log Files
- Controlling Archive Lag

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 7–2 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 7–2, 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 7–2, first LGWR writes to A_LOG1 in conjunction with B_LOG1, then A_LOG2 in conjunction with B_LOG2, and so on. 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 `INVALID` 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.

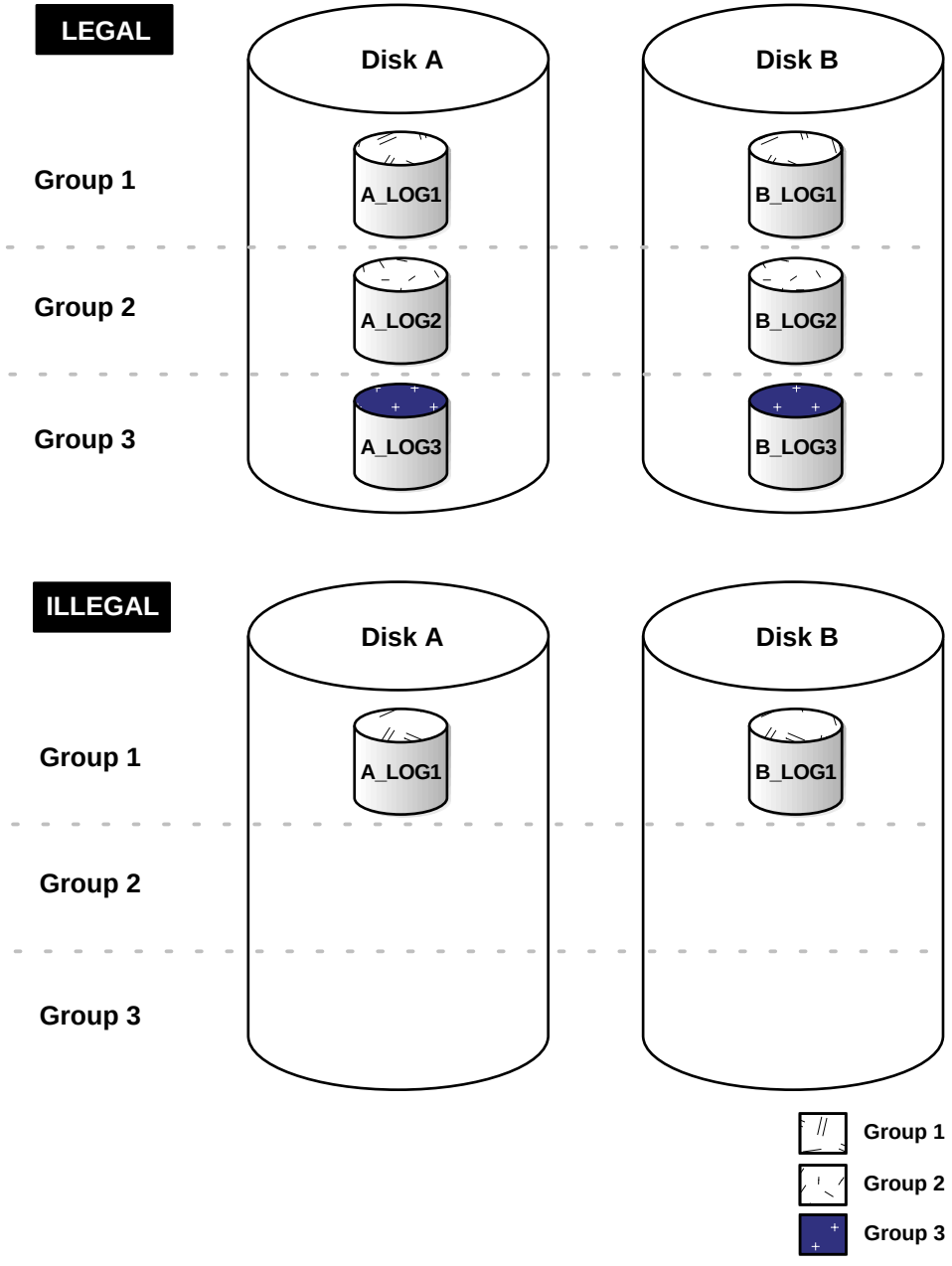
If	Then
LGWR can successfully write to at least one member in a group	Writing proceeds as normal. LGWR simply writes to the available members of a group and ignores the unavailable members.
LGWR cannot access the next group at a log switch because the group needs to be archived	Database operation temporarily 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. If the database checkpoint has moved beyond the lost redo log, 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 7–3 shows legal and illegal multiplexed online redo log configurations. The second configuration is illegal because it has only one group.

Figure 7–3 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:** *Oracle9i User-Managed Backup and Recovery Guide* for more information about how the online redo log affects backup and recovery

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 for each 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:** Your operating system specific Oracle documentation. The default size of online redo log files is operating system dependent.

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 for each 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 specific default value.
- The `MAXLOGMEMBERS` parameter used in the `CREATE DATABASE` statement determines the maximum number of members for each group. As with `MAXLOGFILES`, the only way to override this upper limit is to re-create the database or control file. 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:** Your operating system specific Oracle documentation for the default and legal values of the `MAXLOGFILES` and `MAXLOGMEMBERS` parameters

Controlling Archive Lag

You can force all enabled online redo log threads to switch their current logs in a time-based fashion. In a primary / standby configuration, changes are made available to the standby database by archiving and shipping noncurrent logs of the

primary site to the standby database. The changes that are being applied by the standby database can lag the changes that are occurring on the primary database.

This lag can happen because the standby database must wait for the changes in the primary database's online redo log to be archived (into the archived redo log) and then shipped to it. To control or limit this lag, you set the ARCHIVE_LAG_TARGET initialization parameter. Setting this parameter allows you to limit, measured in time, how long the lag can become.

Setting the ARCHIVE_LAG_TARGET Initialization Parameter

When you set the ARCHIVE_LAG_TARGET initialization parameter, you cause Oracle to examine an instance's current online redo log periodically. If the following conditions are met the instance will switch the log:

- The current log was created prior to *n* seconds ago, and the estimated archival time for the current log is *m* seconds (proportional to the number of redo blocks used in the current log), where *n* + *m* exceeds the value of the ARCHIVE_LAG_TARGET initialization parameter.
- The current log contains redo records.

In an Oracle Real Application Clusters environment, the instance also kicks other threads into switching and archiving logs if they are falling behind. This can be particularly useful when one instance in the cluster is more idle than the other instances (as when you are running a 2-node primary / secondary configuration of Oracle Real Application Clusters).

Initialization parameter ARCHIVE_LAG_TARGET specifies the target of how many seconds of redo the standby could lose in the event of a primary shutdown or crash. It also provides an upper limit of how long (in the number of seconds) the current log of the primary database can span. Because the estimated archival time is also considered, this is not the exact log switch time.

The following initialization parameter setting sets the log switch interval to 30 minutes (a typical value).

```
ARCHIVE_LAG_TARGET = 1800
```

A value of 0 disables this time-based log switching functionality. This is the default setting.

In an idle system where no redo is generated over a long period of time (for example, the DBA forgot to shut down the database), Oracle *will not* generate a bunch of empty archived logs. This is because the current log is switched only if it contains redo.

You can set the ARCHIVE_LAG_TARGET initialization parameter even if there is no standby database. For example, the ARCHIVE_LAG_TARGET parameter can be set specifically to force logs to be switched and archived.

ARCHIVE_LAG_TARGET is a dynamic parameter and can be set with the ALTER SYSTEM SET statement.

> **Caution:** The ARCHIVE_LAG_TARGET parameter must be set to the same value in all instances of an Oracle Real Application Clusters environment. Failing to do so results in unspecified behavior and is strongly discouraged.

Factors Affecting the Setting of ARCHIVE_LAG_TARGET

Consider the following factors when determining if you want to set the ARCHIVE_LAG_TARGET parameter and in determining the value for this parameter.

- Overhead of switching (as well as archiving) logs
- How frequently normal log switches occur as a result of log full conditions
- How much redo loss is tolerated in the standby database

Setting ARCHIVE_LAG_TARGET may not be very useful if natural log switches already occur more frequently than the interval specified. However, in the case of irregularities of redo generation speed, the interval does provide an upper limit for the time range each current log covers. If the database becomes idle and redo records stop being generated, the interval forces a log switch causing all redo records generated so far to be switched out, archived, and made available to the standby database.

If the ARCHIVE_LAG_TARGET initialization parameter is set to a very low value, there can be a negative impact on performance. This can force frequent log switches. Set the parameter to a reasonable value so as not to degrade the performance of the primary database.

Creating 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. 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.

> **See Also:** *Oracle9i SQL Reference* for a complete description of the ALTER DATABASE statement

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.

You can also specify the number that identifies the group using the 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.

Relocating and Renaming Online Redo Log Members

You can use operating system commands to relocate online redo logs, then use the ALTER DATABASE statement to make their new names (locations) known to the database. This procedure is necessary, for example, if the disk currently used for some 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 relocating your redo logs, or making any other structural changes to the database, completely back up the database in case you experience problems while performing the operation. As a precaution, after renaming or relocating a set of online redo log files, immediately back up the database's control file.

Use the following steps for relocating redo logs. The example used to illustrate these steps assumes:

- The log files are located on two disks: diska and diskb.
- The 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.

To Rename Online Redo Log Members

1. Shutdown the database.

```
SHUTDOWN
```

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 (or perform other operating system commands) without exiting SQL*Plus by using the HOST command. Some operating systems allow you to use a character in place of the word HOST. For example, you can use ! in UNIX.

```
mv /diska/logs/log1a.rdo /diskc/logs/log1c.rdo
mv /diska/logs/log2a.rdo /diskc/logs/log2c.rdo
```

3. Startup the database, mount, but do not open it.

```
CONNECT / as SYSDBA
STARTUP MOUNT
```

4. Rename the online redo log members.

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

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

5. Open the database for normal operation.

   The online redo log alterations take effect when the database is opened.

```
ALTER DATABASE OPEN;
```

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 inactive. If you need to drop the current group, first force a log switch to occur.
- Make sure an online redo log group is archived (if archiving is enabled) before dropping it. To see whether this has happened, use the V$LOG view.

```
SELECT GROUP#, ARCHIVED, STATUS FROM V$LOG;

   GROUP# ARC STATUS
--------- --- ----------------
        1 YES ACTIVE
        2 NO  CURRENT
        3 YES INACTIVE
        4 YES INACTIVE
```

Drop 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, and you are not using the Oracle Managed Files feature, the operating system files are not deleted

from disk. Rather, the control files of the associated database are updated to drop the members of the group from the database structure. After dropping 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.

When using Oracle-managed files, the cleanup of operating systems files is done automatically for you.

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$LOGFILE view. A redo log file becomes INVALID if Oracle cannot access it. It becomes STALE if Oracle suspects that it is not complete or correct. A stale log file becomes valid again the next time its group is made the active group.
- You can drop an online redo log member only if it is *not* part of an active or current group. If you want to drop a member of an active group, first force a log switch to occur.
- Make sure the group to which an online redo log member belongs is archived (if archiving is enabled) before dropping the member. To see whether this has happened, use the V$LOG view.

To drop specific inactive online redo log members, use the ALTER DATABASE statement with the DROP LOGFILE MEMBER clause.

The following statement drops the redo log /oracle/dbs/log3c.rdo:

```
ALTER DATABASE DROP LOGFILE MEMBER '/oracle/dbs/log3c.rdo';
```

When 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.

To drop a member of an active group, you must first force a log switch.

Forcing Log Switches

A log switch occurs when LGWR stops writing to one 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. Use the `ALTER SYSTEM` statement with the `SWITCH LOGFILE` clause.

The following statement forces a log switch:

```
ALTER SYSTEM SWITCH LOGFILE;
```

Verifying Blocks in Redo Log Files

You can configure Oracle to use checksums to verify blocks in the redo log files. If you set the initialization parameter `DB_BLOCK_CHECKSUM` to `TRUE`, block checking is enabled for all Oracle database blocks written to disk, including redo log blocks. The default value of `DB_BLOCK_CHECKSUM` is `FALSE`.

If you enable block checking, Oracle computes a checksum for each redo log block written to the current log. Oracle writes the checksum 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 attempts 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.

Note: There is some overhead and decrease in database performance with DB_BLOCK_CHECKSUM enabled. Monitor your database performance to decide if the benefit of using data block checksums to detect corruption outweights the performance impact.

See Also: *Oracle9i Database Reference* for a description of the DB_BLOCK_CHECKSUM initialization parameter

Clearing an Online Redo Log File

An online redo log file might become corrupted while the database is open, and ultimately stop database activity because archiving cannot continue. In this situation the ALTER DATABASE CLEAR LOGFILE statement can be used reinitialize the file without shutting down the database.

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

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

This statement overcomes two situations where dropping redo logs is not possible:

- If there are only two log groups
- The corrupt redo log file belongs to the current group

If the corrupt redo log file has not been archived, use the UNARCHIVED keyword in the statement.

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

This statement clears the corrupted redo logs and avoids archiving them. The cleared redo logs are available for use even though they were not archived.

If you clear a log file that is needed for recovery of a backup, then you can no longer recover from that backup. 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 `UNRECOVERABLE DATAFILE` clause in the `ALTER DATABASE CLEAR LOGFILE` statement.

If you clear a redo log needed to bring an offline tablespace online, you will not be able to bring the tablespace online again. You will have to drop the tablespace or perform an incomplete recovery. Note that tablespaces taken offline normal do not require recovery.

See Also: *Oracle9i User-Managed Backup and Recovery Guide* for more information about clearing redo log files

Viewing Online Redo Log Information

Use the following views to display online redo log information.

View	Description
V$LOG	Displays the redo log file information from the control file
V$LOGFILE	Identifies redo log groups and members and member status
V$LOG_HISTORY	Contains log history information

The following query returns the control file information about the online redo log for a database.

```
SELECT * FROM V$LOG;

GROUP#  THREAD#    SEQ    BYTES  MEMBERS  ARC STATUS     FIRST_CHANGE# FIRST_TIM
------  -------  -----  -------  -------  --- ---------  ------------- ---------
     1        1  10605  1048576        1  YES ACTIVE          11515628 16-APR-00
     2        1  10606  1048576        1  NO  CURRENT         11517595 16-APR-00
     3        1  10603  1048576        1  YES INACTIVE        11511666 16-APR-00
     4        1  10604  1048576        1  YES INACTIVE        11513647 16-APR-00
```

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

```
SELECT * FROM V$LOGFILE;
```

```
GROUP#   STATUS  MEMBER
------  -------  --------------------------------
     1           D:\ORANT\ORADATA\IDDB2\REDO04.LOG
     2           D:\ORANT\ORADATA\IDDB2\REDO03.LOG
     3           D:\ORANT\ORADATA\IDDB2\REDO02.LOG
     4           D:\ORANT\ORADATA\IDDB2\REDO01.LOG
```

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

> **See Also:** *Oracle9i Database Reference* for detailed information about these views

8

Managing Archived Redo Logs

This chapter describes how to archive redo data. It contains 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 by Specifying Multiple ARCn Processes
- Controlling Trace Output Generated by the Archivelog Process
- Viewing Information About the Archived Redo Log

> **See Also:** *Oracle9i Real Application Clusters Administration* for information specific to archiving in the Oracle Real Application Clusters environment

What Is the Archived Redo Log?

Oracle enables you to save filled groups of online redo log files to one or more offline destinations, known collectively as the **archived redo log**, or more simply archive logs. The process of turning online redo log files into archived redo log files is called **archiving**. This process is only possible if the database is running in **ARCHIVELOG mode**. You can choose automatic or manual archiving.

An archived redo log file is a copy of one of the identical filled members of an online redo log group. It includes the redo entries present in the identical member of a redo log group and also preserves the group's unique log sequence number. For example, if you are multiplexing your online redo log, and if Group 1 contains member files `a_log1` and `b_log1`, then the archiver process (ARC*n*) will archive one of these identical members. Should `a_log1` become corrupted, then ARC*n* can still archive the identical `b_log1`. The archived redo log contains a copy of every group created since you enabled archiving.

When running in `ARCHIVELOG` mode, the log writer process (LGWR) is not allowed to reuse and hence overwrite an online redo log group until it has been archived. The background process ARC*n* automates archiving operations when automatic archiving is enabled. Oracle starts multiple archiver processes as needed to ensure that the archiving of filled online redo logs does not fall behind.

You can use archived redo logs to:

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

Choosing Between NOARCHIVELOG and ARCHIVELOG Mode

This section describes the issues you must consider when choosing to run your database in `NOARCHIVELOG` or `ARCHIVELOG` mode, and contains these topics:

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

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. 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 specify 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:

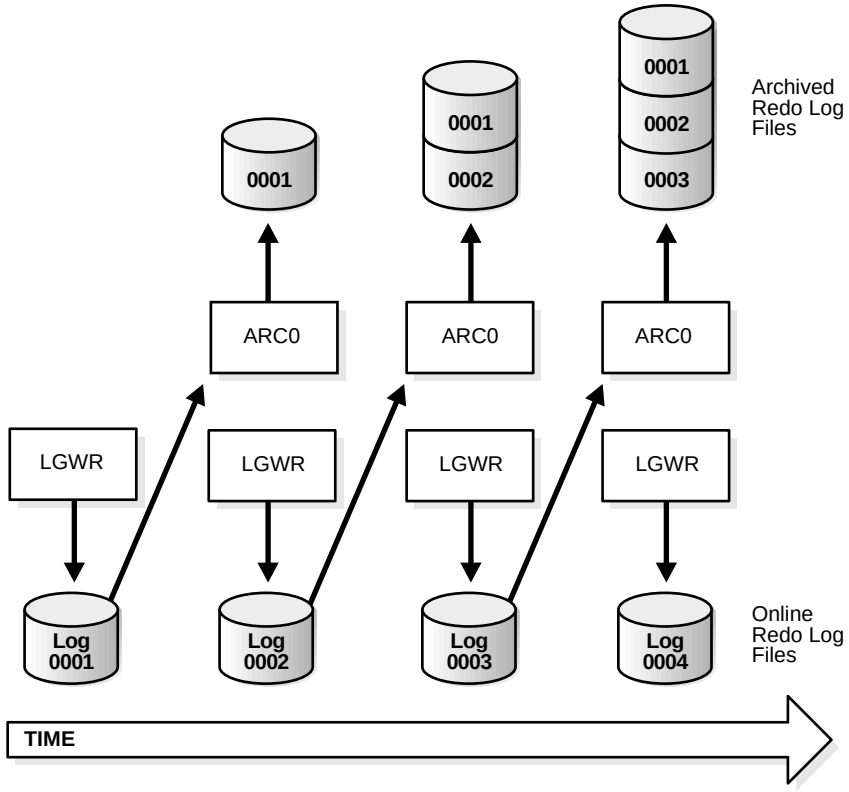
- A database backup, together with online and archived redo log files, guarantees that you can recover all committed transactions in the event of an operating system or disk failure.
- You can use a backup taken while the database is open and in normal system use if you keep an archived log.
- You can 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 8–1 illustrates how the archiver process (ARC0 in this illustration) archives the filled online redo log files to generate the database's archived redo log.

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.

Figure 8–1 Online Redo Log File Use in ARCHIVELOG Mode



Controlling the Archiving Mode

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

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

> **See Also:** Your Oracle operating system specific documentation contains 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.

> **Note:** If a database is automatically created during Oracle installation, the initial archiving mode of the database is operating system specific.

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 steps switch a database's archiving mode from `NOARCHIVELOG` to `ARCHIVELOG`:

1. Shut down the database instance.

   ```
   SHUTDOWN
   ```

   An open database must first be closed and any associated instances shut down before you can switch the database'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. See *Oracle9i User-Managed Backup and Recovery Guide.*

3. Edit the initialization parameter file to include initialization parameters specifying whether automatic archiving is enabled (see "Enabling Automatic Archiving" on page 8-6) and the destinations for the archive log files (see "Specifying Archive Destinations" on page 8-9).
4. Start a new instance and mount, but do not open, the database.

   ```
   STARTUP MOUNT
   ```

   To enable or disable archiving, the database must be mounted but not open.
5. Switch the database's archiving mode. Then open the database for normal operations.

   ```
   ALTER DATABASE ARCHIVELOG;
   ALTER DATABASE OPEN;
   ```

> **See Also:** *Oracle9i Real Application Clusters Administration* for more information about switching the archiving mode when using Oracle9*i* Real Application Clusters

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 8-9.

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 8-9.

Caution: 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 clause. 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. Those settings may or may not enable automatic archiving.

Controlling the Number of Archiver Processes

Oracle starts additional archiver processes (ARC*n*) as needed to ensure that the automatic processing of filled redo log files does not fall behind. However, if you want to avoid any runtime overhead of invoking additional ARC*n* processes, you can specify the number of processes to be started at instance startup using the LOG_ARCHIVE_MAX_PROCESSES initialization parameter. Up to 10 ARC*n* processes can be started.

This parameter also limits the number of ARC*n* processes that can be started for the instance. No more than the specified number of processes can ever be started.

The LOG_ARCHIVE_MAX_PROCESSES is dynamic, and can be changed using the ALTER SYSTEM statement. The following statement increases (or decreases) the number of ARC*n* processes currently running.

```
ALTER SYSTEM SET LOG_ARCHIVE_MAX_PROCESSES=3;
```

There is usually no need to change the LOG_ARCHIVE_MAX_PROCESSES initialization parameter from its default value of 1, because Oracle will adequately adjust ARC*n* processes according to system workload.

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. It is possible that the instance can 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 ALTER SYSTEM statement 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;
```

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 dynamic performance (V$) views, listed in "Viewing Information About the Archived Redo Log" on page 8-22, to access archive information.

The following topics are contained in this section

Specifying Archive Destinations

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

Meth	Initialization Parameter	Host	Example
1	LOG_ARCHIVE_DEST_*n* where: *n* is an integer from 1 to 10	Local or remote	LOG_ARCHIVE_DEST_1 = 'LOCATION= /disk1/arc' LOG_ARCHIVE_DEST_2 = 'SERVICE = standby1'
2	LOG_ARCHIVE_DEST and LOG_ARCHIVE_DUPLEX_DEST	Local only	LOG_ARCHIVE_DEST = '/disk1/arc' LOG_ARCHIVE_DUPLEX_DEST ='/disk2/arc'

See Also:

- *Oracle9i Database Reference* for additional information about the initialization parameters used to control the archiving of redo logs
- *Oracle9i Data Guard Concepts and Administration* for information about using the LOG_ARCHIVE_DEST_*n* initialization parameter for specifying a standby destination. There are additional keywords that can be specified with this initialization parameter and that are not discussed in this book.

Method 1: 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 10) to specify from one to ten different destinations for archival. Each numerically-suffixed parameter uniquely identifies an individual destination.

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

Keyword	Indicates	Example
LOCATION	A local file system location.	LOG_ARCHIVE_DEST_1 = 'LOCATION=/disk1/arc'
SERVICE	Remote archival through Oracle Net service name.	LOG_ARCHIVE_DEST_2 = 'SERVICE=standby1'

If you use the LOCATION keyword, specify a valid path name for your operating system. If you specify SERVICE, 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. 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 the LOG_ARCHIVE_DEST_*n* initialization parameter:

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

   ```
   SHUTDOWN
   ```

2. Edit the LOG_ARCHIVE_DEST_*n* parameter to specify from one to ten archiving locations. The LOCATION keyword specifies an operating system specific path name. For example, enter:

   ```
   LOG_ARCHIVE_DEST_1 = 'LOCATION = /disk1/archive'
   LOG_ARCHIVE_DEST_2 = 'LOCATION = /disk2/archive'
   LOG_ARCHIVE_DEST_3 = 'LOCATION = /disk3/archive'
   ```

   If you are archiving to a standby database, use the SERVICE keyword to specify a valid net service name from the tnsnames.ora file. For example, enter:

   ```
   LOG_ARCHIVE_DEST_4 = 'SERVICE = standby1'
   ```

3. 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 specify an optional **secondary** archive destination. 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;
   ```

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 generates 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_101.arc
   ```

   See Also:

   - *Oracle9i User-Managed Backup and Recovery Guide*
   - *Oracle9i Data Guard Concepts and Administration.*

   for information about archiving to standby databases

Understanding Archive Destination Status

Each archive destination has the following variable characteristics that determine its status:

- **Valid/Invalid**—indicates whether the disk location or service name information is specified and valid
- **Enabled/Disabled**—indicates the availability state of the location and whether Oracle can use the destination
- **Active/Inactive**—indicates whether there was a problem accessing the destination

Several combinations of these characteristics are possible. To obtain the current status and other information about each destination for an instance, query the V$ARCHIVE_DEST view.

The characteristics determining a locations status that appear in the view are shown in Table 8–1. Note that for a destination to be used, its characteristics must be valid, enabled, and active.

Table 8–1 Destination Status

	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.
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.

The LOG_ARCHIVE_DEST_STATE_*n* (where *n* is an integer from 1 to 10) initialization parameter allows you to control the availability state of the specified destination (*n*). The destination state can have two values: ENABLE and DEFER. ENABLE indicates that Oracle can use the destination, whereas DEFER indicates that the location is temporarily disabled.

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 through a network to either a local or remote standby database.

Normal Transmission Mode

In normal transmission mode, the archiving destination is another disk drive of the database server. In this configuration archiving does not contend with other files required by the instance and can complete more quickly. Specify the destination with either the LOG_ARCHIVE_DEST_*n* or LOG_ARCHIVE_DEST parameters.

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.

> **Caution:** You can maintain a standby database on a local disk, but Oracle strongly encourages you to maximize disaster protection by maintaining your standby database at a remote site.

If you are operating your standby database in **managed recovery mode**, you can keep your standby database 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 Oracle Net. Indicate a remote archival by specifying a Oracle Net 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. 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:

- *Oracle9i Data Guard Concepts and Administration*
- *Oracle Net Services 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, Oracle provides you with options. Discussions of these options are contained in the following sections:

- 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 10, 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 the following:

- 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 by LOG_ARCHIVE_DEST is mandatory.

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

Sample Scenarios: Specifying the Number of Successful Destinations

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 8–2 illustrates the possible values for LOG_ARCHIVE_MIN_SUCCEED_DEST=*n* in this case.

Table 8–2 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.
4 or greater	ERROR: The value is greater than the number of destinations.

This scenario shows that even though you do not explicitly set any of your destinations to MANDATORY using the LOG_ARCHIVE_DEST_*n* parameter, Oracle must successfully archive to one or more of 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 8–3 shows the possible values for LOG_ARCHIVE_MIN_SUCCEED_DEST=*n*.

Table 8–3 LOG_ARCHIVE_MIN_SUCCEED_DEST Values for Scenario 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 or greater	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 of destinations.

Re-Archiving to a Failed Destination

Use the REOPEN attribute of the LOG_ARCHIVE_DEST_*n* parameter to specify 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. In this situation, consider the following options:

- Archive manually to the failed destination.
- Change the destination by deferring the destination, specifying the destination as optional, or changing the service.
- Drop the destination.

When using the REOPEN keyword, note the following:

- ARC*n* reopens a destination only when *starting* an archive operation from the beginning of the log file, never *during* a current operation. ARC*n* always retries the log copy from the beginning.
- If 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 by Specifying Multiple ARC*n* Processes

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.

You can 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 ARC*n* 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 is always active. Query the V$ARCHIVE_PROCESSES view to see information about the state of each archive process. Processes that have stopped show as being in the IDLE state.

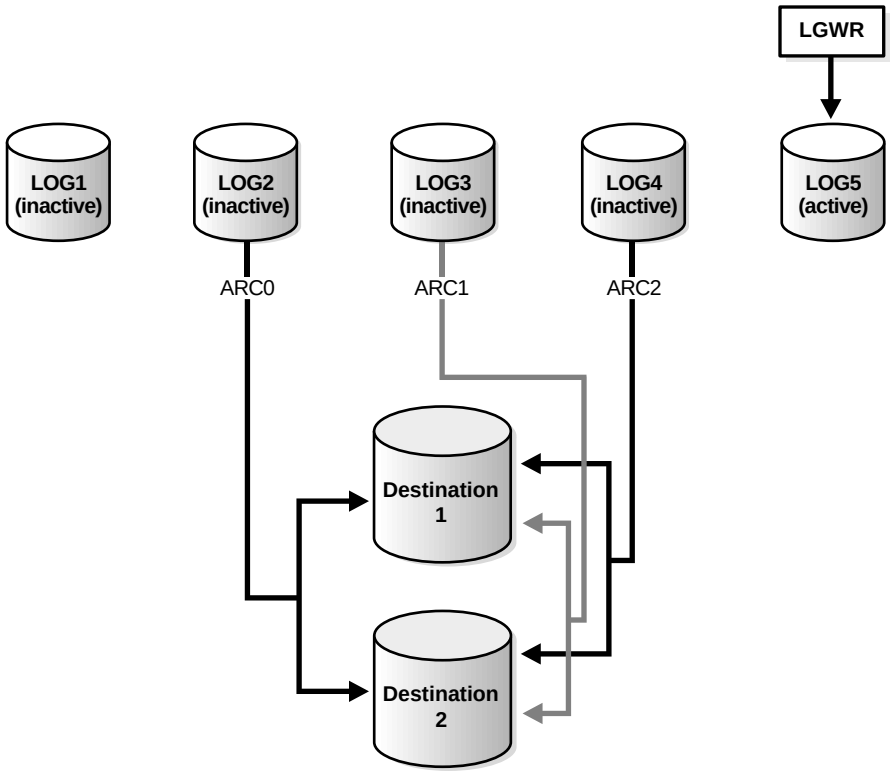
Creating multiple processes is especially useful when you:

- 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. 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 8–2 illustrates, each instance of ARC*n* assumes responsibility for a single log file and archives it to all of the defined destinations.

Figure 8–2 Using Multiple ARCn Processes



See Also: *Oracle9i Database Performance Guide and Reference* for more information about tuning the archiving process

Controlling Trace Output Generated by the Archivelog Process

As discussed in "Trace Files and the Alert File" on page 5-15, 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 for each archivelog destination.
4	Track archival operational phase.
8	Track archivelog destination activity.
16	Track detailed archivelog destination activity.
32	Track archivelog destination parameter modifications.
64	Track ARC*n* 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 still generate the appropriate alert and trace entries.

You can change the value of this parameter dynamically using the `ALTER SYSTEM` statement. For example:

```
ALTER SYSTEM SET LOG_ARCHIVE_TRACE=12
```

Changes initiated in this manner will take effect at the start of the next archiving operation.

> **See Also:** *Oracle9i Data Guard Concepts and Administration* for information about using this parameter with a standby database

Viewing Information About the Archived Redo Log

You can display information about the archived redo logs using the following:

- Fixed Views
- The ARCHIVE LOG LIST Command

Fixed Views

There are several dynamic performance views that contain useful information about archived redo logs.

Dynamic Performance 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:** *Oracle9i Database Reference*. for detailed descriptions of data dictionary views

The ARCHIVE LOG LIST Command

The SQL*Plus command `ARCHIVE LOG LIST` can be used to show archiving information for the connected instance. For example:

```
SQL> ARCHIVE LOG LIST

Database log mode              Archive Mode
Automatic archival             Enabled
Archive destination            D:\ORANT\oradata\IDDB2\archive
Oldest online log sequence     11160
Next log sequence to archive   11163
Current log sequence           11163
```

This display tells you all the necessary information regarding the archived redo log settings for the current instance:

- The database is currently operating in `ARCHIVELOG` mode.
- Automatic archiving is enabled.
- The archived redo log's destination is `D:\ORANT\oradata\IDDB2\archive.`
- The oldest filled online redo log group has a sequence number of 11160.
- The next filled online redo log group to archive has a sequence number of 11163.
- The current online redo log file has a sequence number of 11163.

> **See Also:** *SQL*Plus User's Guide and Reference* for more information on the `ARCHIVE LOG LIST` command

9

Using LogMiner to Analyze Redo Log Files

The Oracle LogMiner utility enables you to query redo log files through a SQL interface. Redo log files contain information about the history of activity on a database.

This chapter discusses the following topics:

- Understanding the Value of Analyzing Redo Log Files
- Things to Know Before You Begin
- Using LogMiner
- Example Uses of LogMiner

See Also:

- *Oracle9i Database Reference* for detailed information about initialization parameters and LogMiner views mentioned in this chapter
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about LogMiner PL/SQL packages

This chapter describes LogMiner functionality as it is used from the command line. You also have the option of accessing LogMiner functionality through the Oracle LogMiner Viewer graphical user interface (GUI). The LogMiner Viewer is a part of Oracle Enterprise Manager.

Understanding the Value of Analyzing Redo Log Files

Oracle redo log files contain every change made to user data and to the data dictionary in a database. Therefore, redo log files are the only source that contains all the necessary information to perform recovery operations. Because redo log data is often kept in archived files, the data is already available. There should be no additional operations needed to obtain the data that LogMiner uses.

The following are some of the potential uses for data contained in redo log files:

- Pinpointing when a logical corruption to a database, such as errors made at the application level, may have begun. An example of an error made at the application level could be if a user mistakenly updated a database to give all employees 100 percent salary increases rather than 10 percent increases. It is important to know exactly when corruption began so that you know when to initiate time-based or change-based recovery. This enables you to restore the database to the state it was in just before corruption.
- Determining what actions you would have to take to perform fine-grained recovery at the transaction level. If you fully understand and take into account existing dependencies, it may be possible to perform a table-based Undo operation to roll back a set of changes. Normally you would have to restore the table to its previous state and then apply an archived log file to roll it forward.
- Performance tuning and capacity planning.
- Performing post-auditing.

Things to Know Before You Begin

Before you begin using LogMiner, it is important to understand how LogMiner works with redo log files and dictionary files. This will help you in getting accurate results and in planning the use of your system resources. The following concepts are discussed in this section:

- Redo Log Files
- Dictionary Options
- Tracking of DDL Statements
- Storage Management
- Extracting Data Values from Redo Log Files
- LogMiner Restrictions

- LogMiner Views

After you read this section, see "Using LogMiner" on page 9-8 for the specific steps involved in using LogMiner.

Redo Log Files

When you run LogMiner, you specify the names of redo log files that you want to analyze. LogMiner retrieves information from those redo log files and returns it through the V$LOGMNR_CONTENTS view.

You can then use SQL to query the V$LOGMNR_CONTENTS view, as you would any other view. Each select operation that you perform against the V$LOGMNR_CONTENTS view causes the redo log files to be read sequentially.

Keep the following things in mind about redo log files:

- The redo log files must be from a release 8.0 or later Oracle database. However, some of the LogMiner release 9.0.1 features only work with redo log files produced on an Oracle9*i* or later database. See "Understanding the Value of Analyzing Redo Log Files" on page 9-2 for details.
- The redo log files must use the same database character set as the database on which LogMiner is running.
- In general, the analysis of redo log files requires a dictionary that was generated from the same database that generated the redo log files.
- If you are using a dictionary in flat file format or in the redo log files, then the redo log files you want to analyze can be from the database on which LogMiner is running or from other databases. If you are using the online catalog as the LogMiner dictionary, you can only analyze redo log files from the database on which LogMiner is running.
- LogMiner must be running on the same hardware platform that generated the redo log files being analyzed. However, it does not have to be on the same system.

It is important to specify the correct redo log files when running LogMiner. If you omit redo log files that contain some of the data you need, you will get inaccurate results when you query V$LOGMNR_CONTENTS.

To determine which redo log files are being analyzed, you can look at the V$LOGMNR_LOGS view, which contains one row for each log file.

See "Specifying Redo Log Files for Analysis" on page 9-12 for more information.

Dictionary Options

To fully translate the contents of redo log files, LogMiner requires access to a database dictionary.

LogMiner uses the dictionary to translate internal object identifiers and datatypes to object names and external data formats. Without a dictionary, LogMiner returns internal object IDs and presents data as hex bytes.

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'));"
```

LogMiner gives you three choices for your source dictionary: extracting dictionary data to a flat file, extracting dictionary data to redo log files, or using the online catalog (the dictionary currently in use for the database).

Extracting the Dictionary to a Flat File or to Redo Log Files

A LogMiner dictionary file contains information that identifies the database it was created from and the time it was created. This information is used to validate the dictionary against the selected redo log files.

The dictionary file must have the same database character set and be created from the same database as the log files being analyzed. In general, the analysis of redo log files requires a dictionary that was generated from the same database that generated the redo log files.

The `DBMS_LOGMNR_D.BUILD` procedure allows you to extract the dictionary to a flat file or to the redo log files.

Extracting the Dictionary to a Flat File While the data dictionary is being extracted to a flat file, DDL statements can be issued by other users. Therefore, there is a possibility that the extracted file may not contain a consistent snapshot of the data dictionary.

When the dictionary is in a flat file, fewer system resources are used than when it is contained in the redo log files.

It is recommended that you regularly back up the dictionary extracts to ensure correct analysis of older redo log files.

Extracting the Dictionary to the Redo Log Files While the dictionary is being extracted to the redo log stream, no DDL statements can be executed. Therefore, the dictionary snapshot is guaranteed to be consistent.

The process of extracting the dictionary to the redo log files does consume database resources, but if you limit the extraction to off-peak hours, this should not be a problem and it is faster than extracting to a flat file. Depending on the size of the dictionary, it may be contained in multiple redo log files.

It is recommended that you periodically back up the redo log files so that the information is saved and available at a later date. Ideally, this will not involve any extra steps because if your database is being properly managed, there should already be a process in place for backing up and restoring archived redo log files. Again, because of the time required, it is good practice to do this during off-peak hours.

See "Extracting a Dictionary" on page 9-9 for more information about extracting a dictionary using one of these options.

Using the Online Catalog

To direct LogMiner to use the dictionary currently in use for the database, specify the online catalog as your dictionary source when you start LogMiner**.**

The online catalog contains the latest information about the database. However, the online catalog may not be correct in relation to the redo log files you are analyzing if it has changed significantly since the redo log files were generated.

See "Starting LogMiner" on page 9-13 for information about specifying the online catalog by using the `DICT_FROM_ONLINE_CATALOG` option.

Tracking of DDL Statements

LogMiner automatically builds its own internal dictionary from the source dictionary that you specify at startup (either a flat file dictionary, a dictionary in the redo logs, or an online catalog).

If your source dictionary is a flat file dictionary or a dictionary in the redo log files, you can use the `DDL_DICT_TRACKING` option to direct LogMiner to track data definition language (DDL) statements. With this option set, LogMiner applies any DDL statements seen in the redo logs to its internal dictionary. The updated information is then returned in the `SQL_REDO` column of the `V$LOGMNR_CONTENTS` view.

The ability to track DDL statements helps you monitor schema evolution because changes in the logical structure of a table (because of DDL operations such as adding or dropping of columns) can be handled. In addition, data manipulation language (DML) operations performed on new tables created after the dictionary was extracted are also shown.

> **Note:** It is important to understand that the LogMiner internal dictionary is not the same as the LogMiner dictionary contained in a flat file or in redo log files. LogMiner does update its internal dictionary, but it does *not* update the dictionary that is contained in a flat file or in redo log files.

The `DDL_DICT_TRACKING` option is best used when a single pass is to be made through the `V$LOGMNR_CONTENTS` view. If multiple passes are to be made, keep the following considerations in mind:

- If you also set the `NO_DICT_RESET_ONSELECT` option, the dictionary will not refresh itself after each select operation. Therefore, you may get incorrect information for objects that have been modified in the redo log files.
- If you do *not* set the `NO_DICT_RESET_ONSELECT` option, it may take a while for the dictionary to refresh itself after each select operation performed against `V$LOGMNR_CONTENTS`.

For more information about these options, see Starting LogMiner on page 9-13.

Storage Management

In Oracle9*i*, LogMiner may use the database to store backup data when the data dictionary snapshot is read from the redo log files or when the data dictionary is read from a flat file and `DDL_DICT_TRACKING` is specified.

The data dictionary snapshot is read from the redo log files into tables in the `SYSTEM` schema. Therefore, Oracle recommends that you extend the `SYSTEM` tablespace by adding new data files to it (using the `ALTER TABLESPACE ADD DATAFILE` statement).

Extracting Data Values from Redo Log Files

LogMiner enables you to make queries based on actual data values. For instance, you could issue a query to select all updates to the table `scott.emp` or all deletions performed by user `scott`. You could also perform a query to show all updates to

scott.emp that increased sal more than a certain amount. Data such as this can be used to analyze system behavior and to perform auditing tasks.

LogMiner data extraction from redo log files is performed using the mine functions, DBMS_LOGMNR.MINE_VALUE and COLUMN_PRESENT. These functions are part of the DBMS_LOGMNR package. See *Oracle9i Supplied PL/SQL Packages and Types Reference* for details.

LogMiner Restrictions

The following restrictions apply:

- The following are not supported:
  - Data types LONG and LOB
  - Simple and nested abstract data types (ADTs)
  - Collections (nested tables and VARRAYs)
  - Object Refs
  - Index Organized Tables (IOTs)

  If LogMiner sees any of these, it will not be able to generate data for the SQL_REDO and SQL_UNDO columns of the V$LOGMNR_CONTENTS view. However, all of the other data in V$LOGMNR_CONTENTS will still be valid.
- For LogMiner to support direct path insert operations, supplemental logging must be enabled and ARCHIVELOG mode be turned on.
- LogMiner cannot be run when the Oracle database is operating in a shared server environment. (However, you can analyze redo log files that were created in a shared server environment.)

LogMiner Views

LogMiner provides the following views. You can use SQL to query them as you would any other view.

- V$LOGMNR_CONTENTS

  Shows changes made to user and table information.
- V$LOGMNR_DICTIONARY

Shows information about the LogMiner dictionary file, provided the dictionary was created using the STORE_IN_FLAT_FILE option. The information shown includes the database name and status information.

- V$LOGMNR_LOGS

  Shows information about specified log files. There is one row for each log file.

- V$LOGMNR_PARAMS

  Shows information about optional LogMiner parameters, including starting and ending system change numbers (SCNs) and starting and ending times.

> **See Also:** *Oracle9i Database Reference* for detailed information about the contents of these views

Using LogMiner

To run LogMiner, you use two PL/SQL packages:

- DBMS_LOGMNR

  Contains the procedures necessary to initialize and run LogMiner. These procedures include interfaces to specify log filenames, filter criteria, and LogMiner session characteristics.

- DBMS_LOGMNR_D

  Queries the dictionary tables of the current database and creates a LogMiner dictionary file. See "Dictionary Options" on page 9-4 for more information about dictionary files.

The LogMiner packages are owned by the SYS schema. Therefore, if you are not connected as user SYS, you must include SYS in your call. For example:

```
EXECUTE SYS.DBMS_LOGMNR.END_LOGMNR
```

> **See Also:**
>
> - *Oracle9i Supplied PL/SQL Packages and Types Reference* for details about syntax and parameters for these LogMiner packages
> - *Oracle9i Application Developer's Guide - Fundamentals* for information about executing PL/SQL procedures

The rest of this section describes the steps in a typical LogMiner session. Each step is described in its own subsection.

1. Extracting a Dictionary
2. Specifying Redo Log Files for Analysis
3. Starting LogMiner
4. Analyzing Output from V$LOGMNR_CONTENTS
5. Using LogMiner to Perform Object-Level Recovery
6. Ending a LogMiner Session

Extracting a Dictionary

To use LogMiner you must supply it with a dictionary by doing one of the following:

- Extract database dictionary information to a flat file
- Extract database dictionary information to the redo log files
- Specify use of the online catalog by using the `DICT_FROM_ONLINE_CATALOG` option. See "Starting LogMiner" on page 9-13 for information about this, and other, options.

Extracting the Dictionary to a Flat File

To extract database dictionary information to a flat file, use the `DBMS_LOGMNR_D.BUILD` procedure.

`DBMS_LOGMNR_D.BUILD` requires access to a directory where it can place the dictionary file. Because PL/SQL procedures do not normally access user directories, you must specify a directory for use by the `DBMS_LOGMNR_D.BUILD` procedure or the procedure will fail. To specify a directory, set the initialization parameter, `UTL_FILE_DIR`, in the `init.ora` file.

For example, to set `UTL_FILE_DIR` to use `/oracle/database` as the directory where the dictionary file is placed, enter the following in the init.ora file:

```
UTL_FILE_DIR = /oracle/database
```

For the changes to the init.ora file to take effect, you must stop and restart the database.

> **See Also:** *Oracle9i Database Reference* for more information about the init.ora file

To ensure that the DBMS_LOGMNR_D.BUILD procedure completes successfully, be sure to specify the necessary parameters, as shown in the following examples. Also be sure that no DDL operations occur while the dictionary is being built.

The steps for extracting a dictionary to a flat file depend on whether you are creating it for an Oracle9*i* database or an Oracle8 database.

Create a Dictionary Flat File for an Oracle9*i* Database

1. To specify where the dictionary file should be placed, set the UTL_FILE_DIR parameter in the init.ora file.

   For example, to set UTL_FILE_DIR to use /oracle/database as the directory where the dictionary file is placed, enter the following in the init.ora file:

   ```
   UTL_FILE_DIR = /oracle/database
   ```

   Remember that for the changes to the init.ora file to take effect, you must stop and restart the database.

2. If the database is closed, use SQL*Plus to mount and then open the database whose redo log files you want to analyze. For example, entering the STARTUP command mounts and opens the database:

   ```
   SQLPLUS> STARTUP
   ```

3. Execute the PL/SQL procedure DBMS_LOGMNR_D.BUILD. Specify both a filename for the dictionary and a directory path name for the file. This procedure creates the dictionary files. For example, enter the following to create the file dictionary.ora in /oracle/database:

   ```
   SQLPLUS>EXECUTE DBMS_LOGMNR_D.BUILD('dictionary.ora',
   SQLPLUS>'/oracle/database/',
   SQLPLUS>options => DBMS_LOGMNR_D.STORE_IN_FLAT_FILE);
   ```

   You could also specify a filename and location without specifying the STORE_IN_FLAT_FILE option. The result would be the same.

Create a Dictionary Flat File for an Oracle8 Database Although LogMiner only runs on databases of release 8.1 or higher, you can use it to analyze redo log files from release 8.0 databases. However, the LogMiner functionality available when analyzing a log file depends on the log file version. That is, log files for Oracle9*i* have been augmented to take advantage of LogMiner functionality, so log files

created with older releases of Oracle may have limitations on the operations and datatypes supported by LogMiner.

1. Use your operating system's copy 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. If the database is closed, use SQL*Plus to mount and then open the database whose files you want to analyze. For example, enter:

   ```
   SQLPLUS> 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
   ```

   You may need to enter the complete path to the script.

4. To specify where the dictionary file should be placed, set the `UTL_FILE_DIR` parameter in the `init.ora` file.

   For example, to set `UTL_FILE_DIR` to use `/oracle/database` as the directory where the dictionary file is placed, enter the following in the init.ora file:

   ```
   UTL_FILE_DIR = /oracle/database
   ```

   Remember that for the changes to the init.ora file to take effect, you must stop and restart the database.

5. Execute the PL/SQL procedure `DBMS_LOGMNR_D.BUILD`. This procedure creates the dictionary files. Specify both a filename and a directory path name for the dictionary file. For example, enter the following to create file `dictionary.ora` in `/oracle/database`:

   ```
   SQLPLUS>EXECUTE DBMS_LOGMNR_D.BUILD('dictionary.ora',
   SQLPLUS>'/oracle/database/',
   SQLPLUS>options => DBMS_LOGMNR_D.STORE_IN_FLAT_FILE);
   ```

   You could also specify a filename and location without specifying the `STORE_IN_FLAT_FILE` option. The result would be the same.

Extracting a Dictionary to the Redo Log Files

To extract a dictionary to the redo log files, the database must be in ARCHIVELOG mode.

If you try to specify a filename and location when using the STORE_IN_REDO_LOGS option, an error is returned.

```
SQLPLUS>EXECUTE DBMS_LOGMNR_D.BUILD (
SQLPLUS>options => DBMS_LOGMNR_D.STORE_IN_REDO_LOGS);
```

> **See Also:** *Oracle9i Recovery Manager User's Guide* for more information on ARCHIVELOG mode

Specifying Redo Log Files for Analysis

To specify the redo log files that you want to analyze, execute the DBMS_LOGMNR.ADD_LOGFILE procedure, as demonstrated in the following steps. You can add and remove log files in any order.

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 redo log files by specifying the NEW option of 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 redo log files by specifying the ADDFILE option of the DBMS_LOGMNR.ADD_LOGFILE procedure. 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 redo log files by specifying the REMOVEFILE option of the DBMS_LOGMNR.ADD_LOGFILE procedure. 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);
```

Starting LogMiner

After you have create a dictionary file and specify which redo log files to analyze, you can start LogMiner and begin your analysis. Take the following steps:

1. Execute the DBMS_LOGMNR.START_LOGMNR procedure to start LogMiner.

   It is recommended that you specify a dictionary option. If you do not, LogMiner cannot translate internal object identifiers and datatypes to object names and external data formats. Therefore, it would return internal object IDs and present data as hex bytes.

   Note that if you are specifying the name of a flat file dictionary, you must supply a fully qualified filename for the dictionary file. For example, to start LogMiner using /oracle/database/dictionary.ora, issue the following command:

   ```
   EXECUTE DBMS_LOGMNR.START_LOGMNR(
   DICTFILENAME =>'/oracle/database/dictionary.ora');
   ```

   If you are not specifying a flat file dictionary name, then specify either the DICT_FROM_REDO_LOGS or DICT_FROM_ONLINE_CATALOG option.

2. Optionally, set the startTime and endTime parameters to filter data by time. 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'));
   ```

   The timestamps should not be used to infer ordering of redo records. You can infer the order of redo records by using the SCN.

3. Instead of specifying a start time and end time, you can 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);
   ```

The startScn and endScn parameters override the startTime and endTime parameters in situations where all are specified.

If no start or end parameters are specified, the entire log file is read from start to end, for each SELECT statement issued.

4. If desired, you can also use the OPTIONS parameter to set the following session characteristics:

COMMITTED_DATA_ONLY

Only rows belonging to committed transactions are shown in the V$LOGMNR_CONTENTS view. This enables you to filter out rolled back transactions and transactions that are in progress.

If long-running transactions are present in the redo log files being analyzed, use of this option may cause an "Out of Memory" error.

The default is for LogMiner to show rows corresponding to all of the transactions.

SKIP_CORRUPTION

Any corruptions in the redo log files are skipped during select operations from the V$LOGMNR_CONTENTS view. Rows that are retrieved after the corruption are flagged with a "Log File Corruption Encountered" message. Additionally, for every corrupt redo record encountered, an informational row is returned that indicates how many blocks were skipped.

The default is for the select operation to terminate at the first corruption it encounters in the log file.

DDL_DICT_TRACKING

If the dictionary in use is either a flat file or in the redo log files, LogMiner ensures that its internal dictionary is updated if a DDL event is found in the redo log files. This ensures that SQL_REDO and SQL_UNDO information is correct for objects that are modified in the redo log files after the LogMiner internal dictionary was built.

The default is for this option to be disabled.

This option is not valid with the DICT_FROM_ONLINE_CATALOG option.

NO_DICT_RESET_ONSELECT

This option is only valid if the DDL_DICT_TRACKING option is also specified. It prevents LogMiner from reloading its dictionary at the beginning of each select operation on the V$LOGMNR_CONTENTS view. This can be an advantage

because it can be time consuming to refresh the dictionary if a DDL operation has updated the internal LogMiner dictionary. However, you should be aware that if you use this option, you may get incorrect SQL_REDO and SQL_UNDO information for objects that are modified in the redo log files because the dictionary has not been refreshed.

The NO_DICT_RESET_ONSELECT option should not be specified if you want complete reconstructed SQL statements returned from subsequent selects.

The following example shows how LogMiner behaves when the NO_DICT_RESET_ONSELECT and DDL_DICT_TRACKING options are specified.

1. Start LogMiner with the NO_DICT_RESET_ONSELECT and DDL_DICT_TRACKING options specified, as follows:

```
execute DBMS_LOGMNR.START_LOGMNR(OPTIONS =>
DBMS_LOGMNR.DDL_DICT_TRACKING +
DBMS_LOGMNR.NO_DICT_RESET_ONSELECT +
DBMS_LOGMNR.DICT_FROM_REDO_LOGS);
```

2. Issue the following SQL query:

```
SELECT sql_redo FROM SYS.V$LOGMNR_CONTENTS;
```

3. The SQL_REDO that is returned looks as follows:

```
SQL_REDO
--------------------------------------------------------------------------------
create table scott.customer(name varchar2(32), phone_day varchar2(20),
phone_evening varchar2(20))

insert into "SCOTT"."CUSTOMER"("NAME","PHONE_DAY","PHONE_EVENING")
values ('Nadine Gordimer','847-123-1234','415-123-1234')

insert into "SCOTT"."CUSTOMER"("NAME","PHONE_DAY","PHONE_EVENING")
values ('Saul Bellow','847-123-1234','415-123-1234');

commit;

alter table scott.customer drop (phone_evening)

insert into "SCOTT"."CUSTOMER"("NAME","PHONE_DAY") values ('Gabriel
Garcia Marquez','044-1270-123-1234');
commit;
```

The SELECT statement correctly applied the CREATE TABLE and ALTER TABLE statements to LogMiner's internal dictionary and reconstructed valid SQL_REDO statements.

At the end of this select operation, the definition of the table scott.customer contained in the internal dictionary has only two columns because the ALTER TABLE statement dropped the phone_evening column.

4. Issue the same SQL query again that you issued earlier:

```
SELECT sql_redo FROM SYS.V$LOGMNR_CONTENTS;
```

5. The SQL_REDO that is returned looks as follows:

```
SQL_REDO
--------------------------------------------------------------------------------
create table scott.customer(name varchar2(32), phone_day varchar2(20),
phone_evening varchar2(20))
insert into "SCOTT"."CUSTOMER"("COL 1","COL 2","COL 3") values
(HEXTORAW('4e6164696e6520476f7264696d6572'),HEXTORAW('3834372d3132332d313233
34'),

HEXTORAW('3431352d3132332d31323334'));

insert into "SCOTT"."CUSTOMER"("COL 1","COL 2","COL 3") values
(HEXTORAW('5361756c2042656c6c6f77'),HEXTORAW('3834372d3132332d31323334'),

HEXTORAW('3431352d3132332d31323334'));

commit;

alter table scott.customer drop (phone_evening)

insert into "SCOTT"."CUSTOMER"("NAME","PHONE_DAY") values ('Gabriel
Garcia Marquez','044-1270-123-1234');

commit;
```

Because NO_DICT_RESET_ONSELECT was specified when LogMiner was started, LogMiner does not reload its dictionary when this second SELECT statement is executed. Therefore, the updated dictionary is not used to translate the redo stream and this SELECT operation cannot fully translate the first two INSERT statements. Instead, is shows the SQL_REDO for them as hex bytes. However, the third INSERT statement can be fully translated

because it corresponds to the definition of scott.customer table in the LogMiner dictionary.

Thus, the NO_DICT_RESET_ONSELECT option should not be specified if you want the complete reconstructed SQL statements returned from subsequent selects.

DICT_FROM_ONLINE_CATALOG

If set, LogMiner uses the dictionary currently in use for the database. This option is not valid with the DDL_DICT_TRACKING option.

DICT_FROM_REDO_LOGS

If set, LogMiner expects to find a dictionary in the redo log files that you specified with the DBMS_LOGMNR.ADD_LOGFILE procedure.

To see which redo log files contain a dictionary, look at the V$LOGMNR_LOGS view.

If you want to analyze redo log files for a specific period, you must use a dictionary that is consistent back to the beginning of that period. It is important to realize that if you have performed any DDL operations such as dropping columns or tables, the dictionary may not be synchronized with data in redo log files that were created before those DDL operations.

Analyzing Output from V$LOGMNR_CONTENTS

LogMiner output is contained in the V$LOGMNR_CONTENTS view. After LogMiner is started, you can issue SQL statements at the command line to query the data contained in V$LOGMNR_CONTENTS.

When a SQL select operation is executed against the V$LOGMNR_CONTENTS view, the redo log files are read sequentially. Translated records from the redo log files are returned as rows in the V$LOGMNR_CONTENTS view. This continues until either the filter criteria specified at startup (endTime or endScn) are met or the end of the log file is reached.

LogMiner returns all of the rows in SCN order unless you have used the COMMITTED_DATA_ONLY option to specify that only committed transactions should be retrieved.

SCN order is the order normally applied in media recovery.

The following sample query returns 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.
```

Using LogMiner to Perform Object-Level Recovery

LogMiner processes redo log files, translating their contents into SQL statements that represent the logical operations performed on 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).

Provided you fully understand and take into account existing dependencies, you may be able to apply the SQL_UNDO statements to roll back the original changes to the database.

Ending a LogMiner Session

To properly end a LogMiner session, use the DBMS_LOGMNR.END_LOGMNR procedure, as follows:

```
EXECUTE DBMS_LOGMNR.END_LOGMNR;
```

This procedure closes all of the log files and allows all of the database and system resources allocated by LogMiner to be released.

If this procedure is not executed, LogMiner retains all of its allocated resources until the end of the Oracle session in which it was invoked. It is particularly important to use this procedure to end LogMiner if either the DDL_DICT_TRACKING option or the DICT_FROM_REDO_LOGS option was used.

Example Uses of LogMiner

This section provides the following example uses of LogMiner.

- Example: Tracking Changes Made By a Specific User
- Example: Calculating Table Access Statistics

Example: Tracking Changes Made By a Specific User

In this example, you are interested in seeing all of the changes to the database in a specific time range by one of your users: `joedevo`. You perform this operation in the following steps:

- Step 1: Creating the Dictionary File
- Step 2: Adding Redo Log Files and Limiting the Search Range
- Step 3: Starting LogMiner and Analyzing the Data

Step 1: Creating the Dictionary File To use LogMiner to analyze `joedevo`'s data, you must create a dictionary file before starting LogMiner. Take the following steps:

1. In the `init.ora` file, set the initialization parameter `UTL_FILE_DIR` to `/user/local/dbs`:

   ```
   UTL_FILE_DIR = /user/local/dbs
   ```

2. Start SQL*Plus and then connect to the database:

   ```
   CONNECT SYSTEM/password
   ```

3. Open the database to create the dictionary file:

   ```
   STARTUP
   ```

4. Name the dictionary orcldict.ora and place it in the directory `/user/local/dbs`:

   ```
   EXECUTE DBMS_LOGMNR_D.BUILD(
   DICTIONARY_FILENAME => 'orcldict.ora',
   DICTIONARY_LOCATION => '/usr/local/dbs');
   ```

5. The dictionary was created and can be used later. You can shut down the database:

   ```
   SHUTDOWN;
   ```

Step 2: Adding Redo Log Files and Limiting the Search Range Now that the dictionary is created, you decide to view the changes that happened at a specific time. Take the following steps:

1. Start SQL*Plus, connect as SYSTEM, then start the instance:

```
CONNECT SYSTEM/password
STARTUP NOMOUNT
```

2. Supply the list of logfiles to be analyzed. The Options flag is set to indicate this is a new list:

```
EXECUTE DBMS_LOGMNR.ADD_LOGFILE(
LOGFILENAME => 'log1orc1.ora',
OPTIONS => DBMS_LOGMNR.NEW);
```

3. Add a file to the existing list. The OPTIONS flag is set to indicate that you are adding a file to the existing list:

```
EXECUTE DBMS_LOGMNR.ADD_LOGFILE(
LOGFILENAME => 'log2orc1.ora',
OPTIONS => DBMS_LOGMNR.ADDFILE);
```

Step 3: Starting LogMiner and Analyzing the Data At this point, the V$LOGMNR_CONTENTS view is available for queries. You decide to find all of the changes made by user joedevo to the salary table. You discover that 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. Take the following steps:

1. Start LogMiner and 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'));
```

2. Query the V$LOGMNR_CONTENTS view to see the results of your search:

```
SELECT sql_redo, sql_undo FROM V$LOGMNR_CONTENTS
WHERE USERNAME = 'joedevo' AND TABLENAME = 'salary';
```

3. For both the SQL_REDO and SQL_UNDO columns, two rows are returned (the format of the data display will be different on your screen):

```
SQL_REDO                                  SQL_UNDO
--------                                  --------
```

```
delete * from SALARY
where EMPNO = 12345
and ROWID = 'AAABOOAABAAEPCABA';

insert into SALARY(NAME, EMPNO, SAL)
values('JOEDEVO',12345,2500)

2 rows selected
```

```
insert into SALARY(NAME,EMPNO, SAL)
values ('JOEDEVO', 12345,500)


delete * from SALARY
where EMPNO = 12345
and ROWID = 'AAABOOAABAAEPCABA';
```

Example: Calculating Table Access Statistics

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. Assume that you already created the dictionary and added the redo log files you want to search. Take the following steps:

1. Start LogMiner and specify a range of times:

   ```
   EXECUTE DBMS_LOGMNR.START_LOGMNR(
   STARTTIME => TO_DATE('07-Aug-1998 08:30:00', 'DD-MON-YYYY HH:MI:SS')
   ENDTIME => TO_DATE('15-Aug-1998 08:45:00', 'DD-MON-YYYY HH:MI:SS'),
   DICTFILENAME => '/usr/local/dict.ora');
   ```

2. Query the V$LOGMNR_CONTENTS view to determine which tables were modified in the time range you specified, as shown in the following example. (This query filters out system tables that traditionally have a $ in their name.)

   ```
   SELECT seg_owner, seg_name, count(*) AS Hits FROM
   V$LOGMNR_CONTENTS WHERE seg_name NOT LIKE '%$' GROUP BY
   seg_owner, seg_name;
   ```

3. The following data is displayed (properly formatted):

   ```
   SEG_OWNER          SEG_NAME          Hits
   ---------          --------          ----
   CUST               ACCOUNT            384
   SCOTT              EMP                 12
   SYS                DONOR               12
   UNIV               DONOR              234
   UNIV               EXECDONOR          325
   UNIV               MEGADONOR           32
   ```

10

Managing Job Queues

This chapter describes how to use job queues to schedule the periodic execution of user jobs, and contains the following topics:

Enabling Processes Used for Executing Jobs

You can schedule routines (jobs) to be run periodically using the job queue. To schedule a job you submit it to the job queue, using the Oracle supplied DBMS_JOBS package, and specify the frequency at which the job is to be run. Additional functionality enables you to alter, disable, or delete a job that you previously submitted.

Job queue (J*nnn)* processes execute jobs in the job queue. For each instance, these job queue processes are dynamically spawned by a coordinator job queue (CJQ0) background process. The coordinator periodically selects jobs that are ready to run from the jobs shown in the DBA_JOBS view. It orders them by time, and then spawns J*nnn* processes to run the selected jobs. Each J*nnn* process executes one of the selected jobs.

The JOB_QUEUE_PROCESSES initialization parameter controls whether a coordinator job queue process is started by an instance. If this parameter is set to 0, no coordinator job queue process is started at database startup, and consequently no job queue jobs are executed. The JOB_QUEUE_PROCESSES initialization parameter also specifies the maximum number of J*nnn* processes that can concurrently run on an instance. The maximum number of processes that can be specified is 1000.

The following initialization parameter setting causes the coordinator job queue process to start at database startup, and allows the spawning of a maximum of 60 concurrent J*nnn* processes.

```
JOB_QUEUE_PROCESSES = 60
```

In any given period that the coordinator job queue process scans the jobs shown in the DBA_JOBS view, it spawns at most only the number of J*nnn* processes required to execute the jobs it has selected. While the above example allows for 60 concurrent J*nnn* processes, if only 20 jobs are selected for execution, then the coordinator spawns, or reuses, only the number of J*nnn* processes necessary to execute the 20 jobs (at least, 20). Any idle existing J*nnn* processes are considered available for reuse.

When a J*nnn* process finishes execution of a job, it polls for another job to execute. If there are no jobs selected for execution, it enters an idle state, but wakes up periodically to poll again. If, after a predetermined number of tries, it still finds no jobs to execute, it terminates.

The JOB_QUEUE_PROCESSES initialization parameter is dynamic and it can be modified by an ALTER SYSTEM statement. For example, the following statement sets the maximum number of concurrent J*nnn* processes allowed to 20.

```
ALTER SYSTEM SET JOB_QUEUE_PROCESSES = 20;
```

If the new value is lower than the previous setting and less than the number of currently executing J*nnn* processes, the excess processes are allowed to complete before they are terminated.

J*nnn* processes will not execute jobs if the instance is running in restricted mode.

> **See also:** "Restricting Access to an Open Database" on page 4-10 for information about enabling and disabling restricted mode

Managing Job Queues

This section describes the various aspects of managing job queues and contains 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 are procedures of the `DBMS_JOB` package. They are described 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 10-4.

Procedure	Description
REMOVE	Removes a specified job from the job queue. See "Removing a Job from the Job Queue" on page 10-10.
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 10-10.
WHAT	Alters the job description for a specified job. See "Altering a Job" on page 10-10.
NEXT_DATE	Alters the next execution time for a specified job. See "Altering a Job" on page 10-10.
INTERVAL	Alters the interval between executions for a specified job. See "Altering a Job" on page 10-10.
BROKEN	Sets or resets the job broken flag. If a job is marked as broken, Oracle does not attempt to execute it. See "Broken Jobs" on page 10-12.
RUN	Forces a specified job to run. See "Forcing a Job to Execute" on page 10-13.

See Also:

- *Oracle9i Supplied PL/SQL Packages and Types Reference* for syntax information for the DBMS_JOB package, and for information about other options available when using the DBMS_JOB package in an Oracle Real Application Clusters environment

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 are creating. You must use this job number whenever you want to alter or remove the job. See "Job Number" on page 10-7.
WHAT	This is the PL/SQL code you want to have executed. See "Job Definition" on page 10-7.

Parameter	Description
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 10-8.
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.

For example, consider the following statements that submits 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 or submitting user if ALTER SESSION SET CURRENT_SCHEMA statement has been issued)
- MAC privileges (if using Oracle Label Security)

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 all of these environment characteristics every time a job is executed. NLS_LANGUAGE and NLS_TERRITORY parameters determine the 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:

- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the DBMS_SQL package
- *Oracle9i SQL Reference* for information about use of the ALTER SESSION statement to alter a job's environment

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 Owner

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 Number

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 Definition

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.

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);'`

> **Note:** Running a job from a job is not supported. You will receive an error message if you attempt to do so. For example, the following statements produces the "`ORA-32317 cannot run a job from another job`" error message:
>
> ```
> declare
>   jobno number;
> begin
>   dbms_job.submit(jobno, 'dbms_job.run(23587);');
>   dbms_job.run(jobno);
> end;
> ```

Job Execution Interval

If a job should be executed periodically at a set interval, use a date expression similar to 'SYSDATE + 7' in the INTERVAL parameter. 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.

The INTERVAL date function is evaluated immediately before a job is executed. When the job completes successfully, the date calculated from INTERVAL becomes the new NEXT_DATE. 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 the INTERVAL date function evaluates to NULL and the job completes successfully, the job is deleted from the queue.

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'')'.

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

Jnnn processes execute jobs. To execute a job, the process creates a session to run the job. When a *Jnnn* process runs a job, the job is run in the same environment in which it was submitted and with the *owner's* default privileges. The owner must be explicitly granted the necessary object privileges for all objects referenced within the job definition.

When you force a job to run using the procedure `DBMS_JOB.RUN`, the job is run by your user process and with *your* default privileges only. Privileges granted to you through roles are unavailable. You must be explicitly granted the necessary object privileges for all objects referenced within the job definition.

Job Queue Locks

Oracle uses job queue locks to ensure that a job is executed in only 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` column is always 0 for JQ locks. The `ID2` column 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 Also:

- "Viewing Job Queue Information" on page 10-14 for more information about views
- *Oracle9i Database Reference* for more information about the locking views
- *Oracle9i Database Concepts* for more information about locking

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:

- 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. If the job fails 16 times, Oracle automatically marks the job as broken and no longer tries to execute it. However, between attempts, you have the opportunity to correct the problem that is preventing the job from running. This will not disturb the retry cycle, and Oracle will eventually attempt to run the job again.

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 altered to execute 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 DBMS_JOB.CHANGE, the current value remains unchanged.

> **Note:** When you change a job's definition using the WHAT parameter in the procedure DBMS_JOB.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 the procedure DBMS_JOB.WHAT, Oracle records your current environment. This becomes the new environment for the job.

NEXT_DATE

You can alter the next execution time for 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 call DBMS_JOB.BROKEN for a job that 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 to zero.

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 execute 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 set to 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 (using V$SESSION or V$LOCK, as shown earlier), you can disconnect the session using the SQL statement

ALTER SYSTEM. For examples of viewing information about jobs and sessions, see the next section, "Viewing Job Queue Information".

See Also:

- *Oracle9i Database Reference* for more information on V$SESSION
- "Terminating Sessions" on page 10-2

Viewing Job Queue Information

You can view information about jobs in the job queue using the data dictionary views listed below:

View	Description
DBA_JOBS ALL_JOBS USER_JOBS	DBA view describes all the jobs in the database. ALL view describes all jobs that are accessible to the current user. USER view describes all jobs owned by the current 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.

Displaying Information About a Job

The following query creates a listing of the job number, next execution time, failure count, 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-JUN-01  00:00:00         4  N
  14144  24-OCT-01  16:35:35         0  N
  41762  01-JUN-01  00:00:00        16  Y
3 rows selected.
```

Displaying Information About Running Jobs

You can also display information about only the jobs currently running. The following 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: *Oracle9i Database Reference* for more information on data dictionary views

11

Managing Tablespaces

This chapter describes the various aspects of tablespace management, and contains the following topics:

- Guidelines for Managing Tablespaces
- Creating Tablespaces
- Managing Tablespace Allocation
- Altering Tablespace Availability
- Using Read-Only Tablespaces
- Dropping Tablespaces
- Troubleshooting Tablespace Problems with DBMS_SPACE_ADMIN
- Transporting Tablespaces Between Databases
- Viewing Tablespace Information

> **See Also:** Chapter 3, "Using Oracle-Managed Files" for information about creating datafiles and tempfiles that are both created and managed by the Oracle database server

Guidelines for Managing Tablespaces

Before working with tablespaces of an Oracle database, familiarize yourself with the guidelines provided in the following sections:

- Use Multiple Tablespaces
- Specify Tablespace Default Storage Parameters
- Assign Tablespace Quotas to Users

> **See Also:** *Oracle9i Database Concepts* for a complete discussion of database structure, space management, tablespaces, and datafiles

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. This enables 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 need for your database design.

Specify Tablespace Default Storage Parameters

When you create a new dictionary-managed 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.

See Also: "Managing Tablespace Allocation" on page 11-14

Assign Tablespace Quotas to Users

Grant to users who will be creating tables, clusters, materialized views, indexes, and other objects the privilege to create the object and a **quota** (space allowance or limit) in the tablespace intended to hold the object'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.

See Also: "Assigning Tablespace Quotas" on page 24-18

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.

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.

You can create tablespaces of different block sizes than the standard database block size specified by the DB_BLOCK_SIZE initialization parameter. However, your buffer cache in SGA memory must be configured for the nonstandard block sizes.

To create a new tablespace, use the SQL statement CREATE TABLESPACE or CREATE TEMPORARY TABLESPACE. You must have the CREATE TABLESPACE system privilege to create a tablespace. Later, you can use the ALTER TABLESPACE or ALTER DATABASE statements to alter the tablespace. You must have the ALTER TABLESPACE or ALTER DATABASE system privilege, correspondingly.

Prior to Oracle8*i*, all tablespaces were created as **dictionary-managed**. Dictionary-managed tablespaces rely on data dictionary tables to track space utilization. Beginning with Oracle8*i*, you were able to create **locally managed** tablespaces, which use bitmaps (instead of data dictionary tables) to track used and free space. Because of the better performance and greater ease of management of locally managed tablespaces, beginning in Oralcle9*i* the default for non-SYSTEM permanent tablespaces is locally managed whenever the type of extent management is not explicitly specified.

You can also create a special type of tablespace called an undo tablespace. This tablespace is specifically designed to contain undo records. These are records generated by Oracle that are used to roll back, or undo, changes to the database for recovery, read consistency, or as requested by a ROLLBACK statement. Creating and managing undo tablespaces is the subject of Chapter 13, "Managing Undo Space".

Permanent and temporary tablespaces are discussed in the following sections:

- Locally Managed Tablespaces
- Dictionary-Managed Tablespaces

- Temporary Tablespaces

See Also:

- Chapter 2, "Creating an Oracle Database" and your Oracle installation documentation for your operating system for information about tablespaces that are created at installation
- *Oracle9i SQL Reference* for more information about the syntax and use of the `CREATE TABLESPACE`, `CREATE TEMPORARY TABLESPACE`, `ALTER TABLESPACE`, and `ALTER DATABASE` statements.
- "Specifying Database Block Sizes" on page 2-30 for information about initialization parameters necessary to create tablespaces with nonstandard block sizes

Locally Managed Tablespaces

Locally managed tablespaces track all extent information in the tablespace itself, using bitmaps, resulting in the following benefits:

- Improved concurrency and speed of space operations, because 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, because locally managed temporary tablespaces (used, for example, for sorts) are locally managed and thus do not generate any undo 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 provides maintenance procedures for locally managed tablespaces.

See Also: "Troubleshooting Tablespace Problems with DBMS_SPACE_ADMIN" on page 11-28

Creating a Locally Managed Tablespace

To create a locally managed tablespace, you specify LOCAL in the EXTENT MANAGEMENT clause of the CREATE TABLESPACE statement. Optionally, you can omit the EXTENT MANAGEMENT clause; locally managed is the default. You then have two options. You can have Oracle manage extents for you automatically with the AUTOALLOCATE option (the default), or you can specify that the tablespace is managed with uniform extents of a specific size (UNIFORM SIZE).

Note: When you do not explicitly specify the type of extent management for a permanent non-SYSTEM tablespace that you are creating, the default is locally managed. The following rules apply:

- If a default storage clause is specified where INITIAL = NEXT and PCTINCREASE = 0, then Oracle creates a uniform locally managed tablespace with uniform extent size = INITIAL.
- If the default storage clause is not specified, or if it is specified with PCTINCREASE not equal to 0 and / or INITIAL not equal to NEXT, then Oracle creates a locally managed tablespace with extents managed automatically (AUTOALLOCATE)
- Extraneous storage clauses (for example, MINEXTENTS and MAXEXTENTS) are ignored.
- The SYSTEM tablespace is always dictionary managed.

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 drawback.

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, if the tablespace block size is 2K, is equivalent to 64 Oracle blocks) is represented by a bit in the extent bitmap for this file.

```
CREATE TABLESPACE lmtbsb DATAFILE '/u02/oracle/data/lmtbsb01.dbf' SIZE 50M
    EXTENT MANAGEMENT LOCAL UNIFORM SIZE 128K;
```

> **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.

Specifying Segment Space Management in Locally Managed Tablespaces

When you create a locally managed tablespace using the CREATE TABLESPACE statement, the SEGMENT SPACE MANAGEMENT clause allows you to specify how free and used space within a segment is to be managed. Your choices are:

- MANUAL

  Specifying this keyword tells Oracle that you want to use free lists for managing free space within segments. Free lists are lists of data blocks that have space available for inserting rows. MANUAL is the default.

- AUTO

  This keyword tells Oracle that you want to use bitmaps to manage the free space within segments. A bitmap, in this case, is a map that describes the status of each data block within a segment with respect to the amount of space in the block available for inserting rows. As more or less space becomes available in a data block, its new state is reflected in the bitmap. Bitmaps allow Oracle to manage free space more automatically, and thus, this form of space management is called automatic segment-space management.

Free lists have been the traditional method of managing free space within segments. Bitmaps, however, provide a simpler and more efficient way of managing segment space. They provide better space utilization and completely eliminate any need to

specify and tune the PCTUSED, FREELISTS, and FREELISTS GROUPS attributes for segments created in the tablespace. If such attributes should be specified, they are ignored.

The following statement creates tablespace lmtbsb with automatic segment-space management:

```
CREATE TABLESPACE lmtbsb DATAFILE '/u02/oracle/data/lmtbsb01.dbf' SIZE 50M
    EXTENT MANAGEMENT LOCAL
    SEGMENT SPACE MANAGEMENT AUTO;
```

Your specification at tablespace creation time of your method for managing available space in segments, applies to all segments subsequently created in the tablespace. Also, your choice of method cannot be subsequently altered. Only permanent, locally managed tablespaces can specify automatic segment-space management.

Note: For LOBs, you cannot specify automatic segment-space management.

Altering a Locally Managed Tablespace

You cannot alter a locally managed tablespace to a locally managed temporary tablespace, nor can you changed its method of segment space management. Coalescing free extents is unnecessary for locally managed tablespaces.

Some reasons for using the ALTER TABLESPACE statement for locally managed tablespaces include:

- Adding a datafile. For example:

  ```
  ALTER TABLESPACE lmtbsb
     ADD DATAFILE '/u02/oracle/data/lmtbsb02.dbf' SIZE 1M;
  ```

- Altering a tablespace's availability (ONLINE / OFFLINE). See "Altering Tablespace Availability" on page 11-19.
- Making a tablespace read-only or read-write. See "Using Read-Only Tablespaces" on page 11-22.
- Renaming a datafile, or enabling / disabling the autoextension of the size of a datafile in the tablespace. See Chapter 12, "Managing Datafiles".

Dictionary-Managed Tablespaces

Starting with Oracle9*i*, the default for extent management when creating a tablespace is locally managed. However, you can explicitly specify that you want to create a dictionary-managed tablespace. For dictionary-managed tablespaces, 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, the following statement creates the tablespace `tbsa`, with the following characteristics:

- The data of the new tablespace is contained in a single datafile, 50M in size.
- The tablespace is explicitly created as a dictionary-managed tablespace by specifying `EXTENT MANAGEMENT DICTIONARY`.
- The default storage parameters for any segments created in this tablespace are explicitly set.

The following statement creates the tablespace `tbsb`:

```
CREATE TABLESPACE tbsb
    DATAFILE '/u02/oracle/data/tbsa01.dbf' SIZE 50M
    EXTENT MANAGEMENT DICTIONARY
    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.

This next example creates tablespace `tbsb`, but this time a block size that differs from the standard database block size (as specified by the `DB_BLOCK_SIZE` initialization parameter).

```
CREATE TABLESPACE tbsb
    DATAFILE '/u02/oracle/data/tbsb01.dbf' SIZE 50M
```

```
EXTENT MANAGEMENT DICTIONARY
BLOCKSIZE 8K
DEFAULT STORAGE (
    INITIAL 50K
    NEXT 50K
    MINEXTENTS 2
    MAXEXTENTS 50
    PCTINCREASE 0);
```

Note: In order for the BLOCKSIZE clause to succeed, you must have the DB_CACHE_SIZE and at least one DB_*n*K_CACHE_SIZE initialization parameter set, and the integer you specify in this clause must correspond with the setting of one DB_*n*K_CACHE_SIZE parameter setting. Although redundant, specifying a BLOCKSIZE equal to the standard block size, as specified by the DB_BLOCK_SIZE initialization parameter, is allowed.

For information about these parameters, see "Setting Initialization Parameters that Affect the Size of the SGA" on page 2-31.

Altering a Dictionary-Managed Tablespace

One reason for using an ALTER TABLESPACE statement is to add a datafile. The following statement creates a new datafile for the tbsa tablespace:

```
ALTER TABLESPACE tbsa
   ADD DATAFILE '/u02/oracle/data/tbsa02.dbf' SIZE 1M;
```

Other 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 11-16.
- Coalescing free space in a tablespace. See "Coalescing Free Space in Dictionary-Managed Tablespaces" on page 11-16.
- Altering a tablespace's availability (ONLINE/OFFLINE). See "Altering Tablespace Availability" on page 11-19.
- Making a tablespace read-only or read-write. See "Using Read-Only Tablespaces" on page 11-22.

- Adding or renaming a datafile, or enabling / disabling the autoextension of the size of a datafile in the tablespace. See Chapter 12, "Managing Datafiles".

Temporary Tablespaces

To improve the concurrence of multiple sort operations, reduce their overhead, or avoid Oracle space management operations altogether, create **temporary tablespaces**. A temporary tablespace can be shared by multiple users and can be assigned to users with the CREATE USER statement when you create users in the database.

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 using 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.

See Also:

- Chapter 24, "Managing Users and Resources" for information about assigning temporary tablespaces to users
- *Oracle9i Database Reference* for more information about the V$SORT_SEGMENT and V$SORT_USAGE views
- *Oracle9i Database Performance Guide and Reference* for a discussion on tuning sorts

Creating a Locally Managed Temporary Tablespace

Because space management is much simpler and more efficient in locally managed tablespaces, they are ideally suited for temporary tablespaces. Locally managed temporary tablespaces use **tempfiles**, which do not modify data outside of the temporary tablespace or generate any redo for temporary tablespace data. 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.

To create a locally managed temporary tablespace, you use the CREATE TEMPORARY TABLESPACE statement, which requires that you have the CREATE TABLESPACE system privilege.

The following statement creates a temporary tablespace in which each extent is 16M. Each 16M extent (which is the equivalent of 8000 blocks when the standard block size is 2K) is represented by a bit in the bitmap for the file.

```
CREATE TEMPORARY TABLESPACE lmtemp TEMPFILE '/u02/oracle/data/lmtemp01.dbf'
     SIZE 20M REUSE
   EXTENT MANAGEMENT LOCAL UNIFORM SIZE 16M;
```

> **Note:** On some operating systems, Oracle does not allocate space for the tempfile until the tempfile blocks are actually accessed. This delay in space allocation results in faster creation and resizing of tempfiles, but it requires that sufficient disk space is available when the tempfiles are later used. Please refer to your operating system documentation to determine whether Oracle allocates tempfile space in this way on your system.

Altering a Locally Managed Temporary Tablespace

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 a temporary file:

```
ALTER DATABASE TEMPFILE '/u02/oracle/data/lmtemp02.dbf' RESIZE 4M;
```

The following statement drops a temporary file and deletes the operating system file:

```
ALTER DATABASE TEMPFILE '/u02/oracle/data/lmtemp02.dbf' DROP
     INCLUDING DATAFILES;
```

The tablespace to which this tempfile belonged remains. A message is written to the alert file for the datafile that was deleted. If an operating system error prevents the deletion of the file, the statement still succeeds, but a message describing the error is written to the alert file.

It is also possible, but not shown, to AUTOEXTEND a tempfile, and to rename (RENAME FILE) a tempfile.

Creating a Dictionary-Managed Temporary Tablespace

To identify a tablespace as temporary during tablespace creation, specify the TEMPORARY keyword on the CREATE TABLESPACE statement. You cannot specify EXTENT MANAGEMENT LOCAL for a temporary tablespace created in this fashion. To create a locally managed temporary tablespace, use the CREATE TEMPORARY TABLESPACE statement, which is the preferred method of creating a temporary tablespace.

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)
     EXTENT MANAGEMENT DICTIONARY
     TEMPORARY;
```

Altering a Dictionary-Managed Temporary Tablespace

You can 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 *Oracle9i SQL Reference*.

> **Note:** When you take dictionary-managed temporary tablespaces offline with the `ALTER TABLESPACE ... OFFLINE` statement, returning them online does not affect their temporary status.

You can change an existing permanent dictionary-managed tablespace to a temporary tablespace, using the `ALTER TABLESPACE` statement. For example:

```
ALTER TABLESPACE tbsa TEMPORARY;
```

Managing Tablespace Allocation

When you create a tablespace, you determine what physical datafiles 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 in this section.

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 in this section.

These following topics are contained in this section:

- Storage Parameters in Locally Managed Tablespaces
- Storage Parameters for Dictionary-Managed Tablespaces
- Coalescing Free Space in Dictionary-Managed Tablespaces

> **See Also:** Chapter 12, "Managing Datafiles"

Storage Parameters in Locally Managed Tablespaces

You cannot specify default storage parameters for locally managed tablespaces, nor can you specify `MINIMUM_EXTENT`. 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 (create objects) in a locally managed tablespace, the storage clause specified at create time 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:

- *Oracle9i Database Performance Guide and Reference* for more discussion of the effects of these parameters
- *Oracle9i SQL Reference* for a complete description of storage parameters

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	Specifies the percent by which each extent, after the second (NEXT) extent, grows
MINEXTENTS	Specifies 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 ALTER TABLESPACE statement.

```
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.

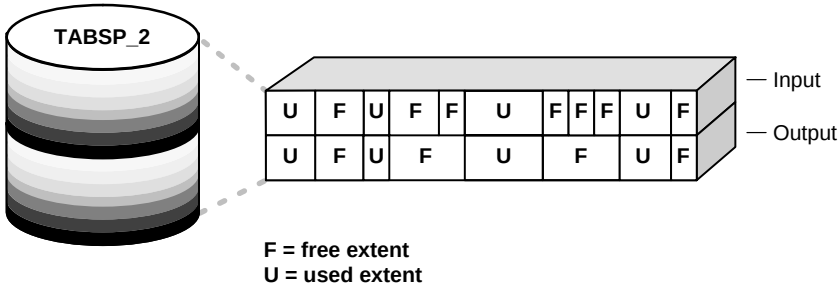
This fragmentation is addressed in several ways:

- When attempting to allocate a new extent for a segment, Oracle first tries to find a free extent large enough for the new extent. If no free extent that is large enough is found, Oracle then coalesces adjacent free extents in the tablespace and looks again. This coalescing is *always* performed by Oracle whenever it cannot find a free extent into which the new extent will fit.
- 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 manually.
- 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.

- 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.

Figure 11–1 Coalescing Free Space



Note: Coalescing free space is not necessary for locally managed tablespaces because bitmaps automatically track adjacent free space.

See Also: *Oracle9i Database Concepts* for detailed information on allocating extents and coalescing free space

Manually Coalescing Free Space

If you find that fragmentation of space in a tablespace is high (contiguous space on your disk appears as noncontiguous), 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. 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 following views for monitoring free space in a tablespace:

- DBA_FREE_SPACE
- DBA_FREE_SPACE_COALESCED

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 (for example, blocks starting with BLOCK_IDs 2, 4, 6, 16) that has not been coalesced. After coalescing the tablespace using the ALTER TABLESPACE statement shown previously, the results of this query would read:

```
 BLOCK_ID   BYTES      BLOCKS
```

```
---------- ---------- ----------
         2     131072         16
        27     311296         38
2 rows selected.
```

The DBA_FREE_SPACE_COALESCED view displays statistics for coalescing activity. It is also useful in determining if you need to coalesce space.

> **See Also:** *Oracle9i Database Reference* for more information about these views

Altering Tablespace Availability

You can take an online tablespace offline so that this portion of the database is temporarily unavailable for general use. The rest of the database is open and available for users to access data. Conversely, you can bring an offline tablespace online to make the schema objects within the tablespace available to database users. The database must be open.

To alter the availability of a tablespace, use the SQL statement ALTER TABLESPACE. You must have the ALTER TABLESPACE or MANAGE TABLESPACE system privilege to perform this action.

You can also take all of the datafiles or tempfiles in a tablespace offline, and bring them back online, without affecting the OFFLINE or ONLINE status of the tablespace itself.

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 can 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. When OFFLINE NORMAL is specified, Oracle takes a checkpoint for all datafiles of the tablespace as it takes them offline. NORMAL is the default.
TEMPORARY	A tablespace can be taken offline temporarily, even if there are error conditions for one or more files of the tablespace. When OFFLINE TEMPORARY is specified, Oracle takes offline the datafiles that are not already offline, checkpointing them as it does so. If no files are offline, but you use the temporary 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 taking a checkpoint on any of the datafiles. When you specify OFFLINE IMMEDIATE, media recovery for the tablespace is required before the tablespace can be brought online. You cannot take a tablespace offline immediately if the database is running in NOARCHIVELOG mode.
FOR RECOVER	Takes the database tablespaces in the recovery set offline for tablespace point-in-time recovery. For additional information, see *Oracle9i User-Managed Backup and Recovery Guide.*

Caution: 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. It will not require recovery, even if after incomplete recovery you reset the redo log sequence using an ALTER DATABASE OPEN RESETLOGS statement.

Specify TEMPORARY only when you cannot take the tablespace offline normally. In this case, only the files taken offline because of errors need to be recovered before the tablespace can be brought online. Specify IMMEDIATE only after trying both the normal and temporary options.

The following example takes the users tablespace offline normally:

```
ALTER TABLESPACE users OFFLINE NORMAL;
```

Before taking an online tablespace offline, consider taking the following actions:

- Verify that the tablespace contains no active rollback segments. Such a tablespace cannot be taken offline.
- You may want to alter the tablespace allocation of any users who have been assigned the tablespace as either a default or temporary tablespace. This is advisable because they will not be able to access objects or sort areas in the tablespace while it is offline.

See Also: "Taking Rollback Segments Offline" on page 13-23

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. See the *Oracle9i User-Managed Backup and Recovery Guide* for information about performing media recovery.

The following statement brings the `users` tablespace online:

```
ALTER TABLESPACE users ONLINE;
```

Altering the Availability of Datafiles or Tempfiles

Clauses of the `ALTER TABLESPACE` statement enable you to change the online or offline status of all of the datafiles or tempfiles within a tablespace. Specifically, the statements that affect online / offline status are:

- `ALTER TABLESPACE ... DATAFILE {ONLINE|OFFLINE}`
- `ALTER TABLESPACE ... TEMPFILE {ONLINE|OFFLINE}`

You are required only to enter the tablespace name, not the individual datafiles or tempfiles. All of the datafiles or tempfiles are affected, but the online/offline status of the tablespace itself is not changed.

In most cases the above ALTER TABLESPACE statements can be issued whenever the database is mounted, even if it is not open. The database *must not* be open if the tablespace is the SYSTEM tablespace, an undo tablespace, or the default temporary tablespace. The ALTER DATABASE DATAFILE and ALTER DATABASE TEMPFILE statements also have ONLINE/OFFLINE clauses, however in those statements require that you enter all of the filenames for the tablespace.

The syntax is different from the ALTER TABLESPACE ... ONLINE|OFFLINE statement that alters a tablespace's availability, because that is a different operation. The ALTER TABLESPACE statement takes datafiles offline as well as the tablespace, but it cannot be used to alter the status of a temporary tablespace or its tempfile(s).

Using Read-Only Tablespaces

Making a tablespace read-only prevents write operations on the datafiles in the tablespace. The primary purpose of read-only tablespaces is to eliminate the need to perform backup and recovery of large, static portions of a database, 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.

Note: Making a tablespace read-only cannot in itself be used to satisfy archiving or data publishing requirements, because the tablespace can only be brought online in the database in which it was created. However, you can meet such requirements by using the transportable tablespace feature.

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.

Read-only tablespaces can be transported to other databases. And, since read-only tablespaces can never be updated, they can reside on CD-ROM or WORM (Write Once-Read Many) devices.

The following topics are discussed in this section:

- Making a Tablespace Read-Only
- Making a Read-Only Tablespace Writable
- Creating a Read-Only Tablespace on a WORM Device
- Delaying the Opening of Datafiles in Read Only Tablespaces

See Also:

- *Oracle9i Database Concepts* for more information about read-only tablespaces
- "Transporting Tablespaces Between Databases" on page 11-31

Making a Tablespace Read-Only

All tablespaces are initially created as read-write. Use the `READ ONLY` clause in the `ALTER TABLESPACE` statement to change a tablespace to read-only. You must have the `ALTER TABLESPACE` or `MANAGE TABLESPACE` system privilege.

Before you can make a tablespace read-only, the following conditions must be met.

- The tablespace must be online.

  This is necessary to ensure that there is no undo information that needs to be applied to the tablespace.

- The tablespace 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 can issue a query that accesses all of the blocks of the tables in the tablespace just before making it read-only. A simple query, such as `SELECT COUNT (*)`, executed against each table ensures that the data blocks in the tablespace can be subsequently accessed most efficiently. This eliminates the need for 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 write operations (DML statements) are allowed against the tablespace. Existing transactions that modified the tablespace are allowed to commit or rollback. Once all transactions (in the database) have completed, the tablespace becomes read-only.

> **Note:** This transitional read-only state only occurs if the value of the initialization parameter COMPATIBLE is 8.1.0 or greater. If this parameter is set to a value less than 8.1.0, the ALTER TABLESPACE ... READ ONLY statement fails if any active transactions exist.

If you find it is taking a long time for the 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 and note its session address (saddr).

```
SELECT SQL_TEXT, SADDR
    FROM V$SQLAREA,V$SESSION
    WHERE V$SQLAREA.ADDRESS = V$SESSION.SQL_ADDRESS
        AND SQL_TEXT LIKE 'alter tablespace%';

SQL_TEXT                                 SADDR
---------------------------------------- --------
alter tablespace tbs1 read only          80034AF0
```

- The start SCN of each active transaction is stored in the V$TRANSACTION view. Displaying this view sorted by ascending start SCN lists the transactions in execution order. Since you know the session address of the transaction entry for the read-only statement, it can be located in the V$TRANSACTION view. All transactions with lesser 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:** *Oracle9i User-Managed Backup and Recovery Guide* for information about recovering a database with read-only datafiles

Making a Read-Only Tablespace Writable

Use the `READ WRITE` keywords in the `ALTER TABLESPACE` statement to change a tablespace to allow write operations. You must have the `ALTER TABLESPACE` or `MANAGE TABLESPACE` system privilege.

A prerequisite to making the tablespace read-write is that all of the datafiles in the tablespace, as well as the tablespace itself, must be online. Use the `DATAFILE ... ONLINE` clause of the `ALTER DATABASE` statement to bring a datafile online. The `V$DATAFILE` view lists the current status of datafiles.

The following statement makes the `flights` tablespace writable:

```
ALTER TABLESPACE flights READ WRITE;
```

Making a read-only tablespace writable updates the control file entry for the datafiles, so that you can use the read-only version of the datafiles as a starting point for recovery.

Creating a Read-Only Tablespace on a WORM Device

Follow these steps to create a read-only tablespace on a CD-ROM or WORM (Write Once-Read Many) device.

1. Create a writable tablespace on another device. Create the objects that belong in the tablespace and insert your data.
2. Alter the tablespace to make it read-only.
3. Copy the datafiles of the tablespace onto the WORM device. Use operating system commands to copy the files.

4. Take the tablespace offline.
5. Rename the datafiles to coincide with the names of the datafiles you copied onto your WORM device. Use `ALTER TABLESPACE` with the `RENAME DATAFILE` clause. Renaming the datafiles changes their names in the control file.
6. Bring the tablespace back online.

Delaying the Opening of Datafiles in Read Only Tablespaces

When substantial portions of a very large database are stored in read-only tablespaces that are located on slow-access devices or hierarchical storage, you should consider setting the `READ_ONLY_OPEN_DELAYED` initialization parameter to `TRUE`. This speeds certain operations, primarily opening the database, by causing datafiles in read-only tablespaces to be accessed for the first time only when an attempt is made to read data stored within them.

Setting `READ_ONLY_OPEN_DELAYED=TRUE` has the following side-effects:

- A missing or bad read-only file is not detected at open time. It is only discovered when there is an attempt to access it.
- `ALTER DATABASE CHECK DATAFILES` does not check read-only files.
- `ALTER TABLESPACE ... ONLINE` and `ALTER DATABASE DATAFILE ... ONLINE` does not check read-only files. They are checked only upon the first access.
- `V$RECOVER_FILE`, `V$BACKUP`, and `V$DATAFILE_HEADER` do not access read-only files. Read-only files are indicated in the results list with the error "`DELAYED OPEN`", with zeroes for the values of other columns.
- `V$DATAFILE` does not access read-only files. Read-only files have a size of "0" listed.
- `V$RECOVER_LOG` does not access read-only files. Logs they could need for recovery are not added to the list.
- `ALTER DATABASE NOARCHIVELOG` does not access read-only files.It proceeds even if there is a read-only file that requires recovery.

Notes:

- RECOVER DATABASE and ALTER DATABASE OPEN RESETLOGS continue to access all read-only datafiles regardless of the parameter value. If you want to avoid accessing read-only files for these operations, those files should be taken offline.
- If a backup control file is used, the read-only status of some files may be inaccurate. This can cause some of these operations to return unexpected results. Care should be taken in this situation.

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.

Caution: 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, the file pointers in the control file of the associated database are removed. You can optionally direct Oracle to delete the operating system files (datafiles) that constituted the dropped tablespace. If you do not direct Oracle to delete the datafiles at the same time that it deletes the tablespace, you must later use the appropriate commands of your operating system to delete them.

You cannot drop a tablespace that contains any active segments. For example, if a table in the tablespace is currently being used or the tablespace contains an active rollback segment, you cannot drop the tablespace. For simplicity, take the tablespace offline before dropping it.

To drop a tablespace, use the DROP TABLESPACE statement. The following statement drops the users tablespace, including the segments in the tablespace:

```
DROP TABLESPACE users INCLUDING CONTENTS;
```

If the tablespace is empty (does not contain any tables, views, or other structures), you do not need to specify the INCLUDING CONTENTS 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.

To delete the datafiles associated with a tablespace at the same time that the tablespace is dropped, use the INCLUDING CONTENTS AND DATAFILES clause. The following statement drops the USER tablespace and its associated datafiles:

```
DROP TABLESPACE users INCLUDING CONTENTS AND DATAFILES;
```

A message is written to the alert file for each datafile that is deleted. If an operating system error prevents the deletion of a file, the DROP TABLESPACE statement still succeeds, but a message describing the error is written to the alert file.

Troubleshooting Tablespace Problems with DBMS_SPACE_ADMIN

Note: The DBMS_SPACE_ADMIN package provides administrators with defect diagnosis and repair functionality for locally managed tablespaces. It cannot be used for dictionary-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 of a given segment.
TABLESPACE_VERIFY	Verifies that the bitmaps and extent maps for the segments in the tablespace are in sync.

Procedure	Description
TABLESPACE_REBUILD_BITMAPS	Rebuilds the appropriate bitmap.
TABLESPACE_FIX_BITMAPS	Marks the appropriate data block address 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 can result in lost and unrecoverable data if not used properly. You should work with Oracle Support Services if you have doubts about these procedures.

See Also: *Oracle9i Supplied PL/SQL Packages and Types Reference* for details about the DBMS_SPACE_ADMIN package

Scenario 1: Fixing Bitmap When Allocated Blocks are Marked Free (No Overlap)

The TABLESPACE_VERIFY procedure discovers that a segment has allocated blocks that are marked free in the bitmap, but no overlap between segments is reported.

In this scenario, perform the following tasks:

1. Call the SEGMENT_DUMP procedure to dump the ranges that the administrator allocated to the segment.
2. For each range, call the TABLESPACE_FIX_BITMAPS procedure with the TABLESPACE_EXTENT_MAKE_USED option to mark the space as used.
3. Call TABLESPACE_REBUILD_QUOTAS to fix up quotas.

Scenario 2: Dropping a Corrupted Segment

You cannot drop a segment because the bitmap has segment blocks marked "free". The system has automatically marked the segment corrupted.

In this scenario, perform the following tasks:

1. Call the SEGMENT_VERIFY procedure with the SEGMENT_VERIFY_EXTENTS_GLOBAL option. If no overlaps are reported, then proceed with steps 2 through 5.
2. Call the SEGMENT_DUMP procedure to dump the DBA ranges allocated to the segment.
3. For each range, call TABLESPACE_FIX_BITMAPS with the TABLESPACE_EXTENT_MAKE_FREE option to mark the space as free.
4. Call SEGMENT_DROP_CORRUPT to drop the SEG$ entry.
5. Call TABLESPACE_REBUILD_QUOTAS to fix up quotas.

Scenario 3: Fixing Bitmap Where Overlap is Reported

The TABLESPACE_VERIFY procedure reports some overlapping. Some of the real data must be sacrificed based on previous internal errors.

After choosing the object to be sacrificed, in this case say, table t1, perform the following tasks:

1. Make a list of all objects that t1 overlaps.
2. Drop table t1. If necessary, follow up by calling the SEGMENT_DROP_CORRUPT procedure.
3. Call the SEGMENT_VERIFY procedure on all objects that t1 overlapped. If necessary, call the TABLESPACE_FIX_BITMAPS procedure to mark appropriate bitmap blocks as used.
4. Rerun the TABLESPACE_VERIFY procedure to verify the problem is resolved.

Scenario 4: Correcting Media Corruption of Bitmap Blocks

A set of bitmap blocks has media corruption.

In this scenario, perform the following tasks:

1. Call the TABLESPACE_REBUILD_BITMAPS procedure, either on all bitmap blocks, or on a single block if only one is corrupt.

2. Call the TABLESPACE_REBUILD_QUOTAS procedure to rebuild quotas.
3. Call the TABLESPACE_VERIFY procedure to verify that the bitmaps are consistent.

Scenario 5: Migrating from a Dictionary-Managed to a Locally Managed Tablespace

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 contains the following topics:

- Introduction to Transportable Tablespaces
- Limitations
- Compatibility Considerations for Transportable Tablespaces
- Transporting Tablespaces Between Databases: A Procedure
- Object Behaviors
- Using Transportable Tablespaces

Introduction to Transportable Tablespaces

Note: You must be using the Enterprise Edition of Oracle8i (or higher) to generate a transportable tablespace set. However, you can use any edition of Oracle8*i* (or higher) to plug a transportable tablespace set into an Oracle database.

See "Compatibility Considerations for Transportable Tablespaces" on page 11-33 for a discussion of database compatibility for transporting tablespaces across release levels.

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. The tablespaces being transported can be either dictionary managed or locally managed. Starting with Oracle9i, the transported tablespaces are not required to be of the same block size as the target database's standard block size. 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
- Performing Tablespace Point-in-Time Recovery (TSPITR)

Moving data using 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:

- *Oracle9i Database Concepts* for more details about transportable tablespaces and their use in data marts and data warehousing
- *Oracle9i Database Migration* for information about transportable tablespace compatibility issues between different Oracle releases

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 Windows NT Oracle databases. However, you cannot transport a tablespace from a Sun Solaris Oracle database to an Windows NT Oracle database.
- 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:
  - Materialized views / replication
  - Function-based indexes
  - Scoped REFs
  - 8.0-compatible advanced queues with multiple recipients

Compatibility Considerations for Transportable Tablespaces

To use the transportable tablespaces feature, the COMPATIBLE initialization parameter for both the source and target databases must be set to 8.1 or higher. If the block size of any tablespace being transported is different from the standard block size for the target database, the COMPATIBLE initialization parameter must be set to 9.0 or higher for the target database. You are not required to be running the same release of Oracle for both the source and target database. Oracle guarantees that the transportable tablespace set is compatible with the target database. If not, an error is signaled at the beginning of the plug-in operation.

It is always possible to transport a tablespace from a database running an *older* release of Oracle (starting with Oracle8*i*) to a database running a *newer* release of Oracle (for example, Oracle9*i*).

When creating a transportable tablespace set, Oracle computes the lowest compatibility level at which the target database must run. This is referred to as the compatibility level of the transportable set. When plugging the transportable set into a target database, Oracle signals an error if the compatibility level of the transportable set is greater than the compatibility level of the target database.

Transporting Tablespaces Between Databases: A Procedure

To move or copy a set of tablespaces, perform the following steps. These steps are illustrated more fully in succeeding sections that detail transporting tablespaces `sales_1` and `sales_2` between databases.

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 operating system copy utility, ftp, or publishing on CDs).
4. Plug in the tablespace.

   Invoke the Import utility to plug the set of tablespaces into the target database.

Step 1: Pick a Self-Contained Set of Tablespaces

There may be logical or physical dependencies between objects in the transportable set and those outside of the set. You can only transport a set of tablespaces that is self-contained. In this context "self-contained" means that there are no references from inside the set of tablespaces pointing outside of the tablespaces. Some examples of self contained tablespace violations are:

- An index inside the set of tablespaces is for a table outside of the set of tablespaces.

  Note: It is not a violation if a corresponding index for a table is outside of the set of tablespaces.

- A partitioned table is partially contained in the set of tablespaces.

  The tablespace set you want to copy must contain either all partitions of a partitioned table, or none of the partitions of a partitioned table. If you want to transport a subset of a partition table, you must exchange the partitions into tables.

- A referential integrity constraint points to a table across a set boundary.

When transporting a set of tablespaces, you can choose to include referential integrity constraints. However, doing so can affect whether or not a set of tablespaces is self-contained. If you decide not to transport constraints, then the constraints are not considered as pointers.

- A table inside the set of tablespaces contains a LOB column that points to 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.

When you invoke the DBMS_TTS package, you specify the list of tablespaces in the transportable set to be checked for self containment. You can optionally specify if constraints must be included. For **strict or full containment**, you must additionally set the TTS_FULL_CHECK parameter to TRUE.

The strict or full containment check is for cases that require capturing not only references going outside the transportable set, but also those coming into the set. Tablespace Point-in-Time Recovery (TSPITR) is one such case where dependent objects must be fully contained or fully outside the transportable set.

For example, it is a violation to perform TSPITR on a tablespace containing a table t but not its index i because the index and data will be inconsistent after the transport. A full containment check ensures that there are no dependencies going outside or coming into the transportable set. See the example for TSPITR in the *Oracle9i User-Managed Backup and Recovery Guide*.

Note: The default for transportable tablespaces is to check for self containment rather than full containment.

Here we determine whether tablespaces sales_1 and sales_2 are self-contained, with referential integrity constraints taken into consideration (indicated by TRUE).

```
EXECUTE dbms_tts.transport_set_check('sales_1,sales_2', TRUE);
```

After invoking this PL/SQL package, you can see all violations by selecting from the TRANSPORT_SET_VIOLATIONS view. If the set of tablespaces is self-contained, this view is empty. The following 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
```

These violations must be resolved before `sales_1` and `sales_2` are transportable. As noted in the next step, one choice for bypassing the integrity constrain violation is to not export the integrity constraints.

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:

- *Oracle9i Application Developer's Guide - Fundamentals* for more information about REFs
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the `DBMS_TTS` package
- *Oracle9i User-Managed Backup and Recovery Guide* for information specific to using the `DBMS_TTS` package for TSPITR

Step 2: Generate a Transportable Tablespace Set

After ensuring you have a self-contained set of tablespaces that 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;
   ALTER TABLESPACE sales_2 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 CONSTRAINTS=n GRANTS=n FILE=expdat.dmp
   ```

> **Note:** Although the Export utility is used, only data dictionary structural information(metadata) for the tablespaces is exported. Hence, this operation goes quickly even for a large tablespace.

When prompted, connect as SYS (or other administrative user) with the SYSDBA system privilege:

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

You must always specify TABLESPACES. In this example, we also specify that:

- Triggers are to be 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 TRIGGERS=n, triggers are not exported.
- Referential integrity constraints are not to be exported
- Grants are not to be exported.
- The name of the structural information export file to be created is expdat.dmp.

If you are performing TSPITR or transport with a strict containment check, use:

```
EXP TRANSPORT_TABLESPACE=y TABLESPACES=(sales_1,sales_2)
   TTS_FULL_CHECK=Y FILE=expdat.dmp
```

If the tablespace sets being transported are not self-contained, export fails and indicate that the transportable set is not self-contained. You must then return to Step 1 to resolve all violations.

> **See Also:** *Oracle9i Database Utilities* for information about using the Export utility

Step 3: Transport the Tablespace Set

Transport *both the datafiles and the export file* of the tablespaces to a place accessible to the target database. You can use any facility for copying flat files (for example, an operating system copy utility, ftp, or publishing on CDs).

Step 4: Plug In the Tablespace Set

> **Note:** If you are transporting a tablespace of a different block size than the standard block size of the database receiving the tablespace set, then you must first have a DB_*n*K_CACHE_SIZE initialization parameter entry in the receiving database's parameter file.
>
> For example, if you are transporting a tablespace with an 8K block size into a database with a 4K standard block size, then you must include a DB_8K_CACHE_SIZE initialization parameter entry in the parameter file. If it is not already included in the parameter file, this parameter can be set using the ALTER SYSTEM SET statement.
>
> See *Oracle9i SQL Reference* for information about specifying values for the DB_*n*K_CACHE_SIZE initialization parameter.

To plug in a tablespace set, perform the following tasks:

1. Plug in the tablespaces and integrate the structural information using the Import utility.

```
IMP TRANSPORT_TABLESPACE=y FILE=expdat.dmp
    DATAFILES=('/db/sales_jan','/db/sales_feb',...)
    TABLESPACES=(sales_1,sales_2) TTS_OWNERS=(dcranney,jfee)
    FROMUSER=(dcranney,jfee) TOUSER=(smith,williams)
```

   When prompted, connect as SYS (or other administrative user) with the SYSDBA system privilege:

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

   In this example we specify the following:

   - TRANSPORT_TABLESPACE=y tells the Export utility that we are transporting a tablespace.
   - The exported file containing the metadata for the tablespaces is expdat.dmp.
   - DATAFILES specifies the datafiles of the transported tablespaces and must be specified.
   - The tablespace names are sales_1 and sales_2.

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.

- FROMUSER and TOUSER are specified to change the ownership of database objects.

  If you do not specify FROMUSER and TOUSER, all database objects (such as tables and indexes) are created under the same user as in the source database. Those users must already exist in the target database. If not, import returns 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. In this example we specify `FROMUSER=(dcranney,jfee)` and `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 is not required 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. Check the import logs to ensure no error has occurred.

When dealing with a large number of datafiles, specifying the list of datafile names in the statement line can be a laborious process. It can even exceed the statement line limit. In this situation, you can use an import parameter file. For example, you can invoke the Import utility as follows:

```
IMP PARFILE='par.f'
```

The file `par.f` file contains the following:

```
TRANSPORT_TABLESPACE=y
FILE=expdat.dmp
DATAFILES=('/db/sales_jan','/db/sales_feb',...)
TABLESPACES=(sales_1,sales_2)
TTS_OWNERS=(dcranney,jfee)
```

```
FROMUSER=(dcranney,jfee)
TOUSER=(smith,williams)
```

2. If necessary, put the tablespaces in the copied space back into read-write mode as follows:

```
ALTER TABLESPACE sales_1 READ WRITE
ALTER TABLESPACE sales_1 READ WRITE
```

> **See Also:** *Oracle9i Database Utilities* for information about using the Import utility

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
- Materialized Views / 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 using 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 returns immediately because it only manipulates structural information. Moving partitions, however, may be slow because the data in the partition can be copied.

> **See Also:** "Transporting and Attaching Partitions for Data Warehousing" on page 11-43 for an example of transporting a partitioned table

Objects

A transportable tablespace set can contain:

- Tables
- Indexes
- Domain 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 using the built-in PL/SQL routine DBMS_AQADM.START_QUEUE.

Indexes

You can transport regular indexes, domain 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 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 cause a compilation error during the subsequent import.

Materialized Views/Replication

Transporting materialized views or replication structural information is not supported. When transporting a tablespace, the materialized view or replication metadata associated with the tables in the tablespace is not exported and, thus, is not be available to the target database.

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 can 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 want to create one partition and attach it to the partitioned `sales` table.

Suppose it is July 1998, and you would like to load the July sales data into the partitioned table. In a staging database, you create a new tablespace, `ts_jul`. You also create a table, `jul_sales`, in that tablespace with exactly the same column types as the `sales` table. You can create the table `jul_sales` using the `CREATE TABLE ... AS SELECT` statement. After creating and populating `jul_sales`, you can also create an index, `jul_sale_index`, for the table, indexing the same column as the local index in the `sales` table. After building the index, transport the tablespace `ts_jul` to the data warehouse.

In the data warehouse, add a partition to the `sales` table for the July sales data. This also creates another partition for the local 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 and it simply switches database pointers. If you know that the data in the new partition does not overlap with data in previous partitions, you are advised to specify the WITHOUT VALIDATION option. Otherwise, the statement goes through all the new data in the new partition in an attempt to validate the range of that partition.

If all partitions of the sales table came from the same staging database (the staging database is never destroyed), the exchange statement always succeeds. In general, however, if data in a partitioned table comes from different databases, it's possible that the exchange operation may fail. For example, if the jan98 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 can load a tablespace with data to be published, generate the transportable set, and copy the transportable set to a CD. This CD can then be distributed.

When customers receive this CD, they can plug it into an existing database without having to copy the datafiles from the CD to disk storage. For example, suppose on a Windows NT machine D: drive is the CD drive. You can 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 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 indicates that it cannot find the removed datafile and does not open the database (unless you set the initialization parameter `READ_ONLY_OPEN_DELAYED` to `TRUE`). When `READ_ONLY_OPEN_DELAYED` is set to `TRUE`, 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 tablespace into each of the databases on which you want 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 in several ways. You can use either a cluster file system or raw disk, because that is required by Oracle9*i* Real Application Clusters. Because Oracle reads only 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 will hang until the NFS operation times out.

Later, you can drop the read-only tablespace in some of the databases. Doing so does not modify the datafiles for the tablespace. Thus, the drop operation does not corrupt the tablespace. Do not make the tablespace read-write unless only one database is mounting the tablespace.

Archive Historical Data Using 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 using the transportable tablespace procedures described in this chapter.

> **See Also:** *Oracle9i Data Warehousing Guide* for more details

Using Transportable Tablespaces to Perform TSPITR

You can use transportable tablespaces to perform tablespace point-in-time recovery (TSPITR).

> **See Also:** *Oracle9i User-Managed Backup and Recovery Guide* for information about how to perform TSPITR using transportable tablespaces

Viewing Tablespace Information

The following data dictionary and dynamic performance views provide useful information about the tablespaces of a database.

View	Description
V$TABLESPACE	Name and number of all tablespaces from the control file.
DBA_TABLESPACES, USER_TABLESPACES	Descriptions of all (or user accessible) tablespaces.
DBA_SEGMENTS, USER_SEGMENTS	Information about segments within all (or user accessible) tablespaces.

View	Description
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$DATAFILE	Information about all datafiles, including tablespace number of owning tablespace.
V$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:** *Oracle9i Database Reference* for complete description of these views

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
```

Displaying 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 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.

12

Managing Datafiles

This chapter describes the various aspects of datafile management, and contains the following topics:

- Guidelines for Managing Datafiles
- Creating Datafiles and Adding Datafiles to a Tablespace
- Changing a Datafile's Size
- Altering Datafile Availability
- Renaming and Relocating Datafiles
- Verifying Data Blocks in Datafiles
- Viewing Datafile Information

> **See Also:** Chapter 3, "Using Oracle-Managed Files" for information about creating datafiles and tempfiles that are both created and managed by the Oracle database server

Guidelines for Managing Datafiles

Datafiles are physical files of the operating system that store the data of all logical structures in the database. They must be explicitly created for each tablespace. Oracle assigns each datafile two associated file numbers, an **absolute file number** and a **relative file number**, that are used to uniquely identify it. These numbers are described in the following table:

Type of File Number	Description
Absolute	Uniquely identifies a datafile in the database. In earlier releases of Oracle, the absolute file number may have been referred to as simply, the "file number."
Relative	Uniquely identifies a datafile within a tablespace. For small and medium size databases, relative file numbers usually have the same value as the absolute file number. However, when the number of datafiles in a database exceeds a threshold (typically 1023), the relative file number differs from the absolute file number.

File numbers are displayed in many data dictionary views.

This section describes aspects of managing datafiles, and contains the following topics:

- Determine the Number of Datafiles
- Determine the Size of Datafiles
- Place Datafiles Appropriately
- Store Datafiles Separate from Redo Log Files

Determine the Number of Datafiles

At least one datafile is required for the `SYSTEM` tablespace of a database. A small system might have a single datafile. The following are some guidelines to consider when determining the number of datafiles for your database.

Determine the Value of the DB_FILES Initialization Parameter

When starting an Oracle instance, the `DB_FILES` initialization parameter indicates the amount of SGA space to reserve for datafile information and thus, the maximum number of datafiles that can be created for the instance. This limit applies

for the life of the instance. You can change the value of DB_FILES (by changing the initialization parameter setting), but the new value does not take effect until you shut down and restart the instance.

Note: The default value of DB_FILES is operating system specific.

When determining a value for DB_FILES, take the following into consideration:

- If the value of DB_FILES is too low, you cannot add datafiles beyond the DB_FILES limit without first shutting down the database.
- If the value of DB_FILES is too high, memory is unnecessarily consumed.

Limitations When Adding Datafiles to a Tablespace

You can add datafiles to tablespaces, subject to the following limitations:

- Operating systems often impose a limit on the number of files a process can open simultaneously. More datafiles cannot be created when the operating system limit of open files is reached.
- Operating systems impose limits on the number and size of datafiles.
- Oracle imposes a maximum limit on the number of datafiles for any Oracle database opened by any instance. This limit is operating system specific.
- You cannot exceed the number of datafiles specified by the DB_FILES initialization parameter.
- When you issue CREATE DATABASE or CREATE CONTROLFILE statements, the MAXDATAFILES parameter specifies an initial size of the datafile portion of the control file. You can only add a new datafile if the value of MAXDATAFILES is less than or equal to the value specified by the DB_FILES initialization parameter. In this case, the control file automatically expands to allow the datafile portion to accommodate more files.

Consider the Performance Impact

The number of datafiles comprising a tablespace, and ultimately the database, can have an impact upon performance.

Oracle allows more datafiles in the database than the operating system defined limit. Oracle's DBW*n* processes can open all online datafiles. Oracle is capable of treating open file descriptors as a cache, automatically closing files when the number of open file descriptors reaches the operating system-defined limit. This can

have a negative performance impact. When possible, adjust the operating system limit on open file descriptors so that it is larger than the number of online datafiles in the database.

See Also:

- Your operating system specific Oracle documentation for more information on operating system limits
- *Oracle9i Real Application Clusters Installation and Configuration* for information about Oracle Real Application Clusters operating system limits
- *Oracle9i SQL Reference* for more information about `MAXDATAFILES` parameter of the `CREATE DATABASE` or `CREATE CONTROLFILE` statement

Determine the Size of Datafiles

The first datafile (in the original `SYSTEM` tablespace) must be at least 150M to contain the initial data dictionary and rollback segment. If you install other Oracle products, they may require additional space in the `SYSTEM` tablespace. See the installation instructions for these products for information about their space requirements.

Place Datafiles Appropriately

Tablespace location is determined by the physical location of the datafiles that constitute that tablespace. Use the hardware resources of your computer appropriately.

For example, if several disk drives are available to store the database, consider placing potentially contending datafiles on separate disks.This way, when users query information, both disk drives can work simultaneously, retrieving data at the same time.

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 Datafiles and Adding Datafiles to a Tablespace

When creating a tablespace, you can estimate the potential size of database objects and create sufficient files on multiple devices, so as to ensure that data is spread evenly across all devices. Later, if needed, you can create additional datafiles and add them to a tablespace to increase the total amount of disk space allocated to it, and consequently the database.

You can create datafiles and associate them with a tablespace using any of the statements listed in the following table. In all cases, you can either specify the file specifications for the datafiles being created, or you can use the Oracle Managed Files feature to create files that are created and managed by the database server. The table includes a brief description of the statement, as used to create datafiles, and references the section of this book where use of the statement is most completely described:

SQL Statement	Description	For more information...
`CREATE TABLESPACE`	Creates a tablespace and the datafiles that comprise it	"Creating Tablespaces" on page 11-4
`CREATE TEMPORARY TABLESPACE`	Creates a locally-managed temporary tablespace and the *tempfiles* (tempfiles are a special kind of datafile) that comprise it	"Creating a Locally Managed Temporary Tablespace" on page 11-11
`ALTER TABLESPACE ... ADD DATAFILE`	Creates and adds a datafile to a tablespace	"Altering a Dictionary-Managed Tablespace" on page 11-10
`ALTER TABLESPACE ... ADD TEMPFILE`	Creates and adds a tempfile to a temporary tablespace	"Creating a Locally Managed Temporary Tablespace" on page 11-11
`CREATE DATABASE`	Creates a database and associated datafiles	"Manually Creating an Oracle Database" on page 2-11
`ALTER DATABASE ... CREATE DATAFILE`	Creates a new empty datafile in place of an old one--useful to re-create a datafile that was lost with no backup.	Not discussed in this book. See *Oracle9i User-Managed Backup and Recovery Guide*.

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.

If a statement that creates a datafile fails, Oracle removes any created operating system files. However, because of the large number of potential errors that can occur with file systems and storage subsystems, there can be situations where you must manually remove the files using operating system commands.

Changing a Datafile's Size

This section describes the various ways to alter the size of a datafile, and contains the following topics:

- Enabling and Disabling Automatic Extension for a Datafile
- Manually Resizing a Datafile

Enabling and Disabling Automatic Extension for a Datafile

You can create datafiles or alter existing datafiles so that they automatically increase in size when more space is needed in the database. The files increase in specified increments up to a specified maximum.

Setting your datafiles to extend automatically provides these advantages:

- Reduces the need for immediate intervention when a tablespace runs out of space
- Ensures applications will not halt because of failures to allocate extents

To determine whether a datafile is auto-extensible, query the `DBA_DATA_FILES` view and examine the `AUTOEXTENSIBLE` column.

You can specify automatic file extension by specifying an `AUTOEXTEND ON` clause when you create datafiles using the following SQL statements:

- `CREATE DATABASE`
- `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:** *Oracle9i SQL Reference* for more information about the SQL statements for creating or altering datafiles

Manually Resizing a Datafile

You can manually increase or decrease the size of a datafile using the ALTER DATABASE statement.

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 enables you to reclaim unused space in the database. This is useful for correcting errors in estimates of space requirements.

In the next example, assume that the datafile /u02/oracle/rbdb1/stuff01.dbf has extended up to 250M. However, because its tablespace now stores smaller objects, the datafile can be reduced in size.

The following statement decreases the size of datafile /u02/oracle/rbdb1/stuff01.dbf:

```
ALTER DATABASE DATAFILE '/u02/oracle/rbdb1/stuff01.dbf'
   RESIZE 100M;
```

> **Note:** It is not always possible to decrease the size of a file to a specific value.

Altering Datafile Availability

You can take individual datafiles or tempfiles of a tablespace offline or similarly, bring them online. Offline datafiles are unavailable to the database and cannot be accessed until they are brought back online.You also have the option of taking all datafiles or tempfiles comprising a tablespace offline or online simply by specifying the name of a tablespace.

One example of where you might be required to alter the availability of a datafile is when Oracle has problems writing to a datafile and automatically takes the datafile offline. Later, after resolving the problem, you can bring the datafile back online manually.

The files of a read-only tablespace can independently be taken offline or brought online just as for read-write tablespaces. Bringing a datafile online 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.

To take a datafile offline, or bring it online, you must have the ALTER DATABASE system privilege. To take all datafiles or tempfiles offline using the ALTER TABLESPACE statement, you must have the ALTER TABLESPACE or MANAGE TABLESPACE system privilege. In an Oracle Real Application Clusters environment, the database must be open in exclusive mode.

This section describes ways to alter datafile availability, and contains the following topics:

- Bringing Datafiles Online or Taking Offline in ARCHIVELOG Mode
- Taking Datafiles Offline in NOARCHIVELOG Mode
- Altering the Availability of All Datafiles or Tempfiles in a Tablespace

---

Note: You can make all datafiles in any tablespace, except 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 11-19.

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: *Oracle9i User-Managed Backup and Recovery Guide* for more information about bringing datafiles online during media recovery

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 enables 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;
```

Altering the Availability of All Datafiles or Tempfiles in a Tablespace

Clauses of the ALTER TABLESPACE statement allow you to change the online or offline status of all of the datafiles or tempfiles within a tablespace. Specifically, the statements that affect online / offline status are:

- ALTER TABLESPACE ... DATAFILE {ONLINE|OFFLINE}
- ALTER TABLESPACE ... TEMPFILE {ONLINE|OFFLINE}

You are required only to enter the tablespace name, not the individual datafiles or tempfiles. All of the datafiles or tempfiles are affected, but the online/offline status of the tablespace itself is not changed.

In most cases the above `ALTER TABLESPACE` statements can be issued whenever the database is mounted, even if it is not open. However, the database *must not* be open if the tablespace is the system tablespace, an undo tablespace, or the default temporary tablespace. The `ALTER DATABASE DATAFILE` and `ALTER DATABASE TEMPFILE` statements also have `ONLINE/OFFLINE` clauses, however in those statements you must enter all of the filenames for the tablespace.

The syntax is different from the `ALTER TABLESPACE ... ONLINE|OFFLINE` statement that alters a tablespace's availability, because that is a different operation. The `ALTER TABLESPACE` statement takes datafiles offline as well as the tablespace, but it cannot be used to alter the status of a temporary tablespace or its tempfile(s).

Renaming and Relocating Datafiles

You can rename datafiles to either change their names or relocate them. Some 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. The procedures do not physically rename any operating system files, nor do they copy files at the operating system level. Renaming and relocating datafiles involves several steps. Read the steps and examples carefully before performing these procedures.

Renaming and Relocating Datafiles for a Single Tablespace

The section offers 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, complete the following steps:

1. Take the non-SYSTEM tablespace that contains the datafiles offline.

   For example:

   ```
   ALTER TABLESPACE users OFFLINE NORMAL;
   ```

2. Rename the datafiles using the operating system.

3. Use the ALTER TABLESPACE statement with the RENAME DATAFILE option to change the filenames within the database.

   For example, the following statement renames the datafiles /u02/oracle/rbdb1/user1.dbf and /u02/oracle/rbdb1/user2.dbf to/u02/oracle/rbdb1/users01.dbf and /u02/oracle/rbdb1/users02.dbf, respectively:

   ```
   ALTER TABLESPACE users
       RENAME DATAFILE '/u02/oracle/rbdb1/user1.dbf',
                       '/u02/oracle/rbdb1/user2.dbf'
                    TO '/u02/oracle/rbdb1/users01.dbf',
                       '/u02/oracle/rbdb1/users02.dbf';
   ```

   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.

4. Back up the database. After making any structural changes to a database, always perform an immediate and complete backup.

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 all located on the same disk.

- The datafiles of the users tablespace are to be relocated to different and separate disk drives.
- You are currently connected with administrator privileges to the open database.
- You have a current backup of the database.

Complete the following steps:

1. 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 DBA_DATA_FILES
WHERE TABLESPACE_NAME = 'USERS';

FILE_NAME                                BYTES
---------------------------------------- ----------
/U02/ORACLE/RBDB1/USERS01.DBF            102400000
/U02/ORACLE/RBDB1/USERS02.DBF            102400000
```

2. Take the tablespace containing the datafiles offline, or shut down the database and restart and mount it, leaving it closed. Either option closes the datafiles of the tablespace.
3. Copy the datafiles to their new locations and rename them using the operating system.

   Note: You can execute an operating system command to copy a file by using the SQL*Plus HOST command.

4. 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';
```

5. Bring the tablespace online, or open 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.

6. 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 the operating system.
3. Use `ALTER DATABASE` to rename the file pointers in the database's control file.

   For example, the following statement renames the datafiles `/u02/oracle/rbdb1/sort01.dbf` and `/u02/oracle/rbdb1/user3.dbf` to `/u02/oracle/rbdb1/temp01.dbf` and `/u02/oracle/rbdb1/users03.dbf`, respectively:

   ```
   ALTER DATABASE
       RENAME FILE '/u02/oracle/rbdb1/sort01.dbf',
                   '/u02/oracle/rbdb1/user3.dbf'
                TO '/u02/oracle/rbdb1/temp01.dbf',
                   '/u02/oracle/rbdb1/users03.dbf;
   ```

   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.

4. Back up the database. After making any structural changes to a database, always perform an immediate and complete backup.

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 are always 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 DBW*n* 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.

Caution: 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.

See Also: Oracle9i Database Reference for information about checksums and the DB_BLOCK_CHECKSUM initialization parameter

Viewing Datafile Information

The following data dictionary views provide useful information about the datafiles of a database:

View	Description
DBA_DATA_FILES	Provides descriptive information about each datafile, including the tablespace to which it belongs and the file id. The file id can be used to join with other views for detail information.

View	Description
DBA_EXTENTS USER_EXTENTS	DBA view describes the extents comprising all segments in the database. Contains the file id of the datafile containing the extent. USER view describes extents of the segments belonging to objects owned by the current user.
DBA_FREE_SPACE USER_FREE_SPACE	DBA view lists the free extents in all tablespaces. Includes the file id of the datafile containing the extent. USER view lists the free extents in the tablespaces accessible to the current user.
V$DATAFILE	Contains datafile information from the control file
V$DATAFILE_HEADER	Contains information from datafile headers

This example illustrates the use of one of these views, V$DATAFILE.

```
SELECT NAME,
    FILE#,
    STATUS,
    CHECKPOINT_CHANGE# "CHECKPOINT"
  FROM   V$DATAFILE;

NAME                                FILE#     STATUS       CHECKPOINT
-------------------------------     -----     -------       ----------
/u01/oracle/rbdb1/system01.dbf          1     SYSTEM              3839
/u02/oracle/rbdb1/temp01.dbf            2     ONLINE              3782
/u02/oracle/rbdb1/users03.dbf           3     OFFLINE             3782
```

FILE# lists the file number of each datafile; the first datafile in the SYSTEM tablespace created with the database is always file 1. STATUS lists other information about a datafile. If a datafile is part of the SYSTEM tablespace, its status is SYSTEM (unless it requires recovery). If a datafile in a non-SYSTEM tablespace is online, its status is ONLINE. If a datafile in a non-SYSTEM tablespace is offline, its status can be either OFFLINE or RECOVER. CHECKPOINT lists the final SCN (system change number) written for a datafile's most recent checkpoint.

> **See Also:** *Oracle9i Database Reference* for a complete description of these views

13

Managing Undo Space

This chapter describes how to manage undo space, either by using undo tablespaces or by using rollback segments. It contains the following topics:

- What is Undo?
- Specifying the Mode for Undo Space Management
- Managing Undo Tablespaces
- Managing Rollback Segments

See Also:

- Chapter 3, "Using Oracle-Managed Files" for information about creating an undo tablespace whose datafiles are both created and managed by the Oracle database server
- *Oracle9i Real Application Clusters Administration* for information about managing undo space in an Oracle Real Application Clusters environment.

What is Undo?

Every Oracle database must have a method of maintaining information that is used to roll back, or undo, changes to the database. Such information consists of records of the actions of transactions, primarily before they are committed. Oracle refers to these records collectively as **undo**.

Undo records are used to:

- Roll back transactions when a ROLLBACK statement is issued
- Recover the database
- Provide read consistency

When a rollback statement is issued, undo records are used to undo changes that were made to the database by the uncommitted transaction. During database recovery, undo records are used to undo any uncommitted changes applied from the redo log to the datafiles. Undo records provide read consistency by maintaining the before image of the data for users who are accessing the data at the same time that another user is changing it.

Historically, Oracle has used rollback segments to store undo. Space management for these rollback segments has proven to be quite complex. Oracle now offers another method of storing undo that eliminates the complexities of managing rollback segment space, and enables DBAs to exert control over how long undo is retained before being overwritten. This method uses an undo tablespace. Both of these methods of managing undo space are discussed in this chapter.

You cannot use both methods in the same database instance, although for migration purposes it is possible, for example, to create undo tablespaces in a database that is using rollback segments, or to drop rollback segments in a database that is using undo tablespaces. However, you must shutdown and restart your database in order to effect the switch to another method of managing undo.

Note: Oracle always uses a SYSTEM rollback segment for performing system transactions. There is only one SYSTEM rollback segment and it is created automatically at CREATE DATABASE time and is always brought online at instance startup. You are not required to perform any operations to manage the SYSTEM rollback segment.

See Also: *Oracle9i Database Concepts* for more information about undo and managing undo space

Specifying the Mode for Undo Space Management

If you use the rollback segment method of managing undo space, you are said to be operating in the manual undo management mode. If you use the undo tablespace method, you are operating in the automatic undo management mode. You determine the mode at instance startup using the UNDO_MANAGEMENT initialization parameter.

Starting an Instance in Automatic Undo Management Mode

The following initialization parameter setting causes the STARTUP command to start an instance in automatic undo management mode:

```
UNDO_MANAGEMENT = AUTO
```

An undo tablespace must be available, into which Oracle will store undo records. The default undo tablespace is created at database creation, or an undo tablespace can be created explicitly. The methods of creating an undo tablespace are explained in "Creating an Undo Tablespace" on page 13-6

When the instance starts up, Oracle automatically selects for use the first available undo tablespace. If there is no undo tablespace available, the instance starts, but uses the SYSTEM rollback segment. This is not recommended in normal circumstances, and an alert message is written to the alert file to warn that the system is running without an undo tablespace.

You can optionally specify at startup that you want an Oracle instance to use a specific undo tablespace. This is done by setting the UNDO_TABLESPACE initialization parameter. For example:

```
UNDO_TABLESPACE = undotbs_01
```

In this case, if you have not already created the undo tablespace (in this example, undotbs_01), the STARTUP command will fail. The UNDO_TABLESPACE parameter can be used to assign a specific undo tablespace to an instance in an Oracle Real Application Clusters environment.

The following is a summary of the initialization parameters for automatic undo management mode:

Initialization Parameter	Description
UNDO_MANAGEMENT	If AUTO, use automatic undo management mode. If MANUAL, use manual undo management mode.
UNDO_TABLESPACE	A dynamic parameter specifying the name of an undo tablespace to use.
UNDO_RETENTION	A dynamic parameter specifying the length of time to retain undo. Default is 900 seconds.
UNDO_SUPPRESS_ERRORS	If TRUE, suppress error messages if manual undo management SQL statements are issued when operating in automatic undo management mode. If FALSE, issue error message. This is a dynamic parameter.

If the initialization parameter file contains parameters relating to manual undo management, they are ignored.

To learn how to manage undo tablespaces, see "Managing Undo Tablespaces" on page 13-5.

> **See Also:** *Oracle9i Database Reference* for complete descriptions of initialization parameters used in automatic undo management mode

Starting an Instance in Manual Undo Management Mode

The following initialization parameter setting causes the STARTUP command to start an instance in manual undo management mode:

```
UNDO_MANAGEMENT = MANUAL
```

If the UNDO_MANAGEMENT initialization parameter is not specified, the instance starts in manual undo management mode. If an UNDO_TABLESPACE initialization parameter is found, it is ignored. For DBAs who want to run their databases in manual undo management mode, their existing initialization parameter file can be used without any changes.

When the instance starts up, it brings online a number of rollback segments as determined by either of the following:

- The ROLLBACK_SEGMENTS initialization parameter
- The TRANSACTIONS and TRANSACTIONS_PER_ROLLBACK_SEGMENT initialization parameters

The following is a summary of initialization parameters that can be specified with manual undo management mode.

Initialization Parameter	Description
ROLLBACK_SEGMENTS	Specifies the rollback segments to be acquired at start up
TRANSACTIONS	Specifies the maximum number of concurrent transactions
TRANSACTIONS_PER_ROLLBACK_SEGMENT	Specifies the number of concurrent transactions that each rollback segment is expected to handle
MAX_ROLLBACK_SEGMENTS	Specifies the maximum number of rollback segments that can be online for any instance

To learn how to manage rollback segments, see "Managing Rollback Segments" on page 13-13.

> **See Also:** *Oracle9i Database Reference* for complete descriptions of initialization parameters used in manual undo management mode

Managing Undo Tablespaces

Oracle strongly ‘recommends operating in automatic undo management mode. The database server can manage undo more efficiently, and automatic undo management mode is less complex to implement and manage. The following sections guide you in the management of undo tablespaces:

- Creating an Undo Tablespace
- Altering an Undo Tablespace
- Dropping an Undo Tablespace
- Switching Undo Tablespaces
- Establishing User Quotas for Undo Space
- Setting the Retention Period for Undo Information
- Viewing Information About Undo Space

> **See Also:** *Oracle9i SQL Reference* for complete descriptions of the SQL statements discussed in the following sections

Creating an Undo Tablespace

There are two methods of creating an undo tablespace. The first method creates the undo tablespace when the CREATE DATABASE statement is issued. This occurs when you are creating a new database, and the instance is started in automatic undo management mode (UNDO_MANAGEMENT = AUTO). The second method is used with an existing database. It uses the CREATE UNDO TABLESPACE statement.

You cannot create database objects in an undo tablespace. It is reserved for system-managed undo data.

Using CREATE DATABASE to Create an Undo Tablespace

You can create a specific undo tablespace using the UNDO TABLESPACE clause of the CREATE DATABASE statement. But, this clause is not required.

If the UNDO TABLESPACE clause is not specified and the CREATE DATABASE statement is executed in automatic undo management mode, a default undo tablespace is created with the name SYS_UNDOTBS. This tablespace is allocated from the default set of files used by the CREATE DATABASE statement and its attributes are determined by Oracle. The initial size is 10M, and it is autoextensible. This method of creating an undo tablespace is only recommended to users who do not have any specific requirements for allocation of undo space.

The following statement illustrates using the UNDO TABLESPACE clause in a CREATE DATABASE statement. The undo tablespace is named undotbs_01 and one datafile, /u01/oracle/rbdb1/undo0101.dbf, is allocated for it.

```
CREATE DATABASE rbdb1
     CONTROLFILE REUSE
...
     UNDO TABLESPACE undotbs_01 DATAFILE '/u01/oracle/rbdb1/undo0101.dbf'
```

If the undo tablespace cannot be created successfully during CREATE DATABASE, the entire CREATE DATABASE operation fails. You must clean up the database files, correct the error and retry the CREATE DATABASE operation.

Using the CREATE UNDO TABLESPACE Statement

The CREATE UNDO TABLESPACE statement is the same as the CREATE TABLESPACE statement, but the UNDO keyword is specified. Oracle determines most of the attributes of the undo tablespace, you can specify only the DATAFILE clause.

This example creates the undotbs_02 undo tablespace:

```
CREATE UNDO TABLESPACE undotbs_02
     DATAFILE '/u01/oracle/rbdb1/undo0201.dbf' SIZE 2M REUSE AUTOEXTEND ON;
```

Altering an Undo Tablespace

Undo tablespaces are altered using the ALTER TABLESPACE statement. However, since most aspects of undo tablespaces are system managed, you need only be concerned with the following actions:

- Adding a datafile
- Renaming a datafile
- Bringing a datafile online or taking it offline
- Beginning or ending an open backup on a datafile

These are also the only attributes you are permitted to alter.

If an undo tablespace runs out of space, or you want to prevent it from doing so, you can add more files to it or resize existing datafiles.

The following example adds another datafile to undo tablespace undotbs_01:

```
ALTER TABLESPACE undotbs_01
     ADD DATAFILE '/u01/oracle/rbdb1/undo0102.dbf' AUTOEXTEND ON NEXT 1M
         MAXSIZE UNLIMITED;
```

You can use the ALTER DATABASE ... DATAFILE statement to resize or extend a datafile.

See Also: "Changing a Datafile's Size" on page 12-6

Dropping an Undo Tablespace

Use the DROP TABLESPACE statement to drop an undo tablespace. The following example drops the undo tablespace undotbs_01:

```
DROP TABLESPACE undotbs_01;
```

An undo tablespace can only be dropped if it is not currently used by any instance. If the undo tablespace contains any outstanding transactions (for example, a transaction died but has not yet been recovered), the DROP TABLESPACE statement fails. However, since DROP TABLESPACE drops an undo tablespace even if it contains unexpired undo information (within retention period), you must be careful not to drop an undo tablespace if undo information is needed by some existing queries.

DROP TABLESPACE for undo tablespaces behaves like DROP TABLESPACE ... INCLUDING CONTENTS. All contents of the undo tablespace are removed.

Switching Undo Tablespaces

You can switch from using one undo tablespace to another. Because the UNDO_TABLESPACE initialization parameter is a dynamic parameter, the ALTER SYSTEM SET statement can be used to assign a new undo tablespace.

The following statement effectively switches to a new undo tablespace:

```
ALTER SYSTEM SET UNDO_TABLESPACE = undotbs_02;
```

Assuming undotbs_01 is the current undo tablespace, after this command successfully executes, the instance uses undotbs_02 in place of undotbs_01 as its undo tablespace.

If any of the following conditions exist for the tablespace being switched to, an error is reported and no switching occurs:

- The tablespace does not exist,
- The tablespace is not an undo tablespace
- The tablespace is already being used by another instance

The database is online while the switch operation is performed, and user transactions can be executed while this command is being executed. When the switch operation completes successfully, all transactions started after the switch operation began are assigned to transaction tables in the new undo tablespace.

The switch operation does not wait for transactions in the old undo tablespace to commit. If there are any pending transactions in the old undo tablespace, the old undo tablespace enters into a PENDING OFFLINE mode (status). In this mode, existing transactions can continue to execute, but undo records for new user transactions cannot be stored in this undo tablespace.

An undo tablespace can exist in this PENDING OFFLINE mode, even after the switch operation completes successfully. A PENDING OFFLINE undo tablespace cannot used by another instance, nor can it be dropped. Eventually, after all active transactions have committed, the undo tablespace automatically goes from the PENDING OFFLINE mode to the OFFLINE mode. From then on, the undo tablespace is available for other instances (in an Oracle Real Application Cluster environment).

If the parameter value for UNDO_TABLESPACE is set to '' (two single quotes), the current undo tablespace will be switched out without switching in any other undo tablespace. This can be used, for example, to unassign an undo tablespace in the event that you want to revert to manual undo management mode.

The following example unassigns the current undo tablespace:

```
ALTER SYSTEM SET UNDO_TABLESPACE = '';
```

Establishing User Quotas for Undo Space

Oracle's Database Resource Manager can be used to establish user quotas for undo space. The Database Resource Manager directive, UNDO_POOL, allows DBAs to limit the amount of undo space consumed by a group of users (resource consumer group).

You can specify an undo pool for each consumer group. An undo pool controls the amount of total undo that can be generated by a consumer group. When the total undo generated by a consumer group exceeds its undo limit, the current UPDATE transaction generating the redo is terminated. No other members of the consumer group can perform further updates until undo space is freed from the pool.

When no UNDO_POOL directive is explicitly defined, users are allowed unlimited undo space.

See Also: Chapter 27, "Using the Database Resource Manager"

Setting the Retention Period for Undo Information

Committed undo information normally is lost when its undo space is overwritten by a newer transaction. But for consistent read purposes, long running queries might require old undo information for undoing changes and producing older images of data blocks. The initialization parameter, UNDO_RETENTION, provides a means of explicitly specifying the amount of undo information to retain. With a proper setting, long running queries can complete without risk of receiving the "snapshot too old" error.

Specifying the Retention Period

Retention is specified in units of seconds, for example 500 seconds. It is persistent and can survive system crashes. That is, undo generated before an instance crash, is retained until its retention time has expired even across restarting the instance. When the instance is recovered, undo information will be retained based on the current setting of the UNDO_RETENTION initialization parameter.

The UNDO_RETENTION parameter can be specified initially in the initialization parameter file, used by the STARTUP process.

```
UNDO_RETENTION = 10
```

The UNDO_RETENTION parameter value can also be changed dynamically at any time using the ALTER SYSTEM command.

```
ALTER SYSTEM SET UNDO_RETENTION = 5
```

The effect of the UNDO_RETENTION parameter is immediate, but it can only be honored if the current undo tablespace has enough space for the active transactions. If an active transaction requires undo space and the undo tablespace does not have available space, the system starts reusing unexpired undo space. Such action can potentially cause some queries to fail with the "snapshot too old" error.

If the UNDO_RETENTION initialization parameter is not specified, the default value is 900 seconds.

Retention Period for Flashback Queries

The retention period for undo information is an important factor in the execution of flashback queries. Oracle's flashback query feature enables you to see a consistent version of the database as of a specified time in the past. You can execute queries, or even applications, as of a previous time in the database. The Oracle supplied DBMS_FLASHBACK package implements this functionality.

The retention period determines how far back in time a database version can be established for flashback queries. Specifically, you must establish an undo retention interval that is long enough that it enables you to construct a snapshot of the database for the oldest version of the database that you are interested in. For example, if an application requires that a version of the database be available reflecting its content 12 hours previously, then UNDO_RETENTION must be set to 43200.

See Also:

- *Oracle9i Application Developer's Guide - Fundamentals* for more information about using the flashback query feature
- *Oracle9i Supplied PL/SQL Packages and Types Reference* for a description of the DBMS_FLASHBACK package

Space Requirement For Undo Retention

Given a specific UNDO_RETENTION parameter setting and some system statistics, the amount of undo space required to satisfy the undo retention requirement can be estimated using the following formula:

UndoSpace = UR * UPS + overhead

where:

UndoSpace	=	number of undo blocks
UR	=	UNDO_RETENTION in seconds
UPS	=	undo blocks for each second
overhead	=	small overhead for metadata (transaction tables, bitmaps, and so forth)

As an example, if UNDO_RETENTION is set to 2 hours, and the transaction rate (UPS) is 200 undo blocks for each second, with a 4K block size, the required undo space is computed as follows:

(2 * 3600 * 200 * 4K) = 5.8GBs.

Such computation can be performed by using information in the V$UNDOSTAT view. In the steady state, you can query the view to obtain the transaction rate. The overhead figure can also be obtained from the view.

Viewing Information About Undo Space

This section lists views that are useful for viewing information about undo space in the automatic undo management mode. In addition to views listed here, you can obtain information from the views available for viewing tablespace and datafile information.

See Also:

- "Viewing Tablespace Information" on page 11-46
- "Viewing Datafile Information" on page 12-14

Undo Space Views

The following views are available for obtaining undo space information:

View	Description
V$UNDOSTAT	Contains statistics for monitoring and tuning undo space. Use this view to help estimate the amount of undo space required for the current workload. Oracle also uses this information to help tune undo usage in the system. This view is available in both the automatic undo management and the manual undo management modes.
V$ROLLSTAT	For automatic undo management mode, information reflects behavior of the undo segments in the undo tablespace
V$TRANSACTION	Contains undo segment information
DBA_UNDO_EXTENTS	Shows the commit time for each extent in the undo tablespace.

See Also: *Oracle9i Database Reference* for complete descriptions of the views used in automatic undo management mode

Monitoring Undo Space

The V$UNDOSTAT view is useful for monitoring the effects of transaction execution on undo space in the current instance. Statistics are available for undo space consumption, transaction concurrency, and length of queries in the instance.

Each row in the view contains statistics collected in the instance for a ten-minute interval. The rows are in descending order by the BEGIN_TIME column value. Each row belongs to the time interval marked by (BEGIN_TIME, END_TIME). Each column represents the data collected for the particular statistic in that time interval. The first row of the view contains statistics for the (partial) current time period. The view contains a total of 144 rows, spanning a 24-hour cycle.

The following example shows the results of a query on the V$UNDOSTAT view.

```
SELECT  BEGIN_TIME, END_TIME, UNDOTSN, UNDOBLKS, TXNCOUNT,
        MAXCONCURRENCY AS "MAXCON"
     FROM V$UNDOSTAT;
```

The results are:

```
BEGIN_TIME          END_TIME            UNDOTSN UNDOBLKS TXNCOUNT MAXCON
------------------- ------------------- ------- -------- -------- ------
07/28/2000 18:26:28  07/28/2000 18:32:13       2      709       55       2
07/28/2000 18:16:28  07/28/2000 18:26:28       2      448       12       2
07/28/2000 14:36:28  07/28/2000 18:16:28       1        0        0       0
07/28/2000 14:26:28  07/28/2000 14:36:28       1        1        1       1
```

```
07/28/2000 14:16:28  07/28/2000 14:26:28       1       10       1       1
...
```

The above example shows how undo space is consumed in the system for the previous 24 hours from the time 18:32:13.

Managing Rollback Segments

If you choose to use rollback segments to store undo, the following sections guide you in their management:

- Guidelines for Managing Rollback Segments
- Creating Rollback Segments
- Altering Rollback Segments
- Explicitly Assigning a Transaction to a Rollback Segment
- Dropping Rollback Segments
- Viewing Rollback Segment Information

Note: The use of rollback segments for managing undo space is being deprecated. Oracle strongly recommends that you use automatic undo management and manage undo space using an UNDO_TABLESPACE.

Guidelines for Managing Rollback Segments

This section describes guidelines to consider before creating or managing the rollback segments of your databases, and contains 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

> **See Also:** *Oracle9i Database Concepts* for additional information about rollback segments

Use Multiple Rollback Segments

Using multiple rollback segment distributes rollback segment contention across many segments and improves system performance. Oracle assigns transactions to rollback segments in round-robin fashion. This results in a fairly even distribution of the number of transactions for each rollback segment. It is also possible to assign a transaction to a specific rollback segment, but this is usually not done.

When a database is created, a single rollback segment named SYSTEM is created in the SYSTEM tablespace. This rollback segment is used in special ways by the Oracle database server, and is not intended for general use. Before you write to objects created in non-SYSTEM tablespaces, you must create and bring online at least one additional rollback segment in a non-SYSTEM tablespace.

> **Note:** When you are initially creating the database, and in order to create additional tablespaces and rollback segments, you must create a second rollback segment in the SYSTEM tablespace. Once these additional rollback segments are created, you should activate the new rollback segments and make the second rollback segment unavailable.

At startup, an instance always acquires (brings online) the SYSTEM rollback segment in addition to any other rollback segments it needs or is directed to acquire. When 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; plan your number of rollback segments to avoid this.

There are a couple of options for activating multiple rollback segments when you start up an instance.

- Use public rollback segments and include the TRANSACTIONS and TRANSACTIONS_PER_ROLLBACK_SEGMENT initialization parameters in your initialization parameter file
- Use private or public rollback segments and specify their names in the ROLLBACK_SEGMENTS initialization parameter

These options are discussed in other guidelines that follow.

There is a limit on the number of rollback segments that can be open simultaneously. This limit is set by the MAX_ROLLBACK_SEGMENTS initialization parameter. Ensure that this parameter is set to a value higher than the number of rollback segments specified in the ROLLBACK_SEGMENTS initialization parameter.

> **See Also:** *Oracle9i Database Reference* for additional information about the TRANSACTIONS, TRANSACTIONS_PER_ROLLBACK_SEGMENT, and ROLLBACK_SEGMENT initialization parameters

Choose Between Public and Private Rollback Segments

A **private rollback segment** must be acquired explicitly by an instance. This can occur at database startup when the rollback segments name is included 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 the statement to do so. In an Oracle Real Application Clusters environment, private rollback segments allow an instance to acquire specific rollback segments.

Public rollback segments form a pool of rollback segments that any instance requiring a rollback segment can use. An instance decides how many of these rollback segments to automatically acquire at instance startup based on the values of the TRANSACTIONS and TRANSACTIONS_PER_ROLLBACK_SEGMENT initialization parameters. Public rollback segments can be shared between Oracle Real Application Cluster instances.

If you are not using the Oracle9*i* Real Application Clusters feature, private and public rollback segments function similarly.

Specify Rollback Segments to Acquire Automatically

When many transactions are concurrently proceeding, they simultaneously generate rollback information. A way of specifying that an appropriate number of rollback segments be acquired automatically at instance startup is to include the TRANSACTIONS and TRANSACTIONS_PER_ROLLBACK_SEGMENT initialization parameters. You must also be using public rollback segments.

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 will need to handle with the initialization parameter TRANSACTIONS_PER_ROLLBACK_SEGMENT. Then, when an instance opens a database, it attempts to acquire at least *n* rollback segments, where *n*=TRANSACTIONS / TRANSACTIONS_PER_ROLLBACK_SEGMENT. When creating your database, or subsequently, you should have created at least *n* public rollback segments.

If you choose to use private rollback segments, these rollback segments will be acquired automatically by an instance at startup if you specify the rollback segments by name in the ROLLBACK_SEGMENTS initialization parameter in the instance's parameter file.

If you use both private and public rollback segments the following might occur. An instance acquires all the rollback segments listed in the ROLLBACK_SEGMENTS initialization parameter, even if more than TRANSACTIONS / TRANSACTIONS_PER_ROLLBACK_SEGMENT segments are specified.

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. 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 (*s*) of each extent of the rollback segment:

$$s = T / n$$

where:

s = calculated size, in bytes, of each extent initially allocated

T = total initial rollback segment size, in bytes

n = number of extents 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 "Monitoring Rollback Segment Statistics" on page 13-27.

Place Rollback Segments in a Separate Tablespace

If possible, create one or more tablespaces 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. 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 contained 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 an Oracle Real Application Clusters environment, it is not necessary to specify `PRIVATE` or `PUBLIC`. The default is `PRIVATE`.

```
CREATE ROLLBACK SEGMENT rbs_02 TABLESPACE rbsspace;
```

> **See Also:** *Oracle9i SQL Reference* for exact syntax, restrictions, and authorization requirements for the SQL statements used in managing rollback segments

Bringing New Rollback Segments Online

New rollback segments are initially offline. You must issue an `ALTER ROLLBACK SEGMENT` statement to bring them online and make them available for use by transactions of an instance. This is described in "Changing the ONLINE/OFFLINE Status of Rollback Segments" on page 13-21.

If you create a private rollback segment, 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 acquired automatically by the instance at instance start up. For example, if two new private rollback segments are created and named `rbs_01` and `rbs_02`, then the `ROLLBACK_SEGMENTS` initialization parameter can be specified as follows:

```
ROLLBACK_SEGMENTS = (rbs_01, rbs_02)
```

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 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 14-9.

Oracle Corporation 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 four 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 four data blocks in any extent. If you want to convert from limited to UNLIMITED, and have less than four data blocks in an extent, your only choice is to drop and recreate the rollback segment.

> **See Also:** *Oracle9i SQL Reference* for a detailed description of storage parameters

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 discussed:

- 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 stops 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 contains the following topics:

- Bringing Rollback Segments Online Manually

- Bringing Rollback Segment Online Automatically
- 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 want to take online rollback segments offline in the following situations:

- 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 using any instance accessing the database that contains the rollback segment.

Bringing Rollback Segments Online Manually You can only bring a rollback segment online if its 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 ALTER ROLLBACK SEGMENT statement with the ONLINE option.

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 status, see "Displaying Rollback Segment Information" on page 13-26.

A rollback segment in the PARTLY AVAILABLE state contains data for an in-doubt or recovered distributed transaction, or for 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.

You might find that all rollback segments are PARTLY AVAILABLE. In this case, you can bring the PARTLY AVAILABLE segment online. 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 more efficient 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. Or, you can use public rollback segments and use the TRANSACTIONS and TRANSACTIONS_PER_ROLLBACK_SEGMENT initialization parameters.

These options are discussed in "Specify Rollback Segments to Acquire Automatically" on page 13-15.

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 attempt 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 that the rollback segment is waiting to go offline, the rollback segment's status in the view DBA_ROLLBACK_SEGS remains ONLINE. 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 13-26.

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 functions 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. Reasons for doing this include:

- You can predict the amount of rollback information generated by a transaction. You can assign the transaction to a rollback segment where you know that the rollback information will fit in the current extents of the segment. Thus, you can reduce the overhead of additional extents being dynamically allocated, and subsequently truncated.
- You know that no long running queries are concurrently reading the same tables, so if you assign small transactions to small rollback segments, those segments will most likely remain in memory.
- You have transactions that modify tables that are concurrently being read by long-running queries. You can assign these transactions to large rollback segments so that the rollback information needed for the read-consistent queries is not overwritten.

To assign a transaction to a rollback segment explicitly, use the SET TRANSACTION statement with the USE ROLLBACK SEGMENT clause. 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 automatically assigns 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 the 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, be 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.

Viewing 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 included:

- Rollback Segment Views
- Displaying Rollback Segment Information
- Monitoring Rollback Segment Statistics

- Displaying All Rollback Segments
- Displaying Whether a Rollback Segment Has Gone Offline

> **See Also:** *Oracle9i Database Reference* for more information about the data dictionary views discussed in this chapter

Rollback Segment Views

The following views are useful for displaying information about rollback segments:

View	Description
DBA_ROLLBACK_SEGS	Describes the rollback segments, including names and tablespaces
DBA_SEGMENTS	Identifies a segment as a rollback segment and contains additional segment information
V$ROLLNAME	Lists the names of all online rollback segments
V$ROLLSTAT	Contains rollback segment statistics
V$TRANSACTION	Contains undo segment information

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 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

Monitoring Rollback Segment Statistics

The V$ROLLSTAT dynamic performance view can be queried to monitor rollback segment statistics. It must be joined with the V$ROLLNAME view to map its segment number to its name.

Some specific columns of interest in the V$ROLLSTAT view 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.
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 SHRINKS 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 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 V$ROLLSTAT 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 an Oracle Real Application Clusters configuration, this query displays information for rollback segments of the current instance only, not those of other instances.

Part III

Schema Objects

Part III describes the creation and maintenace of schema objects in the Oracle database. It includes the following chapters:

14

Managing Space for Schema Objects

This chapter offers guidelines for managing space for schema objects. It contains the following topics:

- Managing Space in Data Blocks
- Setting Storage Parameters
- Managing Resumable Space Allocation
- 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 later chapters.

Managing Space in Data Blocks

This section describes aspects of managing space in data blocks. Data blocks are the finest level of granularity of the structure in which database data is stored on disk. The size of a data block is specified (or defaulted) at database creation.

The PCTFREE and PCTUSED parameters are physical attributes that can be specified when a schema object is created or altered. These parameters allow you to control the use of the free space within a data block. This free space is available for inserts and updates of rows of data.

The PCTFREE and PCTUSED parameters allow you to:

- Improve performance when writing and retrieving data
- Decrease the amount of unused space in data blocks
- Decrease the amount of row chaining between data blocks

The INITRANS and MAXTRANS parameters are also physical attributes that can be specified when schema objects are created or altered. These parameters control the number of concurrent update transactions allocated for data blocks of a schema object, which in turn affects space usage in data block headers and can have an impact upon data block free space.

The following topics are contained in this section:

See Also:

- *Oracle9i Database Concepts* for more information on data blocks
- *Oracle9i SQL Reference* for syntax and other details of the PCTFREE, PCTUSED, INITRANS, and MAXTRANS physical attributes parameters

Specifying the PCTFREE Parameter

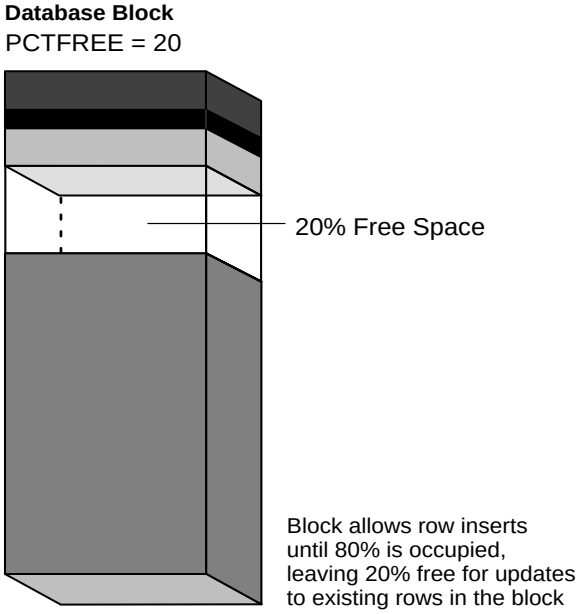
The PCTFREE parameter is used to set the percentage of a block to be reserved for possible updates to rows that already are contained in that block. For example,

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 14–1 illustrates PCTFREE.

Figure 14–1 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.

Ensure that you understand the nature of a 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.

> **Note:** If you alter the PCTFREE value for an object in a tablespace with segments management specified as AUTO, you should also invoke the DBMS_REPAIR.SEGMENT_FIX_STATUS procedure. This ensures that bitmap status is recomputed to reflect the new PCTFREE value for data blocks. See Chapter 22, "Detecting and Repairing Data Block Corruption".

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.

Effects of Specifying a Smaller PCTFREE

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 for each block)

A small PCTFREE might be suitable, for example, for a segment that is rarely changed.

Effects of Specifying a Larger PCTFREE

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 for each 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.

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.

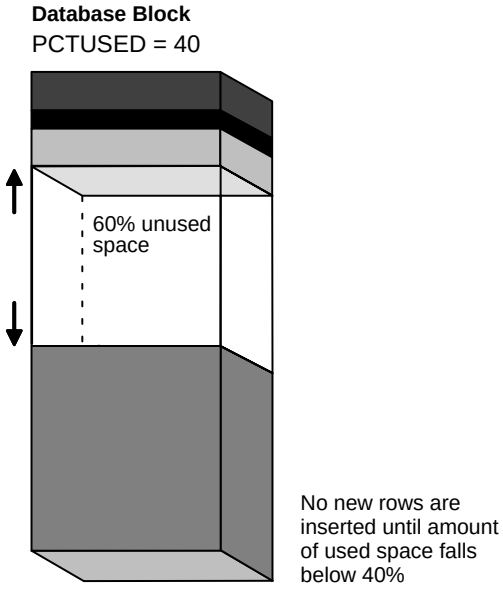
Specifying the PCTUSED Parameter

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 14–2 illustrates this.

Figure 14–2 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.

Note: The PCTUSED parameter is ignored for objects created in locally managed tablespaces with segment space management specified as AUTO. This form of segment space management is discussed in "Specifying Segment Space Management in Locally Managed Tablespaces" on page 11-7.

Effects of Specifying a Smaller PCTUSED

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

Effects of Specifying a Larger PCTUSED

A larger PCTUSED has the following effects:

- Improves space efficiency
- Increases processing cost during INSERT and UPDATE

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.
- 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.

The following table contains examples that show how and why specific values for PCTFREE and PCTUSED are specified for tables.

Example	Scenario	Settings	Explanation
1	Common activity includes UPDATE statements that increase the size of the rows.	PCTFREE=20 PCTUSED=40	PCTFREE is set to 20 to allow enough room for rows that increase in size as a result of updates. PCTUSED is set to 40 so that less processing is done during high update activity, thus improving performance.
2	Most activity includes INSERT and DELETE statements, and UPDATE statements that do not increase the size of affected rows.	PCTFREE=5 PCTUSED=60	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	Scenario	Settings	Explanation
3	The table is very large and storage is a primary concern. Most activity includes read-only transactions.	PCTFREE=5 PCTUSED=40	PCTFREE is set to 5 because this is a large table and you want to completely fill each block.

Specifying the Transaction Entry Parameters: INITRANS and MAXTRANS

INITRANS specifies the number of DML transaction entries for which space is initially reserved in the data block header. Space is reserved in the headers of all data blocks in the associated segment.

As multiple transactions concurrently access the rows of the same data block, space is allocated for each 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 INITRANS and MAXTRANS parameters for the data blocks allocated to a specific schema object should be set individually for each schema 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. This eliminates the overhead of having to allocate transaction entry space, as required when the object is in use. Also, allow a higher MAXTRANS so that no user has to wait to access necessary data blocks.

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, materialized views, and materialized view 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, use the STORAGE clause of the CREATE or ALTER statement for the individual object. The following example illustrates specifying storage parameters when a table is being created:

```
CREATE TABLE  players
        (code  NUMBER(10) PRIMARY KEY,
         lastname  VARCHAR(20),
         firstname VARCHAR(15),
```

```
   position  VARCHAR2(20),
   team VARCHAR2(20))
PCTFREE 10
PCTUSED 40
STORAGE
   (INITIAL 25K
    NEXT 10K
    MAXEXTENTS 10
    MINEXTENTS 3);
```

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:

- *Oracle9i SQL Reference* contains detailed information about storage parameters, including information on how Oracle rounds values and usage restrictions
- Your operating system specific documentation because the settings for some storage values are operating system specific

INITIAL

The size, in bytes, of the first extent allocated when a segment is created. This parameter cannot be specified in an ALTER statement.

Default:	5 data blocks
Minimum:	2 data blocks (in dictionary-managed tablespaces), 3 data blocks (in locally managed tablespaces)
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 Real Application Cluster instances to map each instance to one free list group.

Default:	1
Minimum:	1
Maximum:	Depends on number of Oracle Real Application Cluster instances

This parameter is ignored for objects created in locally managed tablespaces with segment space management specified as AUTO.

For information on the use of this parameter, see *Oracle9i Real Application Clusters Administration*.

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

This parameter is ignored for objects created in locally managed tablespaces with segment space management specified as AUTO.

The use of this parameter is discussed in *Oracle9i Database Performance Guide and Reference*.

OPTIMAL

Relevant only to rollback segments. See Chapter 13, "Managing Undo Space" 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 *Oracle9i Database Performance Guide and Reference*.

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.

Setting Storage Parameters for Data Segments

You set the storage parameters for the data segment of a nonclustered table, materialized view, or materialized view log using the `STORAGE` clause of the `CREATE` or `ALTER` statement for tables, materialized views, or materialized view 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 materialized views into the cluster. Storage parameters specified when creating or altering a *clustered* table or materialized view 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 either of the following ways:

- In the ENABLE ... USING INDEX clause of the CREATE TABLE or ALTER TABLE statement
- In the STORAGE clause of the ALTER INDEX statement

Setting Storage Parameters for LOBs, Varrays, and Nested Tables

A table or materialized view can contain LOB, varray, or nested table column types. These entities can be stored in their own segments. 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.

See Also:

- *Oracle9i Application Developer's Guide - Large Objects (LOBs)*
- *Oracle9i Application Developer's Guide - Fundamentals*
- *Oracle9i SQL Reference*

All of the above books contain more information about creating tables containing LOBs, varrays, and nested tables.

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 (where higher numbers take precedence over lower numbers):

1. ALTER [TABLE|CLUSTER|MATERIALIZED VIEW|MATERIALIZED VIEW LOG|INDEX|ROLLBACK] SEGMENT statement
2. CREATE [TABLE|CLUSTER|MATERIALIZED VIEW|MATERIALIZED VIEW LOG|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.

Example of How Storage Parameters Effect Space Allocation

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 14–1 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.

Managing Resumable Space Allocation

Oracle provides a means for suspending, and later resuming, the execution of large database operations in the event of space allocation failures. This enables you to take corrective action instead of the Oracle database server returning an error to the user. After the error condition is corrected, the suspended operation automatically resumes. This feature is called **resumable space allocation**. The statements that are affected are called resumable statements.

This section contains the following topics:

- Resumable Space Allocation Overview
- Enabling and Disabling Resumable Space Allocation
- Detecting Suspended Statements
- Resumable Space Allocation Example: Registering an AFTER SUSPEND Trigger

Resumable Space Allocation Overview

This section provides an overview of resumable space allocation. It describes how resumable statements work, and specifically defines qualifying statements and error conditions.

How Resumable Statements Work

The following is an overview of how resumable statements work. Details are contained in later sections.

1. A statement executes in a resumable mode only when the client explicitly enables resumable semantics for the session using the `ALTER SESSION` statement.
2. A resumable statement is suspended when one of the following conditions occur (these conditions result in corresponding errors being signalled for nonresumable statements):
   - Out of space condition
   - Maximum extents reached condition
   - Space quota exceeded condition.
3. On suspending a resumable statement's execution, there are mechanisms to perform user supplied operations, log errors, and to query the status of the statement execution. When a resumable statement is suspended the following actions are taken:
   - The error is reported in the alert log.
   - If the user registered a trigger on the `AFTER SUSPEND` system event, the user trigger is executed. A user supplied PL/SQL procedure can access the error message data using the `DBMS_RESUMABLE` package and `DBA/USER_RESUMABLE` view.
4. Suspending a statement automatically results in suspending the transaction. Thus all transactional resources are held through a statement suspend and resume.
5. When the error condition disappears (for example, as a result of user intervention or perhaps sort space released by other queries), the suspended statement automatically resumes execution.

6. A suspended statement can be forced to throw the exception using the `DBMS_RESUMABLE.ABORT()` procedure. This procedure can be called by a DBA, or by the user who issued the statement.
7. A suspension time out interval is associated with resumable statements. A resumable statement that is suspended for the timeout interval (the default is two hours) wakes up and returns the exception to the user.
8. A resumable statement can be suspended and resumed multiple times during execution.

What Operations are Resumable?

> **Note:** Resumable space allocation is fully supported when using locally managed tablespaces. There are certain limitations when using dictionary-managed tablespaces. See "Resumable Space Allocation Limitations for Dictionary-Managed Tablespaces" on page 14-20 for details.

The following operations are resumable:

- Queries

  `SELECT` statements that run out of temporary space (for sort areas) are candidates for resumable execution. When using OCI, the calls `OCIStmtExecute()` and `OCIStmtFetch()` are candidates.

- DML

  `INSERT`, `UPDATE`, and `DELETE` statements are candidates. The interface used to execute them does not matter; it can be OCI, JSQL, PL/SQL, or another interface. Also, `INSERT INTO ... SELECT` from external tables can be resumable.

- Import/Export

  As for SQL*Loader, a command line parameter controls whether statements are resumable after recoverable errors.

- DDL

  The following statements are candidates for resumable execution:

  - `CREATE TABLE ... AS SELECT`
  - `CREATE INDEX`

- ALTER INDEX ... REBUILD
- ALTER TABLE ... MOVE PARTITION
- ALTER TABLE ... SPLIT PARTITION
- ALTER INDEX ... REBUILD PARTITION
- ALTER INDEX ... SPLIT PARTITION
- CREATE MATERIALIZED VIEW
- CREATE MATERIALIZED VIEW LOG

What Errors are Correctable?

There are three classes of correctable errors:

- Out of space condition

  The operation cannot acquire any more extents for a table / index / temporary segment / rollback segment / undo segment / cluster / LOB / table partition / index partition in a tablespace. For example, the following errors fall in this category:

  ```
  ORA-1650 unable to extend rollback segment ... in tablespace ...
  ORA-1653 unable to extend table ... in tablespace ...
  ORA-1654 unable to extend index ... in tablespace ...
  ```

- Maximum extents reached condition

  The number of extents in a table / index / temporary segment / rollback segment / undo segment / cluster / LOB / table partition / index partition equals the maximum extents defined on the object. For example, the following errors fall in this category:

  ```
  ORA-1628 max # extents ... reached for rollback segment ...
  ORA-1631 max # extents ... reached in table ...
  ORA-1654 max # extents ... reached in index ...
  ```

- Space quota exceeded condition

  The user has exceeded his assigned space quota in the tablespace. Specifically, this is noted by the following error:

  ```
  ORA-1536 space quote exceeded for tablespace string
  ```

Resumable Space Allocation Limitations for Dictionary-Managed Tablespaces

There are certain limitations of resumable space allocation when using dictionary-managed tablespaces. These limitations are listed below:

1. If a DDL operation such as CREATE TABLE or CREATE INDEX is executed with an explicit MAXEXTENTS setting which causes an out of space error during its execution, the operation will not be suspended. Instead, it will be aborted. This error is treated as not repairable because the properties of an object (for example, MAXEXTENTS) cannot be altered before its creation. However if a DML operation causes an already existing table or index to reach the MAXEXTENTS limit, it will be suspended and can be resumed later. This restriction can be overcome either by setting the MAXEXTENTS clause to UNLIMITED or by using locally managed tablespaces.
2. If rollback segments are located in dictionary managed tablespaces, then space allocation for rollback segments is not resumable. However, space allocation for user objects(tables, indexes, and the likes) would still be resumable. To workaround the limitation, we recommend using automatic undo management or placing the rollback segments in locally managed tablespaces.

Resumable Statements and Distributed Operations

Remote operations are not supported in resumable mode.

Parallel Execution and Resumable Statements

In parallel execution, if one of the parallel execution server processes encounters a correctable error, that server process suspends its execution. Other parallel execution server processes will continue executing their respective tasks, until either they encounter an error or are blocked (directly or indirectly) by the suspended server process. When the correctable error is resolved, the suspended process resumes execution and the parallel operation continues execution. If the suspended operation is terminated, the parallel operation aborts, throwing the error to the user.

Different parallel execution server processes may encounter one or more correctable errors. This may result in firing an AFTER SUSPEND trigger multiple times, in parallel. Also, if a parallel execution server process encounters a noncorrectable error while another parallel execution server process is suspended, the suspended statement is immediately aborted.

For parallel execution, every parallel execution coordinator and server process has its own entry in DBA/USER_RESUMABLE view.

Enabling and Disabling Resumable Space Allocation

Resumable space allocation is only possible when statements are executed within a session that has resumable mode enabled.

To enable resumable mode for a session, use the following SQL statement:

```
ALTER SESSION ENABLE RESUMABLE;
```

Because suspended statements can hold up some system resources, users must be granted the RESUMABLE system privilege before they are allowed to enable and execute resumable statements.

To disable resumable mode, issue the following statement:

```
ALTER SESSION DISABLE RESUMABLE;
```

The default for a new session is resumable mode disabled.

You can also specify a timeout interval, and you can provide a name used to identify a resumable statement. These are discussed separately in following sections.

See Also: "Setting Default Resumable Mode" on page 14-22

Specifying a Timeout Interval

When you enable resumable mode for a session, you can also specify a timeout interval, after which a suspended statement will error if no intervention has taken place. The following statement specifies that resumable transactions will time out and error after 3600 seconds:

```
ALTER SESSION ENABLE RESUMABLE TIMEOUT 3600;
```

The value of TIMEOUT remains in effect until it is changed by another ALTER SESSION ENABLE RESUMABLE statement, it is changed by another means, or the session ends. The default timeout interval is 7200 seconds.

See Also: "Changing the Timeout Interval" on page 14-22 for other methods of changing the timeout interval for resumable statements

Naming Resumable Statements

Resumable statements can be identified by name. The following statement assigns a name to resumable statements:

```
ALTER SESSION ENABLE RESUMABLE TIMEOUT 3600 NAME 'insert into table';
```

The NAME value remains in effect until it is changed by another ALTER SESSION ENABLE RESUMABLE statement, or the session ends. The default value for NAME is:

```
User USERNAME(USERID), Session SESSIONID, Instance INSTANCEID
```

The name of the statement is used to identify the resumable statement in the DBA_RESUMABLE and USER_RESUMABLE views.

Setting Default Resumable Mode

To set default resumable mode, a DBA can register a database level LOGON trigger to alter a user's session to enable resumable and set a timeout interval.

> **Note:** If there are multiple triggers registered that change default mode and timeout for resumable statements, the result will be unspecified because Oracle does not guarantee the order of trigger invocation.

Changing the Timeout Interval

In addition to the ALTER SESSION ENABLE RESUMABLE statement, there are other methods for setting or changing the timeout interval.

The DBMS_RESUMABLE package contains procedures for setting the timeout period for a specific session or for the current session. A DBA can change the default system timeout by creating a system wide AFTER SUSPEND trigger that calls DBMS_RESUMABLE to set it. For example, the following code sample sets a system wide default timeout to one hour:

```
CREATE OR REPLACE TRIGGER resumable_default_timeout
AFTER SUSPEND
ON DATABASE
BEGIN
   DBMS_RESUMABLE.SET_TIMEOUT(3600);
END;
```

Detecting Suspended Statements

When a resumable statement is suspended, the error is not raised to the client. In order for corrective action to be taken, Oracle provides alternative methods for notifying users of the error and for providing information about the circumstances.

AFTER SUSPEND System Event and Trigger

When a resumable statement encounter a correctable error, the system internally generates the AFTER SUSPEND system event. Users can register triggers for this event at both the database and schema level. If a user registers a trigger to handle this system event, the trigger is executed after a SQL statement has been suspended.

SQL statements executed within a AFTER SUSPEND trigger are always nonresumable and are always autonomous. Transactions started within the trigger use the SYSTEM rollback segment. These conditions are imposed to overcome deadlocks and reduce the chance of the trigger experiencing the same error condition as the statement.

Users can use the USER_RESUMABLE or DBA_RESUMABLE views, or the DBMS_RESUMABLE.SPACE_ERROR_INFO function, within triggers to get information about the resumable statements.

Triggers can also call the DBMS_RESUMABLE package to abort suspended statements and modify resumable timeout values.

> **See Also:** *Oracle9i Application Developer's Guide - Fundamentals* for information about system events, triggers, and attribute functions

Views Containing Information About Resumable Statements

The following views can be queried to obtain information about the status of resumable statements:

View	Description
DBA_RESUMABLE USER_RESUMABLE	These views contain rows for all currently executing or suspended resumable statements. They can be used by a DBA, AFTER SUSPEND trigger, or another session to monitor the progress of, or obtain specific information about, resumable statements.
V$SESSION_WAIT	When a statement is suspended the session invoking the statement is put into a wait state. A row is inserted into this view for the session with the EVENT column containing "suspended on space error".

> **See Also:** *Oracle9i Database Reference* for specific information about the columns contained in these views

DBMS_RESUMABLE Package

The DBMS_RESUMABLE package helps control resumable statements. The following procedures are available:

Procedure	Description
ABORT(sessionID)	This procedure aborts a suspended resumable statement. The parameter sessionID is the session ID in which the statement is executing. For parallel DML/DDL, sessionID is any session ID which participates in the parallel DML/DDL. Oracle guarantees that the ABORT operation always succeeds. It may be called either inside or outside of the AFTER SUSPEND trigger. The caller of ABORT must be the owner of the session with sessionID, have ALTER SYSTEM privilege, or have DBA privileges.
GET_SESSION_ TIMEOUT(sessionID)	This function returns the current timeout value of resumable statements for the session with sessionID. This returned timeout is in seconds. If the session does not exist, this function returns -1.
SET_SESSION_ TIMEOUT(sessionID, timeout)	This procedure sets the timeout interval of resumable statements for the session with sessionID. The parameter timeout is in seconds. The new timeout setting will applies to the session immediately. If the session does not exist, no action is taken.
GET_TIMEOUT()	This function returns the current timeout value of resumable statements for the current session. The returned value is in seconds.
SET_ TIMEOUT(timeout)	This procedure sets a timeout value for resumable statements for the current session. The parameter timeout is in seconds. The new timeout setting applies to the session immediately.

See Also: *Oracle9i Supplied PL/SQL Packages and Types Reference* for syntax and additional information about using the DBMS_ RESUMABLE package

Resumable Space Allocation Example: Registering an AFTER SUSPEND Trigger

This example illustrates the use of resumable statements. A system wide AFTER SUSPEND trigger is created and registered as user SYS at the database level. Whenever a resumable statement is suspended in any session, this trigger can have either of two effects:

- If the rollback segment has reached its space limit, then a message is sent to the DBA and the statement is aborted.
- If any other recoverable error has occurred, the timeout interval is reset to 8 hours.

```
CREATE OR REPLACE TRIGGER resumable_default
AFTER SUSPEND
ON DATABASE
DECLARE
   /* declare transaction in this trigger is autonomous */
   /* this is not required because transactions within a trigger
      are always autonomous */
   PRAGMA AUTONOMOUS_TRANSACTION;
   cur_sid           NUMBER;
   cur_inst          NUMBER;
   errno             NUMBER;
   err_type          VARCHAR2;
   object_owner      VARCHAR2;
   object_type       VARCHAR2;
   table_space_name  VARCHAR2;
   object_name       VARCHAR2;
   sub_object_name   VARCHAR2;
   error_txt         VARCHAR2;
   msg_body          VARCHAR2;
   ret_value         BOOLEAN;
   mail_conn         UTL_SMTP.CONNECTION;
BEGIN
   -- Get session ID
   SELECT DISTINCT(SID) INTO cur_SID FROM V$MYSTAT;

   -- Get instance number
   cur_inst := userenv('instance');

   -- Get space error information
   ret_value :=
   DBMS_RESUMABLE.SPACE_ERROR_INFO(err_type,object_type,object_owner,
        table_space_name,object_name, sub_object_name);
   /*
   -- If the error is related to rollback segments, log error, send email
   -- to DBA, and abort the statement. Otherwise, set timeout to 8 hours.
   --
   -- sys.rbs_error is created by DBA manually and defined as
   -- sql_text VARCHAR2(1000), error_msg VARCHAR2(4000),
   -- suspend_time DATE)
```

```
   */

   IF OBJECT_TYPE = 'ROLLBACK SEGMENT' THEN
       /* LOG ERROR */
       INSERT INTO sys.rbs_error (
           SELECT SQL_TEXT, ERROR_MSG, SUSPEND_TIME
           FROM DBMS_RESUMABLE
           WHERE SESSION_ID = cur_sid AND INSTANCE_ID = cur_inst
        );
       SELECT ERROR_MSG INTO error_txt FROM DBMS_RESUMABLE
           where SESSION_ID = cur_sid and INSTANCE_ID = cur_inst;

        -- Send email to receipient via UTL_SMTP package
        msg_body:='Subject: Space Error Occurred

                   Space limit reached for rollback segment ' || object_name ||
                   on ' || TO_CHAR(SYSDATE, 'Month dd, YYYY, HH:MIam') ||
                   '. Error message was ' || error_txt;

        mail_conn :- UTL_SMTP.OPEN_CONNECTION('localhost', 25);
        UTL_SMTP.HELO(mail_conn, 'localhost');
        UTL_SMTP.MAIL(mail_conn, 'sender@localhost');
        UTL_SMTP.RCPT(mail_conn, 'recipient@localhost');
        UTL_SMTP.DATA(mail_conn, msg_body);
        UTL_SMTP.QUIT(mail_conn);

        -- Abort the statement
        DBMS_RESUMABLE.ABORT(cur_sid);
    ELSE
        -- Set timeout to 8 hours
        DBMS_RESUMABLE.SET_TIMEOUT(28800);
    END IF;

    /* commit autonomous transaction */
    COMMIT;
END;
```

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 can 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 want to deallocate). However, if the segment is completely empty, you can release space using the TRUNCATE ... DROP STORAGE statement.

For segments in locally managed tablespaces with segment space management specified as AUTO, the following output parameters still determine the high water mark, put their meaning is somewhat altered:

- LAST_USED_EXTENT_FILE_ID
- LAST_USED_EXTENT_BLOCK_ID
- LAST_USED_BLOCK

Specifically, it is possible for some blocks below the high water mark to be unformatted. Neither the UNUSED_SPACE nor the FREE_SPACE procedure of DBMS_SPACE accurately accounts for unused space when segment space management is specified as AUTO. Use the SPACE_USAGE procedure instead.

> **See Also:** *Oracle9i Supplied PL/SQL Packages and Types Reference* contains the description of the DBMS_SPACE package

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.

You can verify the deallocated space is freed by examining the DBA_FREE_SPACE view.

See Also:

- *Oracle9i SQL Reference* for details on the syntax and options associated with deallocating unused space
- *Oracle9i Database Reference* for more information about the DBA_FREE_SPACE view

Examples of Deallocating Space

This section provides some space deallocation examples.

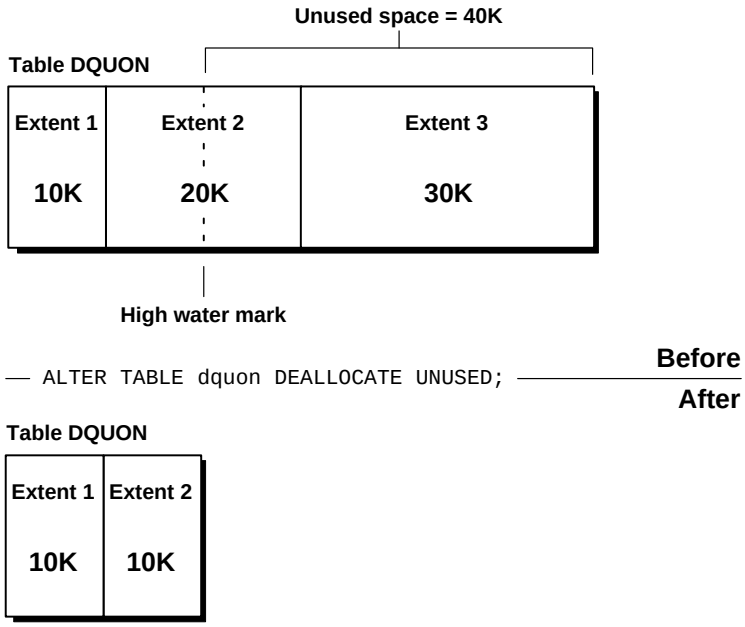
Deallocating Space Example 1:

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 14–3 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 14–3 Deallocating All Unused Space



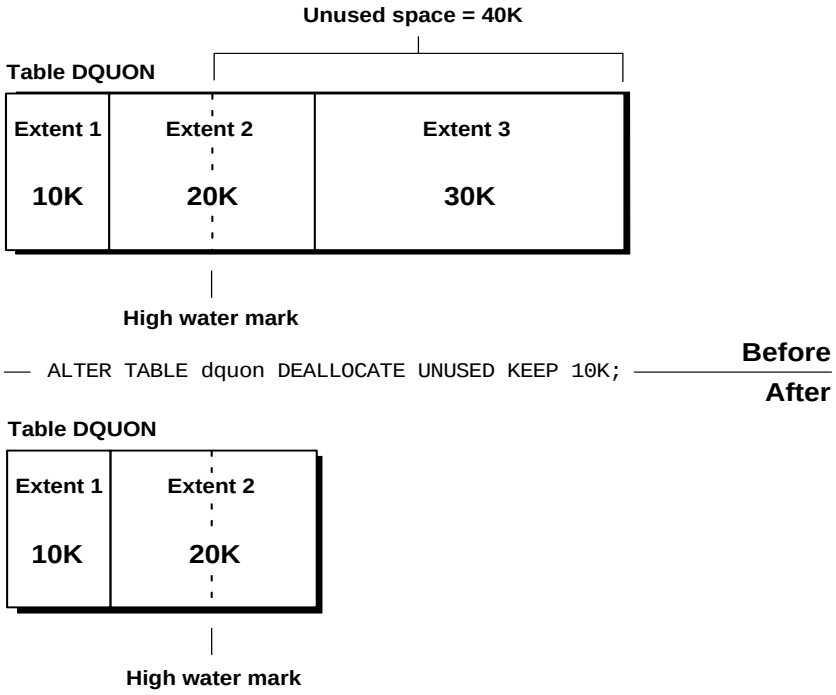
But, if you had issued the following statement specifying the KEEP keyword, then 10K above the high water mark would be kept, and the rest of the unused space would be deallocated from dquon.

```
ALTER TABLE dquon DEALLOCATE UNUSED KEEP 10K;
```

In effect, the third extent is deallocated and the second extent remains intact.

Figure 14–4 illustrates this situation.

Figure 14–4 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;
```

Deallocating Space Example 2:

Consider the situation illustrated by Figure 14–3. 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)
```

Deallocating Space 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 14–3 and Figure 14–4 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 14–4 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 14–3 does 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 *Oracle9i SQL Reference* contain extensive descriptions of datatypes and their space requirements.

15

Managing Tables

This chapter describes the various aspects of managing tables, and includes the following topics:

- Guidelines for Managing Tables
- Creating Tables
- Altering Tables
- Redefining Tables Online
- Dropping Tables
- Managing Index-Organized Tables
- Managing External Tables
- Viewing Information About Tables

See Also:

- Chapter 14, "Managing Space for Schema Objects" is recommended reading before attempting tasks in this chapter.
- Chapter 21, "General Management of Schema Objects" presents additional aspects of managing tables, such as specifying integrity constraints and analyzing tables.

Guidelines for Managing Tables

This section describes guidelines to follow when managing tables. Following these guidelines can make the management of your tables easier, and improve performance both when creating the table and later querying or updating it.

The following topics are discussed:

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. Clustered tables are the subject of Chapter 18, "Managing Clusters".

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 14-2.

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 is to 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 suffer, 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 24, "Managing Users and Resources" contains information about assigning default tablespaces and tablespace quotas to users.

Consider Parallelizing Table Creation

You can utilize parallel execution when creating tables using a subquery (AS SELECT) in the CREATE TABLE statement. Because multiple processes work together to create the table, performance of the table creation operation is improved.

Parallelizing table creation is discussed in the section "Parallelizing Table Creation" on page 15-8.

Consider Using NOLOGGING When Creating Tables

To create a table most efficiently use the NOLOGGING clause in the CREATE TABLE ... AS SELECT statement. The NOLOGGING clause causes minimal redo information to be generated during the table creation. This has the following benefits:

- Space is saved in the redo log files.
- The time it takes to create the table is decreased.
- Performance improves for parallel creation of large tables.

The NOLOGGING clause also specifies that subsequent direct loads using SQL*Loader and direct load INSERT operations are not logged. Subsequent DML statements (UPDATE, DELETE, and conventional path insert) are unaffected by the NOLOGGING attribute of the table and generate redo.

If you cannot afford to lose the table after you have created it (for example, you will no longer have access to the data used to create the table) you should take a backup immediately after the table is created. In some situations, such as for tables that are created for temporary use, this precaution may not be necessary.

In general, the relative performance improvement of specifying NOLOGGING is greater for larger tables than for smaller tables. For small tables, NOLOGGING has little effect on the time it takes to create a table. However, for larger tables the performance improvement can be significant, especially when you are also parallelizing the table creation.

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 are allocated for the table's data segment, and all of the

table's data is 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 table. (Clustered tables, discussed in Chapter 18, "Managing Clusters", 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 14-9.

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, when the number of extents in a table grows very large, you can 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 large 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 must drop and re-create an index on a very large table (such as when disabling and enabling a constraint, or recreating 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

Here are some restrictions to be aware of before you create tables:

- Tables containing 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 *Oracle9i Database Reference* for this limit.

  Further, 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. This causes additional relational columns to be created. This results in "hidden" relational columns that are not visible in a `DESCRIBE` table statement and are not returned by a `SELECT *` statement. Therefore, when you create an object table, or a relational table with columns of `REF`, varray, nested table, or object type, be aware that the total number of columns that Oracle actually creates for the table can be more than those you specify.

  See Also: *Oracle9i Application Developer's Guide - Object-Relational Features* for more information about user-defined types

Creating Tables

To create a new table in your schema, you must have the `CREATE TABLE` system privilege. To create a table in another user's schema, you must have the `CREATE ANY TABLE` system privilege. Additionally, the owner of the table must have a quota for the tablespace that contains the table, or the `UNLIMITED TABLESPACE` system privilege.

Create tables using the SQL statement `CREATE TABLE`.

See Also: *Oracle9i SQL Reference* for exact syntax of the `CREATE TABLE` and other SQL statements discussed in this chapter

Creating a Table

When user `scott` issues the following statement, he creates a 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 21-17. Several segment attributes are also explicitly specified for the table. These are explained in Chapter 14, "Managing Space for Schema Objects".

Creating a Temporary Table

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 truncates the table (delete all rows) after each commit.
- `ON COMMIT PRESERVE ROWS` specifies that the temporary table is session specific and Oracle truncates 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:

- *Oracle9i Database Concepts* for more information about temporary tables
- *Oracle9i Application Developer's Guide - Fundamentals* for more examples of temporary table use

Parallelizing Table Creation

When you specify the AS SELECT clause when creating a table, you can utilize parallel execution. The CREATE TABLE ... AS SELECT statement contains two parts: a CREATE part (DDL) and a SELECT part (query). Oracle can parallelize both parts of the statement. The CREATE part is parallelized if *one* of the following is true:

- A PARALLEL clause is included in the CREATE TABLE ... AS SELECT statement
- An ALTER SESSION FORCE PARALLEL DDL statement is specified

The query part is parallelized if *all* of the following are true:

- The query includes a parallel hint specification (PARALLEL or PARALLEL_INDEX) *or* the CREATE part includes the PARALLEL clause *or* the schema objects referred to in the query have a PARALLEL declaration associated with them.
- At least one of the tables specified in the query requires either a full table scan *or* an index range scan spanning multiple partitions.

If you parallelize the creation of a table, that table then has a parallel declaration (the PARALLEL clause) associated with it. Any subsequent DML or queries on the table, for which parallelization is possible, will attempt to use parallel execution.

The following simple example parallelizes the creation of a table:

```
CREATE TABLE emp_dept
     PARALLEL
     AS SELECT * FROM scott.emp
     WHERE deptno = 10;
```

In this example the PARALLEL clause tells Oracle to select an optimum number of parallel execution servers when creating the table.

See Also:

- *Oracle9i Database Concepts* for more information about parallel execution
- *Oracle9i Data Warehousing Guide* for a more detailed discussion about using parallel execution
- "Managing Processes for Parallel Execution" on page 5-18

Automatically Collecting Statistics on Tables

The PL/SQL package DBMS_STATS lets you generate and manage statistics for cost-based optimization. You can use this package to gather, modify, view, export, import, and delete statistics. You can also use this package to identify or name statistics that have been gathered.

You enable DBMS_STATS to automatically gather statistics for a table by specifying the MONITORING clause in the CREATE (or ALTER) TABLE statement. Then, you can effect automated statistics gathering by, for example, setting up a recurring job (perhaps by using job queues) that invokes DBMS_STATS.GATHER_TABLE_STATS with the GATHER STALE option at an appropriate interval for your application.

Monitoring tracks the approximate number of INSERT, UPDATE, and DELETE operations for the table since the last time statistics were gathered. Information about how many rows are affected is maintained in the SGA, until periodically (about every three hours) SMON incorporates the data into the data dictionary. This data dictionary information is made visible through the DBA|ALL|USER_TAB_MODIFICATIONS view. Oracle uses this view to identify tables with stale statistics.

Using the MONITORING clause and the DBMS_STATS package enables the optimizer to generate accurate execution plans, without the need for you to run regular and expensive ANALYZE statements to identify tables that have been modified. The exact mechanism for using the MONITORING clause and the DBMS_STATS package for gathering statistics is discussed in the *Oracle9i Database Performance Guide and Reference*.

To disable monitoring of a table, specify the NOMONITORING clause.

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 or modify LOB columns
- To add or modify object type, nested table, or varray columns
- To enable or disable statistics collection (MONITORING/NOMONITORING)

You can increase the length of an existing column, or decrease it, if all existing data satisfies the new length. You can change a column from byte semantics to CHAR semantics or vice versa. You must set the initialization parameter BLANK_TRIMMING=TRUE to decrease the length of a nonempty CHAR column.

If you are modifying a table to increase the length of a column of datatype CHAR, realize that this can be a time consuming operation and can require substantial additional storage, especially if the table contains many rows. This is because the CHAR value in each row must be blank-padded to satisfy the new column length.

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 14-2.

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 "Specifying the Transaction Entry Parameters: INITRANS and MAXTRANS" on page 14-8.

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 14-9.

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

Caution: 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 can affect the dependent object. See "Managing Object Dependencies" on page 21-25 for information about how Oracle manages dependencies.

Moving a Table to a New Segment or Tablespace

The ALTER TABLE ... MOVE statement enables 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, perhaps you want to allocate an additional extent for a table explicitly. For example, in an Oracle Real Application Clusters environment, an extent of a table can be allocated explicitly for a specific instance.

A new extent can be allocated for a table using the ALTER TABLE statement with the ALLOCATE EXTENT clause.

You can also explicitly deallocate unused space using the DEALLOCATE UNUSED clause of ALTER TABLE. This is described in "Deallocating Space" on page 14-26.

> **See Also:** *Oracle9i Real Application Clusters Administration* for information about using the ALLOCATE EXTENT clause in an Oracle Real Application Clusters environment

Dropping Columns

You can drop columns that are no longer needed from a table, including an index-organized table. This provides a convenient means to free space in a database, and avoids your having to export/import data then re-create indexes and

constraints. 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 results in an error.

> **See Also:** *Oracle9i SQL Reference* for information about additional restrictions and options for dropping columns from a table

Removing Columns from Tables

When you issue an ALTER TABLE ... DROP COLUMN statement, the column descriptor and the data associated with the target column are removed from each row in the table. You can drop multiple columns with one statement. The following statements are examples of dropping columns from the 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 is not displayed in queries or data dictionary views, and its name is removed so that a new column can reuse that name. All constraints, indexes, and statistics defined on the column are also removed.

To mark the 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;
```

Redefining Tables Online

In highly available systems, it is occasionally necessary to redefine large "hot" tables to improve the performance of queries or DML performed against these tables. Oracle provide a mechanism to redefine tables online. This mechanism provides a significant increase in availability compared to traditional methods of redefining tables that require tables to be taken offline.

When a table is redefined online, it is accessible to DML during much of the redefinition process. The table is locked in the exclusive mode only during a very small window which is independent of the size of the table and the complexity of the redefinition.

Online table redefinition enables you to:

- Modify the storage parameters of the table
- Move the table to a different tablespace in the same schema
- Add support for parallel queries

- Add or drop partitioning support
- Re-create the table to reduce fragmentation
- Change the organization of a normal table (heap organized) to an index-organized table and vice versa
- Add or drop a column

The mechanism for performing online redefinition is the PL/SQL package DBMS_REDEFINITION. Execute privileges on this package is granted to EXECUTE_CATALOG_ROLE. In addition to having execute privileges on this package, you must be granted the following privileges:

- CREATE ANY TABLE
- ALTER ANY TABLE
- DROP ANY TABLE
- LOCK ANY TABLE
- SELECT ANY TABLE

Several steps are involved in the redefinition process.

Steps for Online Redefinition of Tables

In order to perform an online redefinition of a table the user must perform the following steps.

1. Verify that the table can be online redefined by invoking the DBMS_REDEFINITION.CAN_REDEF_TABLE() procedure. If the table is not a candidate for online redefinition, then this procedure raises an error indicating why the table cannot be online redefined.
2. Create an empty interim table (in the same schema as the table to be redefined) with all of the desired attributes.
3. Start the redefinition process by calling DBMS_REDEFINITION.START_REDEF_TABLE(), providing the following:
   - The table to be redefined
   - The interim table name
   - The column mapping.

   If the column mapping information is not supplied, then it is assumed that all the columns (with their names unchanged) are to be included in the interim

table. If the column mapping is supplied, then only those columns specified explicitly in the column mapping are considered.

4. Create any triggers, indexes, grants and constraints on the interim table. Any referential constraints involving the interim table (that is, the interim table is either a parent or a child table of the referential constraint) must be created disabled. Until the redefinition process is either completed or aborted, any trigger defined on the interim table will not execute.

   When the redefinition is completed, the triggers, constraints, indexes and grants associated with the interim table replace those on the table being redefined. The referential constraints involving the interim table (created disabled) transfer to the table being redefined and become enabled after the redefinition is complete.

5. Execute the `DBMS_REDEFINITION.FINISH_REDEF_TABLE()` procedure to complete the redefinition of the table. During this procedure, the original table is locked in the exclusive mode for a very small window. This window is independent of the amount of data in the original table. Also, as part of this procedure, the following occurs:

   a. The original table is redefined such that it has all the attributes, indexes, constraints, grants and triggers of the interim table

   b. The referential constraints involving the interim table now involve the post redefined table and are enabled.

6. Optionally rename any indexes that were created on the interim table during step 4 and that are now defined on the redefined table.

The following is the end result of the redefinition process:

- The original table is redefined with the attributes and features of the interim table.
- The triggers, grants, indexes and constraints defined on the interim table after `START_REDEF_TABLE()` and before `FINISH_REDEF_TABLE()` are now defined on the post-redefined table. Any referential constraints involving the interim table before the redefinition process was finished now involve the post-redefinition table and are enabled.
- Any indexes, triggers, grants and constraints defined on the original table (prior to redefinition) are transferred to the interim table and are dropped when the user drops the interim table. Any referential constraints involving the original table before the redefinition now involve the interim table and are disabled.
- Any PL/SQL procedures and cursors defined on the original table (prior to redefinition) are invalidated. They are automatically revalidated (this

revalidation can fail if the shape of the table was changed as a result of the redefinition process) whenever they are used next.

See Also: *Oracle9i Supplied PL/SQL Packages and Types Reference*

Intermediate Synchronization

After the redefinition process has been started by calling START_REDEF_TABLE() and before FINISH_REDEF_TABLE() has been called, it is possible that a large number of DML statements have been executed on the original table. If you know this is the case, it is recommended that you periodically synchronize the interim table with the original table. This is done by calling the DBMS_REDEFINITION.SYNC_INTERIM_TABLE() procedure. Calling this procedure reduces the time taken by FINISH_REDEF_TABLE() to complete the redefinition process.

The small amount of time that the original table is locked during FINISH_REORG_TABLE() is independent of whether SYNC_INTERIM_TABLE() has been called.

Abort and Cleanup After Errors

In the event that an error is raised during the redefinition process, or if you choose to abort the redefinition process, call DBMS_REDEFINITION.ABORT_REDEF_TABLE(). This procedure drops temporary logs and tables associated with the redefinition process. After this procedure is called, the user can drop the interim table and its associated objects.

Example of Online Table Redefinition

This example illustrates online redefinition of nonpartitioned table emp, with columns: empno, name, salary, phone. The table is redefined as follows:

- The column salary is multiplied by a factor of 1.10 and renamed as sal.
- The column phone is dropped.
- A new column deptno with default value of 10 is added.
- The redefined table is partitioned by range on empno.

It is assumed that the DBMS_REDEFINITION.CAN_REDEF_TABLE() procedure has already been run, and that table emp is a valid candidate for redefinition.

The steps in this redefinition are illustrated below.

1. Create an interim table int_emp.

```
CREATE TABLE int_emp
       (empno       NUMBER PRIMARY KEY,
        name        VARCHAR2(100),
        sal         NUMBER,
        deptno      NUMBER DEFAULT 10)
     PARTITION BY RANGE(empno)
       (PARTITION emp1000 VALUES LESS THAN (1000) TABLESPACE tbs_1,
        PARTITION emp2000 VALUES LESS THAN (2000) TABLESPACE tbs_2);
```

2. Start the redefinition process.

```
DBMS_REDEFINITION.START_REDEF_TABLE('u1', 'emp', 'int_emp',
       'empno empno, name name, salary*1.10 sal');
```

3. Create any triggers, indexes and constraints on `int_emp`. During the final step of redefinition, these are transferred back to the original table. Any referential constraints involved on `int_emp` should be disabled. You can define any grants associated with the interim table. These replace the grants on the original table after the redefinition.

4. Optionally, synchronize the interim table `int_emp`.

```
DBMS_REDEFINITION.SYNC_INTERIM_TABLE('u1', 'emp', 'int_emp');
```

5. Complete the redefinition.

```
DBMS_REDEFINITION.FINISH_REDEF_TABLE('u1', 'emp', 'int_emp');
```

   The table `emp` is locked in the exclusive mode only for a small window toward the end of this step. After this call the table `emp` is redefined such that it has all the attributes of the `int_emp` table.

6. Drop the interim table.

Restrictions

The following restrictions apply to the online redefinition of tables:

- Tables must have primary keys to be candidates for online redefinition.
- The table to be redefined and the final redefined table must have the same primary key column.
- Tables that have materialized views and materialized view logs defined on them cannot be online redefined.

- Tables that are materialized view container tables and Advanced Queuing tables cannot be online redefined.
- The overflow table of an index-organized table cannot be online redefined.
- Tables with user-defined types (objects, REFs, collections, typed tables) cannot be online redefined.
- Tables with FILE columns cannot be online redefined.
- Tables with LONG columns cannot be online redefined. Tables with LOB columns are acceptable.
- The table to be redefined cannot be part of a cluster.
- Tables in the SYS and SYSTEM schema cannot be online redefined.
- Temporary tables cannot be redefined.
- There is no horizontal subsetting support.
- Only simple deterministic expressions can be used when mapping the columns in the interim table to those of the original table. For example, subqueries are not allowed.
- If new columns (which are not instantiated with existing data for the original table) are being added as part of the redefinition, then they must not be declared NOT NULL until the redefinition is complete.
- There cannot be any referential constraints between the table being redefined and the interim table.

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;
```

Caution: Before dropping a table, familiarize yourself with the consequences of doing so:

- Dropping a table removes the table definition from the data dictionary. All rows of the table are no longer accessible.
- All indexes and triggers associated with a table are dropped.
- All views and PL/SQL program units dependent on a dropped table remain, yet become invalid (not usable). See "Managing Object Dependencies" on page 21-25 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 table that is dropped are returned to the free space of the tablespace and can be used by any other object requiring new extents or new objects. All rows corresponding to a clustered table are deleted from the blocks of the cluster. Clustered tables are the subject of Chapter 18, "Managing Clusters".

Perhaps instead of dropping a table, you want to truncate it. The TRUNCATE statement provides a fast, efficient method for deleting all rows from a table, but it does not affect any structures associated with the table being truncated (column definitions, constraints, triggers, and so forth) or authorizations. The TRUNCATE statement is discussed in "Truncating Tables and Clusters" on page 21-12.

Managing Index-Organized Tables

This section describes aspects of managing index-organized tables, and includes the following topics:

- What are Index-Organized Tables
- Creating Index-Organized Tables
- Maintaining Index-Organized Tables
- Analyzing Index-Organized Tables
- Using the ORDER BY Clause with Index-Organized Tables
- Converting Index-Organized Tables to Regular Tables

What are Index-Organized Tables

An **index-organized table** has a storage organization that is a variant of a primary B-tree. Unlike an ordinary (heap-organized) table whose data is stored as an unordered collection (heap), data for an index-organized table is stored in a B-tree index structure in a primary key sorted manner. Besides storing the primary key column values of an index-organized table row, each index entry in the B-tree stores the non-key column values as well.

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).

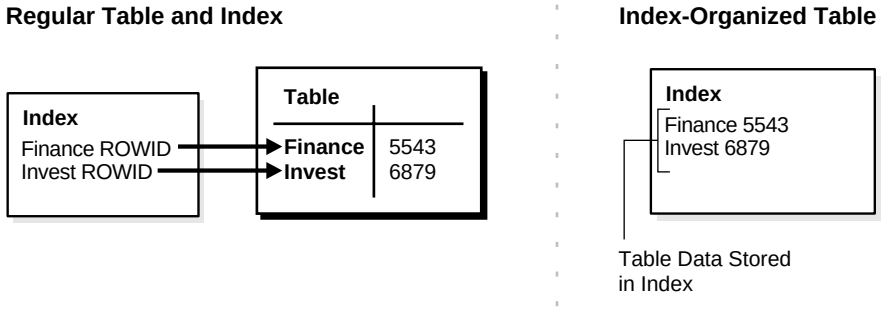
Also, storage requirements are reduced because key columns are not duplicated in the table and index. The remaining non-key columns are stored in the index structure.

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

As shown in Figure 15–1, the index-organized table is somewhat similar to a configuration consisting of an ordinary table and an index on one or more of the table columns, but instead of maintaining two separate storage structures, one for the table and one for the B-tree index, the database system maintains only a single B-tree index. Also, rather than having a row's rowid stored in the index entry, the non-key column values are stored. Thus, each B-tree index entry contains `<primary_key_value, non_primary_key_column_values>`.

Figure 15–1 Structure of Regular Table versus an Index-Organized Table



Applications manipulate the index-organized table just like an ordinary table, using SQL statements. However, the database system performs all operations by manipulating the corresponding B-tree index.

See Also:

- *Oracle9i Database Concepts* for more details about index-organized tables
- *Oracle9i SQL Reference* for details of the syntax involved in creating index-organized tables

Creating Index-Organized Tables

You use the `CREATE TABLE` statement to create index-organized tables, but you must 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. The following example creates an index-organized table containing a column of object type `mytype`:

```
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;
```

> **See Also:** "Creating Partitioned Index-Organized Tables" on page 17-13 for information about creating partitioned index-organized tables

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 can 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:** *Oracle9i SQL Reference* for details about this use of the ANALYZE statement

Using the INCLUDING clause In addition to specifying PCTTHRESHOLD, you can use the INCLUDING 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 (that is, 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 in each index block while improving performance.

You can enable key compression using the COMPRESS clause while:

- creating an index-organized table
- moving an index-organized table

You can also specify the prefix length (as the number of key columns), which identifies how the key columns are broken into a prefix and suffix entry.

```
CREATE TABLE 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:** *Oracle9i Database Concepts* and the *Oracle9i SQL Reference* for more details about key compression

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 can encounter fragmentation as a consequence of incremental updates. However, you can use the ALTER TABLE ... MOVE statement to rebuild the index and reduce this fragmentation.

The following statement rebuilds the index-organized table 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 or EXPORT utilities, or the CREATE TABLE ... AS SELECT statement.

To convert an index-organized table to a regular table:

- Export the index-organized table data using conventional path.
- Create a regular table definition with the same definition.
- Import the index-organized table data, making sure IGNORE=y (ensures that object exists error is ignored).

> **Note:** Before converting an index-organized table to a regular table, be aware that index-organized tables cannot be exported using pre-Oracle8 versions of the Export utility.

See Also: *Oracle9i Database Utilities* for more details about using the IMPORT and EXPORT utilities

Managing External Tables

Oracle allows you read-only access to data in external tables. External tables are defined as tables that do not reside in the database, and can be in any format for which an access driver is provided. By providing Oracle with metadata describing an external table, Oracle is able to expose the data in the external table as if it were data residing in a regular database table. The external data can be queried directly and in parallel using SQL.

You can, for example, select, join, or sort external table data. You can also create views and synonyms for external tables. However, no DML operations (UPDATE, INSERT, or DELETE) are possible, and no indexes can be created, on external tables.

Note: The ANALYZE statement is not supported for gathering statistics for external tables. The DBMS_STATS package should be used for gathering statistics for external tables.

For information about using the DBMS_STATS package, see Oracle9i Database Performance Guide and Reference

---

The means of defining the metadata for external tables is through the CREATE TABLE ... ORGANIZATION EXTERNAL statement. This external table definition can be thought of as a view that allows running any SQL query against external data without requiring that the external data first be loaded into the database. An access driver is the actual mechanism used to read the external data in the table.

Oracle provides an access driver for external tables. It allows the reading of data from external files using the Oracle loader technology. The ORACLE_LOADER access driver provides data mapping capabilities which are a subset of the control file syntax of SQL*Loader utility.

Oracle's external tables feature provides a valuable means for performing basic extraction, transformation, and transportation (ETT) tasks that are common for datawarehousing.

These following sections discuss the DDL statements that are supported for external tables. Only DDL statements discussed are supported, and not all clauses of these statements are supported.

- Creating External Tables

- Altering External Tables
- Dropping External Tables
- System and Object Privileges for External Tables

See Also:

- *Oracle9i Database Utilities* contains more information about external tables and describes the access driver and its access parameters
- *Oracle9i Data Warehousing Guide* for information about using external tables in a datawarehousing environment

Creating External Tables

You create external tables using the `ORGANIZATION EXTERNAL` clause of the `CREATE TABLE` statement. You are not in fact creating a table; that is, an external table does not have any extents associated with it. Rather, you are creating metadata in the data dictionary that enables you to access external data.

The following example creates an external table, then uploads the data to a database table.

EXAMPLE: Creating an External Table and Loading Data

The file `empxt1.dat` contains the following sample data:

```
7369,SMITH,CLERK,7902,17-DEC-1980,800,0,20
7499,ALLEN,SALESMAN,7698,20-FEB-1981,1600,300,30
7521,WARD,SALESMAN,7698,22-FEB-1981,1250,500,30
7566,JONES,MANAGER,7839,02-APR-1981,2975,0,20
7654,MARTIN,SALESMAN,7698,28-SEP-1981,1250,1400,30
7698,BLAKE,MANAGER,7839,01-MAY-1981,2850,0,30
7782,CLARK,MANAGER,7839,09-JUN-1981,2450,0,10
...
```

The file `empxt2.dat` contains the following sample data:

```
7788,SCOTT,ANALYST,7566,19-APR-1987,3000,0,20
7839,KING,PRESIDENT,,17-NOV-1981,5000,0,10
7844,TURNER,SALESMAN,7698,08-SEP-1981,1500,0,30
7876,ADAMS,CLERK,7788,23-MAY-1987,1100,0,20
7900,JAMES,CLERK,7698,03-DEC-1981,950 ,0,30
7902,FORD,ANALYST,7566,03-DEC-1981,3000,0,20
7934,MILLER,CLERK,7782,23-JAN-1982,1300,0,10
```

...

The following SQL statements create an external table and load its data into database table `scott.emp`.

```
SET ECHO ON;
CONNECT  /  AS SYSDBA;

CREATE OR REPLACE DIRECTORY dat_dir AS '/flatfiles/data';
CREATE OR REPLACE DIRECTORY log_dir AS '/flatfiles/log';
CREATE OR REPLACE DIRECTORY bad_dir AS '/flatfiles/bad';

GRANT READ ON DIRECTORY dat_dir TO scott;
GRANT WRITE ON DIRECTORY log_dir TO scott;
GRANT WRITE ON DIRECTORY bad_dir TO scott;

CONNECT scott/tiger;

DROP TABLE empxt;

CREATE TABLE empxt (empno       NUMBER(4),
                    ename       VARCHAR2(10),
                    job         VARCHAR2(9),
                    mgr         NUMBER(4),
                    hiredate    DATE,
                    sal         NUMBER(7,2),
                    comm        NUMBER(7,2),
                    deptno      NUMBER(2)
                   )
     ORGANIZATION EXTERNAL
     (
       TYPE ORACLE_LOADER
       DEFAULT DIRECTORY dat_dir
       ACCESS PARAMETERS
       (
         records delimited by newline
         badfile bad_dir:'empxt%a_%p.bad'
         logfile log_dir:'empxt%a_%p.log'
         fields terminated by ','
         missing field values are null
         ( empno, ename, job, mgr,
           hiredate char date_format date mask "dd-mm-yyyy",
           sal, comm, deptno
         )
       )
```

```
    LOCATION ('empxt1.dat', 'empxt2.dat')
  )
  PARALLEL
  REJECT LIMIT UNLIMITED;

ALTER SESSION ENABLE PARALLEL DML;

INSERT INTO TABLE emp SELECT * FROM empxt;
```

The following paragraphs contain descriptive information about this example.

The first few statements in this example create the directory objects for the operating system directories that contain the data sources, and for the bad record and log files specified in the access parameters. You must also grant READ or WRITE directory object privileges, as appropriate.

The TYPE specification is given only to illustrate its use. If not specified, ORACLE_LOADER is the default access driver. The access parameters, specified in the ACCESS PARAMETERS clause, are opaque to Oracle. These access parameters are defined by the access driver, and are provided to the access driver by Oracle when the external table is accessed. See *Oracle9i Database Utilities* for a description of the ORACLE_LOADER access parameters.

The PARALLEL clause enables parallel query on the data sources. The granule of parallelism is by default a data source, but parallel access within a data source is implemented whenever possible. For example, if PARALLEL=3 were specified, then more than one parallel execution server could be working on a data source. But, parallel access within a data source is provided by the access driver only if all of the following conditions are met:

- The media allows random positioning within a data source
- It is possible to find a record boundary from a random position
- The data files are large enough to make it worthwhile to break up into multiple chunks

> **Note:** Specifying a PARALLEL clause is of value *only* when dealing with large amounts of data. Otherwise, it is not advisable to specify a PARALLEL clause, and doing so can be detrimental.

The REJECT LIMIT clause specifies that there is no limit on the number of errors that can occur during a query of the external data. For parallel access, this limit applies to each parallel query slave independently. For example, if REJECT LIMIT

10 is specified, each parallel query process is allowed 10 rejections. Hence, the only precisely enforced values for REJECT LIMIT on parallel query are 0 and UNLIMITED.

In this example, the INSERT INTO TABLE statement generates a dataflow from the external data source to the Oracle SQL engine where data is processed. As data is parsed by the access driver from the external table sources and provided to the external table interface, the external data is converted from its external representation to its Oracle internal data type.

> **See Also:** *Oracle9i SQL Reference* provides details of the syntax of the CREATE TABLE statement for creating external tables and specifies restrictions on the use of clauses

Altering External Tables

You can use any of the following ALTER TABLE clauses to change the characteristics of an external table. No other clauses are permitted.

ALTER TABLE Clause	Description	Example
REJECT LIMIT	Changes the reject limit	`ALTER TABLE empxt REJECT LIMIT 100;`
DEFAULT DIRECTORY	Changes the default directory specification	`ALTER TABLE empxt` `  DEFAULT DIRECTORY newemp_dir;`

ACCESS PARAMETERS	Allows access parameters to be changed without dropping and recreating the external table metadata	`ALTER TABLE empxt`
		`  ACCESS PARAMETERS`
		`  (FIELDS TERMINATED BY ';');`

LOCATION	Allows data sources to be changed without dropping and recreating the external table metadata	`ALTER TABLE empxt`
		`  LOCATION ('empxt3.txt',`
		`  'empxt4.txt');`

PARALLEL	No difference from regular tables. Allows degree of parallelism to be changed.	No new syntax
ADD COLUMN	No difference from regular tables. Allows a column to be added to an external table.	No new syntax
MODIFY COLUMN	No difference from regular tables. Allows an external table column to be modified.	No new syntax

ALTER TABLE Clause	Description	Example
DROP COLUMN	No difference from regular tables. Allows an external table column to be dropped.	No new syntax
RENAME TO	No difference from regular tables. Allows external table to be renamed.	No new syntax

Dropping External Tables

For an external table, the DROP TABLE statement removes only the table metadata in the database. It has no affect on the actual data, which resides outside of the database.

System and Object Privileges for External Tables

System and object privileges for external tables are a subset of those for regular table. Only the following system privileges are applicable to external tables:

- CREATE ANY TABLE
- ALTER ANY TABLE
- DROP ANY TABLE
- SELECT ANY TABLE

Only the following object privileges are applicable to external tables:

- ALTER
- SELECT

However, object privileges associated with a directory are:

- READ privilege
- WRITE privilege

For external tables, READ privileges are required on directory objects that contain data sources, while WRITE privileges are required for directory objects containing bad, log, or discard files.

Viewing Information About Tables

The following views allow you to access information about tables.

View	Description
DBA_TABLES ALL_TABLES USER_TABLES	DBA view describes all relational tables in the database. ALL view describes all tables accessible to the user. USER view is restricted to tables owned by the user. Some columns in these views contain statistics that are generated by the DBMS_STATS package or ANALYZE statement.
DBA_TAB_COLUMNS ALL_TAB_COLUMNS USER_TAB_COLUMNS	These views describe the columns of tables, views, and clusters in the database. Some columns in these views contain statistics that are generated by the DBMS_STATS package or ANALYZE statement.
DBA_ALL_TABLES ALL_ALL_TABLES USER_ALL_TABLES	These views describe all relational and *object tables* in the database. Object tables are not specifically discussed in this book.
DBA_TAB_COMMENTS ALL_TAB_COMMENTS USER_TAB_COMMENTS	These views display comments for tables and views. Comments are entered using the COMMENT statement.
DBA_COL_COMMENTS ALL_COL_COMMENTS USER_COL_COMMENTS	These views display comments for table and view columns. Comments are entered using the COMMENT statement.
DBA_EXTERNAL_TABLES ALL_EXTERNAL_TABLES USER_EXTERNAL_TABLES	These views list the specific attributes of external tables in the database.
DBA_EXTERNAL_LOCATIONS ALL_EXTERNAL_LOCATIONS USER_EXTERNAL_LOCATIONS	These views list the data sources for external tables.
DBA_TAB_HISTOGRAMS ALL_TAB_HISTOGRAMS USER_TAB_HISTOGRAMS	These views describe histograms on tables and views.
DBA_TAB_COL_STATISTICS ALL_TAB_COL_STATISTICS USER_TAB_COL_STATISTICS	These views provide column statistics and histogram information extracted from the related TAB_COLUMNS views.
DBA_TAB_MODIFICATIONS ALL_TAB_MODIFICATIONS USER_TAB_MODIFICATIONS	These views describe tables that have been modified since the last time table statistics were gathered on them. The views are populated only for tables with the MONITORING attribute. They are not populated immediately, but after a time lapse (usually 3 hours).

View	Description
DBA_UNUSED_COL_TABS ALL_UNUSED_COL_TABS USER_UNUSED_COL_TABS	These views list tables with unused columns, as marked by the ALTER TABLE ... SET UNUSED statement.
DBA_PARTIAL_DROP_TABS ALL_PARTIAL_DROP_TABS USER_PARTIAL_DROP_TABS	These views list tables that have partially completed DROP COLUMN operations. These operations could be incomplete because the operation was interrupted by the user or a system crash.

See Also:

- "Viewing Information About Tables" on page 15-35
- *Oracle9i Database Reference* for complete descriptions of these views
- *Oracle9i Application Developer's Guide - Object-Relational Features* for information about object tables
- *Oracle9i Database Performance Methods* and *Oracle9i Database Performance Guide and Reference* for information about histograms and generating statistics for tables
- "Analyzing Tables, Indexes, and Clusters" on page 21-3

16

Managing Indexes

This chapter discusses the management of indexes, and contains the following topics:

- Guidelines for Managing Indexes
- Creating Indexes
- Altering Indexes
- Monitoring Space Use of Indexes
- Dropping Indexes
- Viewing Index Information

> **See Also:** Chapter 14, "Managing Space for Schema Objects" is recommended reading before attempting tasks described in this chapter.

Guidelines for Managing Indexes

Indexes are optional structures associated with tables and clusters that allow SQL statements to execute more quickly against a table. Just as the index in this manual helps you locate information faster than if there were no index, an Oracle index provides a faster access path to table data. You can use indexes without rewriting any queries. Your results are the same, but you see them more quickly.

Oracle provides several indexing schemes that provide complementary performance functionality. These are:

- B-tree indexes—the default and the most common
- B-tree cluster indexes—defined specifically for cluster
- Hash cluster indexes—defined specifically for a hash cluster
- Global and local indexes—relate to partitioned tables and indexes
- Reverse key indexes—most useful for Oracle Real Application Cluster applications
- Bitmap indexes—compact; work best for columns with a small set of values
- Function-based indexes—contain the precomputed value of a function / expression
- Domain indexes—specific to an application or cartridge.

Indexes are logically and physically independent of the data in the associated table. Being independent structures, they require storage space. You can create or drop an index without affecting the base tables, database applications, or other indexes. Oracle automatically maintains indexes when you insert, update, and delete rows of the associated table. If you drop an index, all applications continue to work. However, access to previously indexed data might be slower.

This section discusses guidelines for managing indexes and contains the following topics:

- Estimate Index Size and Set Storage Parameters
- Specify the Tablespace for Each Index
- Consider Parallelizing Index Creation
- Consider Creating Indexes with NOLOGGING
- Consider Costs and Benefits of Coalescing or Rebuilding Indexes
- Consider Cost Before Disabling or Dropping Constraints

See Also:

- *Oracle9i Database Concepts* for conceptual information about indexes and indexing, including descriptions of the various indexing schemes offered by Oracle
- *Oracle9i Database Performance Guide and Reference* and *Oracle9i Data Warehousing Guide* for information about bitmap indexes
- *Oracle9i Data Cartridge Developer's Guide* for information about defining domain-specific operators and indexing schemes and integrating them into the Oracle database server

Create Indexes After Inserting Table Data

Data is often inserted or loaded into a table using the either the SQL*Loader or Import utility. It is more efficient to create an index for a table after inserting or loading the data. If you create one or more indexes before loading data, Oracle then must update every index as each row is inserted.

Creating an index on a table that already has data requires sort space. Some sort space comes from memory allocated for the index's creator. The amount for each user is determined by the initialization parameter `SORT_AREA_SIZE`. Oracle also swaps sort information to and from temporary segments that are only allocated during the index creation in the users temporary tablespace.

Under certain conditions, data can be loaded into a table with SQL*Loader's direct path load and an index can be created as data is loaded.

See Also: *Oracle9i Database Utilities* for information about using SQL*Loader for direct path load

Index the Correct Tables and Columns

Use the following guidelines for determining when to create an index:

- Create an index if you frequently want to retrieve less than 15% of the rows in a large table. The percentage varies greatly according to the relative speed of a table scan and how clustered the row data is about the index key. The faster the table scan, the lower the percentage; the more clustered the row data, the higher the percentage.
- To improve performance on joins of multiple tables, index columns used for joins.

  Note: Primary and unique keys automatically have indexes, but you might want to create an index on a foreign key.

- Small tables do not require indexes. If a query is taking too long, then the table might have grown from small to large.

Some columns are strong candidates for indexing. Columns with one or more of the following characteristics are candidates for indexing:

- Values are relatively unique in the column.
- There is a wide range of values (good for regular indexes).
- There is a small range of values (good for bitmap indexes).
- The column contains many nulls, but queries often select all rows having a value. In this case, use the following phrase:

  ```
  WHERE COL_X > -9.99 * power(10,125)
  ```

  Using the above phrase is preferable to:

  ```
  WHERE COL_X IS NOT NULL
  ```

  This is because the first uses an index on `COL_X` (assuming that `COL_X` is a numeric column).

Columns with the following characteristics are less suitable for indexing:

- There are many nulls in the column and you do not search on the non-null values.

`LONG` and `LONG RAW` columns cannot be indexed.

The size of a single index entry cannot exceed roughly one-half (minus some overhead) of the available space in the data block.

Order Index Columns for Performance

The order of columns in the CREATE INDEX statement can affect query performance. In general, specify the most frequently used columns first.

If you create a single index across columns to speed up queries that access, for example, col1, col2, and col3; then queries that access just col1, or that access just col1 and col2, are also speeded up. But a query that accessed just col2, just col3, or just col2 and col3 does not use the index.

Limit the Number of Indexes for Each Table

A table can have any number of indexes. However, the more indexes there are, the more overhead is incurred as the table is modified. Specifically, when rows are inserted or deleted, all indexes on the table must be updated as well. Also, when a column is updated, all indexes that contain the column must be updated.

Thus, there is a trade-off between the speed of retrieving data from a table and the speed of updating the table. For example, if a table is primarily read-only, having more indexes can be useful; but if a table is heavily updated, having fewer indexes could be preferable.

Drop Indexes That Are No Longer Required

Consider dropping an index if:

- It does not speed up queries. The table could be very small, or there could be many rows in the table but very few index entries.
- The queries in your applications do not use the index.
- The index must be dropped before being rebuilt.

See Also: "Monitoring Index Usage" on page 16-21

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.

PCTUSED cannot be specified for indexes.

> **See Also:** "Managing Space in Data Blocks" on page 14-2 for information about the PCTFREE parameter.

Estimate Index Size and Set Storage Parameters

Estimating the size of an index before creating one can facilitate better disk space planning and management. You can use the combined estimated size of indexes, along with estimates for tables, 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.

Use the estimated size of an individual index to better manage the disk space that the index uses. When an index is created, you can set appropriate storage parameters and improve I/O performance of applications that use the index. For example, assume that you estimate the maximum size of an index before creating it. If you then set the storage parameters when you create the index, fewer extents are allocated for the table's data segment, and all of the index's data is stored in a relatively contiguous section of disk space. This decreases the time necessary for disk I/O operations involving this index.

The maximum size of a single index entry is approximately one-half the data block size.

> **See Also:** "Setting Storage Parameters" on page 14-9 for specific information about storage parameters

Specify the Tablespace for Each Index

Indexes can be created in any tablespace. An index can be created in the same or different tablespace as the table it indexes. If you use the same tablespace for a table and its index, it can be more convenient to perform database maintenance (such as tablespace or file backup) or to ensure application availability. All the related data is always online together.

Using different tablespaces (on different disks) for a table and its index produces better performance than storing the table and index in the same tablespace. Disk contention is reduced. But, if you use different tablespaces for a table and its index

and one tablespace is offline (containing either data or index), then the statements referencing that table are not guaranteed to work.

Consider Parallelizing Index Creation

You can parallelize index creation, much the same as you can parallelize table creation. Because multiple processes work together to create the index, 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:

- *Oracle9i Database Concepts* for more information about parallel execution
- *Oracle9i Data Warehousing Guide* for information about utilizing parallel execution in a datawarehousing environment

Consider Creating Indexes with NOLOGGING

You can create an index and generate minimal redo log records by specifying `NOLOGGING` in the `CREATE INDEX` statement.

Note: Because indexes created using `NOLOGGING` are not archived, perform a backup after you create the index.

Creating an index with `NOLOGGING` has the following benefits:

- Space is saved in the redo log files.
- The time it takes to create the index is decreased.
- Performance improves for parallel creation of large indexes.

In general, the relative performance improvement is greater for larger indexes created without `LOGGING` than for smaller ones. Creating small indexes without `LOGGING` has little 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

Improper sizing or increased growth can produce index fragmentation. To eliminate or reduce fragmentation, you can rebuild or coalesce the index. But before you perform either task weigh the costs and benefits of each option and choose the one that works best for your situation. Table 16–1 is a comparison of the costs and benefits associated with rebuilding and coalescing indexes.

Table 16–1 To Rebuild or Coalesce ... That Is the Question

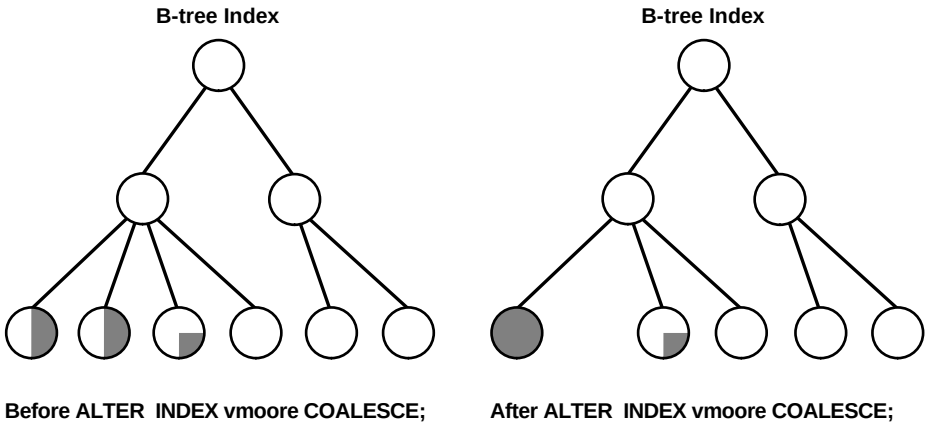
Rebuild Index	Coalesce Index
Quickly moves index to another tablespace	Cannot move index to another tablespace
Higher costs: requires more disk space	Lower costs: does not require more disk space
Creates new tree, shrinks height if applicable	Coalesces leaf blocks within same branch of tree
Enables you 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 16–1 illustrates the effect of an `ALTER INDEX COALESCE` on the index `vmoore`. Before performing the operation, the first two leaf blocks are 50% full. This means you have an opportunity to reduce fragmentation and completely fill the first block, while freeing up the second. In this example, assume that `PCTFREE=0`.

Figure 16–1 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 can save time by leaving the constraint enabled rather than dropping and re-creating the large index. You also have the option of explicitly specifying that you want to keep or drop the index when dropping or disabling a `UNIQUE` or `PRIMARY KEY` constraint.

See Also: "Managing Integrity Constraints" on page 21-17

Creating Indexes

This section describes how to create indexes. To create an index in your own schema, *at least one* of the following conditions must be true:

- The table or cluster to be indexed is in your own schema.
- You have `INDEX` privilege on the table to be indexed.
- You have `CREATE ANY INDEX` system privilege.

To create an index in another schema, *all* of the following conditions must be true:

- You have `CREATE ANY INDEX` system privilege.

- The owner of the other schema has a quota for the tablespaces to contain the index or index partitions, or UNLIMITED TABLESPACE system privilege.

This section contains the following topics:

- Creating an Index Explicitly
- Creating a Unique Index Explicitly
- Creating an Index Associated with a Constraint
- Collecting Incidental Statistics when Creating an Index
- Creating a Large Index
- Creating an Index Online
- Creating a Function-Based Index
- Creating a Key-Compressed Index

> **See Also:** *Oracle9i SQL Reference* for syntax and restrictions on the use of the CREATE INDEX, ALTER INDEX, and DROP INDEX statements

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 and a tablespace are explicitly specified for the index. If you do not specify storage options (such as INITIAL and NEXT) for an index, the default storage options of the default or specified tablespace are automatically used.

Creating a Unique Index Explicitly

Indexes can be unique or nonunique. Unique indexes guarantee that no two rows of a table have duplicate values in the key column (or columns). Nonunique indexes do not impose this restriction on the column values.

Use the CREATE UNIQUE INDEX statement to create a unique index. The following example creates a unique index:

```
CREATE UNIQUE INDEX dept_unique_index ON dept (dname)
      TABLESPACE indx;
```

Alternatively, you can define UNIQUE integrity constraints on the desired columns. Oracle enforces UNIQUE integrity constraints by automatically defining a unique index on the unique key. This is discussed in the following section. However, it is advisable that any index that exists for query performance, including unique indexes, be created explicitly

> **See Also:** *Oracle9i Database Performance Guide and Reference* for more information about creating an index for performance

Creating an Index Associated with a Constraint

Oracle enforces a UNIQUE key or PRIMARY KEY integrity constraint on a table by creating a unique index on the unique key or primary key. This index is automatically created by Oracle when the constraint is enabled. No action is required by you when you issue the CREATE TABLE or ALTER TABLE statement to create the index, but you can optionally specify a USING INDEX clause to exercise control over its creation. This includes both when a constraint is defined and enabled, and when a defined but disabled constraint is enabled.

To enable a UNIQUE or PRIMARY KEY constraint, thus creating an associated index, the owner of the table must have a quota for the tablespace intended to contain the index, or the UNLIMITED TABLESPACE system privilege. A constraint's associated index always assumes the name of the constraint, unless you optionally specify otherwise.

Specifying Storage Options for an Index Associated with a Constraint

You can set the storage options for the indexes associated with UNIQUE and PRIMARY KEY constraints using the USING INDEX clause. The following CREATE TABLE statement enables a PRIMARY KEY constraint and specifies the associated index's storage options:

```
CREATE TABLE emp (
```

```
    empno NUMBER(5) PRIMARY KEY, age INTEGER)
    ENABLE PRIMARY KEY USING INDEX
    TABLESPACE users
    PCTFREE 0;
```

Specifying the Index Associated with a Constraint

If you require more explicit control over the indexes associated with `UNIQUE` and `PRIMARY KEY` constraints, Oracle allows you to:

- Specify an existing index that Oracle is to use to enforce the constraint
- Specify a create index statement that Oracle is to use to create the index and enforce the constraint

These options are specified using the `USING INDEX` clause. The following statements present some examples.

Example 1:

```
CREATE TABLE a (
     a1 INT PRIMARY KEY USING INDEX (create index ai on a (a1)));
```

Example 2:

```
CREATE TABLE b(
     b1 INT,
     b2 INT,
     CONSTRAINT bu1 UNIQUE (b1, b2)
                    USING INDEX (create unique index bi on b(b1, b2)),
     CONSTRAINT bu2 UNIQUE (b2, b1) USING INDEX bi);
```

Example 3:

```
CREATE TABLE c(c1 INT, c2 INT);
CREATE INDEX ci ON c (c1, c2);
ALTER TABLE c ADD CONSTRAINT cpk PRIMARY KEY (c1) USING INDEX ci;
```

If a single statement creates an index with one constraint and also uses that index for another constraint, the system will attempt to rearrange the clauses to create the index before reusing it.

See Also: "Managing Integrity Constraints" on page 21-17

Collecting Incidental Statistics when Creating an Index

Oracle provides you with the opportunity to collect statistics at very little resource cost during the creation or rebuilding of an index. These statistics are stored in the data dictionary for ongoing use by the optimizer in choosing a plan for the execution of SQL statements. The following statement computes index, table, and column statistics while building index emp_ename on column ename of table emp:

```
CREATE INDEX emp_ename ON emp(ename)
     COMPUTE STATISTICS;
```

See Also:

- *Oracle9i Database Performance Guide and Reference* for information about collecting statistics and their use by the optimizer
- "Analyzing Tables, Indexes, and Clusters" on page 21-3

Creating a Large Index

When creating an extremely large index, consider allocating a larger temporary tablespace for the index creation using the following procedure:

1. Create a new temporary tablespace using the CREATE TABLESPACE or CREATE TEMPORARY TABLESPACE statement.
2. Use the TEMPORARY TABLESPACE option of the ALTER USER statement to make this your new temporary tablespace.
3. Create the index using the CREATE INDEX statement.
4. Drop this tablespace using the DROP TABLESPACE statement. Then use the ALTER USER statement to reset your temporary tablespace to your original temporary tablespace.

Using this procedure can avoid the problem of expanding your usual, and usually shared, temporary tablespace to an unreasonably large size that might affect future performance.

Creating an Index Online

You can create and rebuild indexes online. This enables you to update base tables at the same time you are building or rebuilding indexes on that table. You can perform DML operations while the index build is taking place, but DDL operations are not

allowed. Parallel execution is not supported when creating or rebuilding an index online.

The following statements illustrate online index build operations:

```
CREATE INDEX emp_name ON emp (mgr, emp1, emp2, emp3) ONLINE;
```

Note: 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. This is because while the DML on the base table is taking place it holds a lock on that resource. The DDL to build the index cannot proceed until the transaction acting on the base table commits or rolls back, thus releasing the lock.

For example, if you want 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.

See Also: Rebuilding an Existing Index on page 16-20

Creating a Function-Based Index

Function-based indexes facilitate queries that qualify a value returned by a function or expression. The value of the function or expression is precomputed and stored in the index.

See Also:

- *Oracle9i Database Concepts*
- *Oracle9i Data Warehousing Guide*

These books provide additional information about function-based indexes.

Features of Function-Based Indexes

Function-based indexes allow you to:

- Create more powerful sorts

  You can perform case-insensitive sorts with the `UPPER` and `LOWER` functions, descending order sorts with the `DESC` keyword, and linguistic-based sorts with the `NLSSORT` function.

- Precompute the value of a computationally intensive function and store it in the index

  An index can store computationally intensive expression that you access often. When you need to access a value, it is already computed, greatly improving query execution performance.

- Increase the number of situations where the optimizer can perform a range scan instead of a full table scan

  For example, consider the expression in the WHERE clause below:

  ```
  CREATE INDEX idx ON Example_tab(column_a + column_b);
  SELECT * FROM example_tab WHERE column_a + column_b < 10;
  ```

  The optimizer can use a range scan for this query because the index is built on (column_a + column_b). Range scans typically produce fast response times if the predicate selects less than 15% of the rows of a large table. The optimizer can estimate how many rows are selected by expressions more accurately if the expressions are materialized in a function-based index. (Expressions of function-based indexes are represented as virtual columns and ANALYZE can build histograms on such columns.)

- Enable true descending order indexes

  They are treated as a special case of function-based indexes.

  > **Note:** Oracle sorts columns with the DESC keyword in descending order. Such indexes are treated as function-based indexes. Descending indexes cannot be bitmapped or reverse, and cannot be used in bitmapped optimizations. To get the pre-Oracle 8.1 release DESC behavior, remove the DESC keyword from the CREATE INDEX statement.

- Create indexes on object columns and REF columns

  Methods that describe objects can be used as functions on which to build indexes. For example, you can use the MAP method to build indexes on an object type column.

See Also:

- *Oracle9i Globalization and National Language Support Guide* for information about the NLSSORT function
- *Oracle9i Database Performance Guide and Reference* for information about the optimizer
- *Oracle9i Application Developer's Guide - Object-Relational Features* for information about object and REF columns

How Function-Based Indexes Work

For the creation of a function-based index in your own schema, you must be granted the 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 set to TRUSTED
- QUERY_REWRITE_ENABLED set to TRUE
- COMPATIBLE 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 is marked invalid. You must use the ANALYZE VALIDATE INDEX statement to validate this index.

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
     WHERE Area(geo) >5000;
```

Table owners should have `EXECUTE` privileges on the functions used in function-based indexes.

Because a function-based index depends upon any function it is using, it can be invalidated when a function changes. If the function is valid, you can use an `ALTER INDEX ... ENABLE` statement to enable a function-based index that has been disabled. The `ALTER INDEX ... DISABLE` statement allows you to disable the use of a function-based index. Consider doing this if you are working on the body of the function.

Examples of Function-Based Indexes

Some examples of using function-based indexes follow.

Example: Function-Based Index for Case-Insensitive Searches 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(ename));
```

Now the `SELECT` statement uses the function-based index on `UPPER(ename)` to retrieve all employees with names that start with `JOH`:

```
SELECT * FROM emp WHERE UPPER(ename) LIKE 'JOH%';
```

This example also illustrates a case-insensitive search.

Example: Precomputing Arithmetic Expressions with a Function-Based Index 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;
```

Examples: Function-Based Index for Language-Dependent Sorting You can use function-based indexes to support a linguistic sort index. 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, the following statement selects from t_table using the NLS_SORT index:

```
SELECT * FROM t_table ORDER BY name;
```

Rows are ordered using the collation sequence in German.

The following 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. The previous example illustrated a case where NLS_SORT was specified.

Creating a Key-Compressed Index

Creating an index using key compression enables you to eliminate repeated occurrences of key column prefix values.

Key compression breaks an index key into a prefix and a suffix entry. Compression is achieved by sharing the prefix entries among all the suffix entries in an index block. This sharing can lead to huge savings in space, allowing you to store more keys for each index block while improving performance.

Key compression can be useful in the following situations:

- You have a non-unique index where ROWID is appended to make the key unique. If you use key compression here, the duplicate key is stored as a prefix entry on the index block without the ROWID. The remaining rows become suffix entries consisting of only the ROWID.
- You have a unique multi-column index.

You enable key compression using the COMPRESS clause. The prefix length (as the number of key columns) can also be specified to identify how the key columns are

broken into a prefix and suffix entry. For example, the following statement compresses duplicate occurrences of a key in the index leaf block:

```
CREATE INDEX  emp_ename ON emp(ename)
   TABLESPACE users
   COMPRESS 1;
```

The COMPRESS clause can also be specified during rebuild. For example, during rebuild you can disable compression as follows:

```
ALTER INDEX emp_ename REBUILD NOCOMPRESS;
```

> **See Also:** *Oracle9i Database Concepts* for a more detailed discussion of key compression

Altering Indexes

To alter an index, your schema must contain the index or you must have the ALTER ANY INDEX system privilege. Among the actions allowed by the ALTER INDEX statement are:

- Rebuild or coalesce an existing index
- Deallocate unused space or allocate a new extent
- Specify parallel execution (or not) and alter the degree of parallelism
- Alter storage parameters or physical attributes
- Specify LOGGING or NOLOGGING
- Enable or disable key compression
- Mark the index unusable
- Start or stop the monitoring of index usage

You cannot alter an index's column structure.

More detailed discussions of some of these operations are contained in the following sections:

- Altering Storage Characteristics of an Index
- Rebuilding an Existing Index
- Monitoring Index Usage

Altering Storage Characteristics of an Index

Alter the storage parameters of any index, including those created by Oracle to enforce primary and unique key integrity constraints, using the ALTER INDEX statement. For example, the following statement alters the emp_ename index:

```
ALTER INDEX emp_ename
     STORAGE (PCTINCREASE 50);
```

The storage parameters INITIAL and MINEXTENTS cannot be altered. All new settings for the other storage parameters affect only extents subsequently allocated for the index.

For indexes that implement integrity constraints, you can choose to adjust storage parameters by issuing an ALTER TABLE statement that includes the USING INDEX subclause of the ENABLE clause. For example, the following statement changes the storage options of the index created on table emp to enforce the primary key constraint:

```
ALTER TABLE emp
     ENABLE PRIMARY KEY USING INDEX
     PCTFREE 5;
```

Rebuilding an Existing Index

Before rebuilding an existing index, compare the costs and benefits associated with rebuilding to those associated with coalescing indexes as described in Table 16–1 on page 16-8.

When you rebuild an index, you use an existing index as the data source. Creating an index in this manner enables you to change storage characteristics or move to a new tablespace. Rebuilding an index based on an existing data source removes intra-block fragmentation. Compared to dropping the index and using the CREATE INDEX statement, re-creating an existing index offers better performance.

The following statement rebuilds the existing index emp_name:

```
ALTER INDEX emp_name REBUILD;
```

The REBUILD clause must immediately follow the index name, and precede any other options. It cannot be used in conjunction with the DEALLOCATE UNUSED clause.

If have the option of rebuilding the index online. The following statement rebuilds the emp_name index online:

```
ALTER INDEX  REBUILD ONLINE;
```

If you do not have the space required to rebuild an index, you can choose instead to coalesce the index. Coalescing an index can also be done online.

See Also:

- "Creating an Index Online" on page 16-13
- "Monitoring Space Use of Indexes" on page 16-21

Monitoring Index Usage

Oracle provides a means of monitoring indexes to determine if they are being used or not used. If it is determined that an index is not being used, then it can be dropped, thus eliminating unnecessary statement overhead.

To start monitoring an index's usage, issue this statement:

```
ALTER INDEX index MONITORING USAGE
```

Later, issue the following statement to stop the monitoring:

```
ALTER INDEX index NOMONITORING USAGE
```

The view V$OBJECT_USAGE can be queried for the index being monitored to see if the index has been used. The view contains a USED column whose value is YES or NO, depending upon if the index has been used within the time period being monitored. The view also contains the start and stop times of the monitoring period, and a MONITORING column (YES/NO) to indicate if usage monitoring is currently active.

Each time that you specify MONITORING USAGE, the V$OBJECT_USAGE view is reset for the specified index. The previous usage information is cleared or reset, and a new start time is recorded. When you specify NOMONITORING USAGE, no further monitoring is performed, and the end time is recorded for the monitoring period. Until the next ALTER INDEX ... MONITORING USAGE statement is issued, the view information is left unchanged.

Monitoring Space Use of Indexes

If key values in an index are inserted, updated, and deleted frequently, the index can lose its acquired space efficiently over time. Monitor an index's efficiency of space usage at regular intervals by first analyzing the index's structure, using the

ANALYZE INDEX ... VALIDATE STRUCTURE statement, and then querying the INDEX_STATS view:

```
SELECT PCT_USED FROM INDEX_STATS WHERE NAME = 'index';
```

The percentage of an index's space usage varies 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 PCTUSED
- Dropping and rebuilding (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.

See Also: "Analyzing Tables, Indexes, and Clusters" on page 21-3

Dropping Indexes

To drop an index, the index must be contained in your schema, or you must have the DROP ANY INDEX system privilege.

Some reasons for dropping an index include:

- The index is no longer required.
- The index is not providing anticipated performance improvements for queries issued against the associated table. For example, the table might be very small, or there might be many rows in the table but very few index entries.
- Applications do not use the index to query the data.
- The index has become invalid and must be dropped before being rebuilt.
- The index has become too fragmented and must be dropped before being rebuilt.

When you drop an index, all extents of the index'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.

Note: If a table is dropped, all associated indexes are dropped automatically.

See Also: "Managing Integrity Constraints" on page 21-17

Viewing Index Information

The following views display information about indexes:

View	Description
DBA_INDEXES ALL_INDEXES USER_INDEXES	DBA view describes indexes on all tables in the database. ALL view describes indexes on all tables accessible to the user. USER view is restricted to indexes owned by the user. Some columns in these views contain statistics that are generated by the DBMS_STATS package or ANALYZE statement.
DBA_IND_COLUMNS ALL_IND_COLUMNS USER_IND_COLUMNS	These views describe the columns of indexes on tables. Some columns in these views contain statistics that are generated by the DBMS_STATS package or ANALYZE statement.
DBA_IND_EXPRESSIONS ALL_IND_EXPRESSIONS USER_IND_EXPRESSIONS	These views describe the expressions of function-based indexes on tables.
INDEX_STATS	Stores information from the last ANALYZE INDEX ... VALIDATE STRUCTURE statement.
INDEX_HISTOGRAM	Stores information from the last ANALYZE INDEX ... VALIDATE STRUCTURE statement.
V$OBJECT_USAGE	Contains index usage information produced by the ALTER INDEX ... MONITORING USAGE functionality.

See Also: *Oracle9i Database Reference* for a complete description of these views

17

Managing Partitioned Tables and Indexes

This chapter describes various aspects of managing partitioned tables and indexes, and contains the following topics:

- What Are Partitioned Tables and Indexes?
- Partitioning Methods
- Creating Partitioned Tables
- Maintaining Partitioned Tables
- Partitioned Tables and Indexes Examples
- Viewing Information About Partitioned Tables and Indexes

> **See Also:** Chapter 14, "Managing Space for Schema Objects" is recommended reading before attempting tasks described in this chapter.

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 can be partitioned in similar fashion. Each partition can be managed individually, and can function 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.

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:

- *Oracle9i Database Concepts* contains more information about partitioning. Before the first time you attempt to create a partitioned table or index, or perform maintenance operations on any partitioned table, it is recommended that you review the information contained in that book.
- *Oracle9i Data Warehousing Guide* and *Oracle9i Database Concepts* contain information about parallel execution
- *Oracle9i Database Utilities* describes the SQL*Loader, Import, and Export utilities.

Partitioning Methods

There are several partitioning methods offered by Oracle:

- Range partitioning
- Hash partitioning
- List partitioning
- Composite partitioning

Indexes, as well as tables, can be partitioned. A global index can only be partitioned by range, but it can 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.

The following sections can help you decide on a partitioning method appropriate for your needs:

- When to Use the Range Partitioning Method
- When to Use the Hash Partitioning Method
- When to Use the List Partitioning Method
- When to Use the Composite Partitioning Method

When to Use 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 are 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.

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 *Oracle9i Globalization and National Language Support Guide.*

When to Use 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 and manageability 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.

When to Use the List Partitioning Method

Use list partitioning when you require explicit control over how rows map to partitions. You can specify a list of discrete values for the partitioning column in the description for each partition. This is different from range partitioning, where a range of values is associated with a partition, and from hash partitioning, where the user has no control of the row to partition mapping.

The list partitioning method is specifically designed for modeling data distributions that follow discrete values. This cannot be easily done by range or hash partitioning because:

- Range partitioning assumes a natural range of values for the partitioning column. It is not possible to group together out-of-range values partitions.
- Hash partitioning allows no control over the distribution of data because the data is distributed over the various partitions using the system hash function. Again, this makes it impossible to logically group together discrete values for the partitioning columns into partitions.

Further, list partitioning allows unordered and unrelated sets of data to be grouped and organized together very naturally.

Unlike the range and hash partitioning methods, multi-column partitioning is not supported for list partitioning. If a table is partitioned by list, the partitioning key can consist only of a single column of the table. Otherwise all columns that can be partitioned by the range or hash methods can be partitioned by the list partitioning method.

When creating list partitions, you must specify:

- Partitioning method: list
- Partitioning column(s)
- Partition descriptions, each specifying a list of literal values (a **value list**), which are the discrete values of the partitioning columns that qualify a row to be included in the partition.

The following example creates a list-partitioned table. It creates table `sales_by_region` which is partitioned by region; that is, states are grouped together according to their geographical location.

```
CREATE TABLE sales_by_region
      (deptno number,
       deptname varchar2(20),
       quarterly_sales number(10, 2),
       state varchar2(2))
   PARTITION BY LIST (state)
      (PARTITION q1_northwest VALUES ('OR', 'WA'),
       PARTITION q1_southwest VALUES ('AZ', 'UT', 'NM'),
       PARTITION q1_northeast VALUES  ('NY', 'VM', 'NJ'),
       PARTITION q1_southeast VALUES ('FL', 'GA'),
       PARTITION q1_northcentral VALUES ('SD', 'WI'),
       PARTITION q1_southcentral VALUES ('OK', 'TX'));
```

A row is mapped to a partition by checking whether the value of the partitioning column for a row falls within the set of values that describes the partition.

For example, the following rows are inserted as follows:

- `(10, 'accounting', 100, 'WA')` maps to partition `q1_northwest`
- `(20, 'R&D', 150, 'OR')` maps to partition `q1_northwest`
- `(30, 'sales', 100, 'FL')` maps to partition `q1_southeast`
- `(40, 'HR', 10, 'TX')` maps to partition `q1_southwest`
- `(50, 'systems engineering', 10, 'CA')` does not map to any partition in the table

One of the interesting things to note about list partitioning is that there is no apparent sense of ordering between partitions (unlike range partitioning).

When to Use 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 for each partition or descriptions of subpartitions

The following statement creates a composite-partitioned table. In this example, three range partitions are created, each containing eight subpartitions. Because the subpartitions are not named, 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, ts2, ts3, ts4)
  (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.

Creating Partitioned Tables

Creating a partitioned table or index is very similar to creating a non-partitioned table or index (as described in Chapter 15, "Managing Tables"), but you include a partitioning clause. The partitioning clause, and subclauses, that you include depend upon the type of partitioning you want to achieve.

You can partition both regular (heap organized) tables and index-organized tables, including those containing LOB columns. You can create nonpartitioned global indexes, range-partitioned global indexes, and local indexes on partitioned tables.

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 ROW MOVEMENT`.

The following sections present details and examples of creating partitions for the various types of partitioned tables and indexes:

- Creating Range-Partitioned Tables
- Creating Hash-Partitioned Tables
- Creating List-Partitioned Tables
- Creating Composite Partitioned Tables
- Creating Partitioned Index-Organized Tables
- Partitioning Restrictions for Multiple Block Sizes

See Also:

- *Oracle9i SQL Reference* for 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
- *Oracle9i Application Developer's Guide - Large Objects (LOBs)* and *Oracle9i Application Developer's Guide - Fundamentals* for information about creating partitioned tables containing columns with LOBs or other objects stored as LOBs.

Creating Range-Partitioned Tables

The `PARTITION BY RANGE` clause of the `CREATE TABLE` statement specifies 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 inherit the attributes of their underlying table.

In this example, more complexity is added to the example presented earlier for a range-partitioned table. Storage parameters and a `LOGGING` attribute are specified at the table level. These replace the corresponding defaults inherited from the tablespace level for the table itself, and are 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 on `sales_month` for 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));
```

Creating Hash-Partitioned Tables

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 are to reside, are specified. The initial extent size for each hash partition

(segment) is also explicitly stated at the table level, and all partitions 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 constructs the index so that it is equipartitioned with the underlying table. Oracle also ensures that the index 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 are to be stored, but if you do not do so, Oracle uses 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 List-Partitioned Tables

The semantics for creating list partitions are very similar to those for creating range partitions. However, to create list partitions, you specify a `PARTITION BY LIST` clause in the `CREATE TABLE` statement, and the `PARTITION` clauses specify lists of literal values, which are the discrete values of the partitioning columns that qualify rows to be included in the partition. Like for range partitions, 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 inherit the attributes of their underlying table.

In the following example creates table `sales_by_region` and partitions it using the list method. The first two `PARTITION` clauses specify physical attributes, which override the table-level defaults. The remaining `PARTITION` clauses do not specified attributes and those partitions inherit their physical attributes from table-level defaults.

```
CREATE TABLE sales_by_region (item# INTEGER, qty INTEGER,
             store_name VARCHAR(30), state_code VARCHAR(2),
             sale_date DATE)
     STORAGE(INITIAL 10K NEXT 20K) TABLESPACE tbs5
     PARTITION BY LIST (state_code)
```

```
(
PARTITION region_east
   VALUES ('MA','NY','CT','NH','ME','MD','VA','PA','NJ')
   STORAGE (INITIAL 20K NEXT 40K PCTINCREASE 50)
   TABLESPACE tbs8,
PARTITION region_west
   VALUES ('CA','AZ','NM','OR','WA','UT','NV','CO')
   PCTFREE 25 NOLOGGING,
PARTITION region_south
   VALUES ('TX','KY','TN','LA','MS','AR','AL','GA'),
PARTITION region_central
   VALUES ('OH','ND','SD','MO','IL','MI', null, 'IA')
);
```

Creating Composite Partitioned Tables

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 you can specify a STORE IN clause 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 are spread across tablespaces ts7, ts8, and ts9.

```
CREATE INDEX emp_ix ON emp(deptno)
     LOCAL STORE IN (ts7, ts8, ts9);
```

This local index is equipartitioned with the base table as follows:

- It consists of as many partitions as the base table.
- Each index partition consists of as many subpartitions as the corresponding base table partition.
- Index entries for rows in a given subpartition of the base table are stored in the corresponding subpartition of the index.

Creating Partitioned Index-Organized Tables

For index-organized tables, you can use the range or hash partitioning method. However, only range partitioned index-organized tables can contain columns with LOBs. The semantics for creating range or hash-partitioned index-organized tables is similar to that for regular tables with these differences:

- When you create the table you specify the ORGANIZATION INDEX clause, and INCLUDING and OVERFLOW clauses as necessary.
- The PARTITION or PARTITIONS clauses can have OVERFLOW subclauses that allow you to specify attributes of the overflow segments at the partition level.

Specifying an OVERFLOW clause results in the overflow data segments themselves being equi-partitioned with the primary key index segments. Thus, for partitioned index-organized tables with overflow, each partition has an index segment and an overflow data segment.

For index-organized tables, the set of partitioning columns must be a subset of the primary key columns. Since rows of an index-organized table are stored in the primary key index for the table, the partitioning criterion has an effect on the availability. By choosing the partition key to be a subset of the primary key, an insert operation only needs to verify uniqueness of the primary key in a single partition, thereby maintaining partition independence.

Support for secondary indexes on index-organized tables is similar to the support for regular tables, however, certain maintenance operations do not mark global indexes UNUSABLE, as is the case for regular tables.

See Also:

- "Managing Index-Organized Tables" on page 15-20
- "Maintaining Partitioned Tables" on page 17-16
- *Oracle9i Application Developer's Guide - Fundamentals* and *Oracle9i Database Concepts* for more information about index-organized tables

Creating Range-Partitioned Index-Organized Tables

You can partition index-organized tables, and their secondary indexes, 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 OVERFLOW TABLESPACE overflow_ts2,
             ...
             PARTITION VALUES LESS THAN (MAXVALUE)
                   TABLESPACE ts13);
```

Creating Hash-Partitioned Index-Organized Tables

The other option for partitioning index-organized tables is to use the hash method. In the following example the index-organized table, `sales`, is partitioned by the hash method.

```
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
 PARTITION BY HASH (week_no)
        PARTITIONS 16
        STORE IN (ts1, ts2, ts3, ts4)
        OVERFLOW STORE IN (ts3, ts6, ts9);
```

Note: Since a well designed hash function is supposed to distribute rows in a well balanced fashion amongst the partitions, updating the primary key column(s) of a row is very likely to move that row to a different partition. Therefore it is recommended that a hash-partitioned index-organized table with a changeable partitioning key be created with the `ROW MOVEMENT ENABLE` clause explicitly specified. That feature is by default disabled.

Partitioning Restrictions for Multiple Block Sizes

Use caution when creating partitioned objects in a database with tablespaces of multiple block size. The storage of partitioned objects in such tablespaces is subject to some restrictions. Specifically, all partitions of the following entities must reside in tablespaces of the same block size:

- Conventional tables
- Indexes
- Primary key index segments of index-organized tables
- Overflow segments of index-organized tables
- LOB columns stored out of line

Therefore:

- For each conventional table, all partitions of that table must be stored in tablespaces with the same block size.
- For each index-organized table, all primary key index partitions must reside in tablespaces of the same block size, and all overflow partitions of that table must

reside in tablespaces of the same block size. However, index partitions and overflow partitions can reside in tablespaces of different block size.

- For each index (global or local), each partition of that index must reside in tablespaces of the same block size. However, partitions of different indexes defined on the same object can reside in tablespaces of different block sizes.
- For each LOB column, each partition of that column must be stored in tablespaces of equal block sizes. However, different LOB columns can be stored in tablespaces of different block sizes.

When you create or alter a partitioned table or index, all tablespaces you *explicitly specify* for the partitions and subpartitions of each entity must be of the same block size. If you *do not explicitly specify* tablespace storage for an entity, the tablespaces Oracle uses by default must be of the same block size. Therefore you must be aware of the default tablespaces at each level of the partitioned object.

Maintaining Partitioned Tables

This section describes how to perform partition and subpartition maintenance operations for both tables and indexes.

Table 17–1 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 17–1 ALTER TABLE Maintenance Operations for Table Partitions **(Page 1 of 2)**

Maintenance Operation	Range	Hash	List	Composite
Adding Partitions	ADD PARTITION	ADD PARTITION	ADD PARTITION	ADD PARTITION MODIFY PARTITION...ADD SUBPARTITION
Coalescing Partitions	n/a	COALESCE PARTITION	n/a	MODIFY PARTITION...COALESCE SUBPARTITION
Dropping Partitions	DROP PARTITION	n/a	DROP PARTITION	DROP PARTITION
Exchanging Partitions	EXCHANGE PARTITION	EXCHANGE PARTITION	EXCHANGE PARTITION	EXCHANGE PARTITION EXCHANGE SUBPARTITION
Merging Partitions	MERGE PARTITIONS	n/a	MERGE PARTITIONS	MERGE PARTITIONS

Table 17–1 ALTER TABLE Maintenance Operations for Table Partitions **(Page 2 of 2)**

Maintenance Operation	Range	Hash	List	Composite
Modifying Partitions: Adding Values	n/a	n/a	MODIFY PARTITION... ADD VALUES	n/a
Modifying Partitions: Dropping Values	n/a	n/a	MODIFY PARTITION... DROP VALUES	n/a
Modifying Default Attributes	MODIFY DEFAULT ATTRIBUTES	MODIFY DEFAULT ATTRIBUTES	MODIFY DEFAULT ATTRIBUTES	MODIFY DEFAULT ATTRIBUTES MODIFY DEFAULT ATTRIBUTES FOR PARTITION
Modifying Real Attributes of Partitions	MODIFY PARTITION	MODIFY PARTITION	MODIFY PARTITION	MODIFY PARTITION MODIFY SUBPARTITION
Moving Partitions	MOVE PARTITION	MOVE PARTITION	MOVE PARTITION	MOVE SUBPARTITION
Renaming Partitions	RENAME PARTITION	RENAME PARTITION	RENAME PARTITION	RENAME PARTITION RENAME SUBPARTITION
Splitting Partitions	SPLIT PARTITION	n/a	SPLIT PARTITION	SPLIT PARTITION
Truncating Partitions	TRUNCATE PARTITION	TRUNCATE PARTITION	TRUNCATE PARTITION	TRUNCATE PARTITION TRUNCATE SUBPARTITION

Table 17–2 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. The ALTER INDEX clause used for the maintenance operation is shown.

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 indexes reflect the underlying structure of the table, partitioning is maintained automatically when table partitions and subpartitions are affected by maintenance activity. Therefore, partition maintenance on local indexes is less necessary and there are fewer options.

Table 17–2 ALTER INDEX Maintenance Operations for Index Partitions

Maintenance Operation	Type of Index	Type of Index Partitioning		
		Range	Hash/List	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 MODIFY DEFAULT ATTRIBUTES FOR PARTITION
Modifying Real Attributes of Index Partitions	Global	MODIFY PARTITION		
	Local	MODIFY PARTITION	MODIFY PARTITION	MODIFY PARTITION 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 RENAME SUBPARTITION
Splitting Index Partitions	Global	SPLIT PARTITION		
	Local	n/a	n/a	n/a

Note: The following sections discuss maintenance operations on partitioned tables. Where the usability of indexes or index partitions affected by the maintenance operation is discussed, consider the following:

- Only indexes and index partitions that are *not* empty are candidates for being marked UNUSABLE. If they are empty, the USABLE/UNUSABLE status is left unchained.
- Only indexes or index partitions with USABLE status are updated by subsequent DML.

Updating Global Indexes Automatically

Before discussing the individual maintenance operations for partitioned tables and indexes, it is important to discuss the effects of the UPDATE GLOBAL INDEXES clause that can be specified in the ALTER TABLE statement.

By default, many table maintenance operations on partitioned tables invalidate (mark UNUSABLE) global indexes. You must then rebuild the entire global index or, if partitioned, all of its partitions. Oracle enables you to override this default behavior if you specify UPDATE GLOBAL INDEXES in your ALTER TABLE statement for the maintenance operation. Specifying this clause tells Oracle to update the global index at the time it executes the maintenance operation DDL statement. This provides the following benefits:

- The global index is updated in conjunction with the base table operation. You are not required to later and independently rebuild the global index.
- There is higher availability for global indexes, since they do not get marked UNUSABLE. The index remains available even while the partition DDL is executing and it can be used to access other partitions in the table.
- You avoid having to look up the names of all invalid global indexes used for rebuilding them.

But also consider the following performance implications when you specify UPDATE GLOBAL INDEXES:

- The partition DDL statement takes longer to execute since indexes which were previously marked UNUSABLE are updated. However, this must be compared against the time it takes to execute DDL without updating indexes, and then rebuilding all indexes. A rule of thumb is that it is faster to update indexes if the size of the partition is less that 5% of the size of the table.
- The DROP, TRUNCATE, and EXCHANGE operations are no longer fast operations. Again, one must compare the time it takes to do the DDL and then rebuild all global indexes.
- Updates to the index are logged, and redo and undo records are generated. If the entire index is being rebuilt, it can optionally be done NOLOGGING.
- Rebuilding the entire index creates a more efficient index, since it is more compact with space better utilized. Further rebuilding the index allows you change storage options.

Note: The UPDATE GLOBAL INDEXES clause is not supported for partitioned index-organized tables.

The following operations support the UPDATE GLOBAL INDEXES clause:

- ADD PARTITION|SUBPARTITION (hash only)
- COALESCE PARTITION|SUBPARTITION
- DROP PARTITION
- EXCHANGE PARTITION|SUBPARTITIO
- MERGE PARTITION
- MOVE PARTITION|SUBPARTITION
- SPLIT PARTITION
- TRUNCATE PARTITION|SUBPARTITION

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

Use the ALTER TABLE ... ADD PARTITION statement to add a new partition to the "high" end (the point after the last existing partition). To add a partition at the beginning or in the middle of a table, use the SPLIT PARTITION clause.

For example, consider the table, sales, which contains data for the current month in addition to the previous 12 months. On January 1, 1999, you add a partition for January, which is stored in tablespace tsx.

```
ALTER TABLE sales
      ADD PARTITION jan96 VALUES LESS THAN ( '01-FEB-1999' )
      TABLESPACE tsx;
```

Local and global indexes associated with the range-partitioned table remain usable.

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 an existing partition (selected by Oracle) as determined by the hash function.

The following statements show two ways of adding a hash partition to table scubagear. Choosing the first statement adds a new hash partition whose partition name is system generated, and which is 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;
```

Indexes may be marked UNUSABLE as explained in the following table:

Table Type	Index Behavior
Regular (Heap)	■ The local indexes for the new partition, and for the existing partition from which rows were redistributed, are marked UNUSABLE and must be rebuilt. ■ Unless you specify UPDATE GLOBAL INDEXES, all global indexes, or all partitions of partitioned global indexes, are marked UNUSABLE and must be rebuilt.
Index-organized	■ For local indexes, the behavior is the same as for heap tables. ■ All global indexes remain usable.

Adding a Partition to a List-Partitioned Table

The following statement illustrates adding a new partition to a list-partitioned table. In this example physical attributes and NOLOGGING are specified for the partition being added.

```
ALTER TABLE sales_by_region
   ADD PARTITION region_nonmainland VALUES ('HI', 'PR')
      STORAGE (INITIAL 20K NEXT 20K) TABLESPACE tbs_3
      NOLOGGING;
```

Any value in the set of literal values that describe the partition(s) being added must not exist in any of the other partitions of the table.

Local and global indexes associated with the list-partitioned table remain usable.

Adding Partitions to a Composite-Partitioned Table

Partitions can be added at both the range partition level and the hash subpartition level.

Adding a Partition Adding a new range partition to a composite-partitioned table is as described previously in "Adding a Partition to a Range-Partitioned Table". However, 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 are 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.

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;
```

Local index subpartitions corresponding to the added and rehashed subpartitions must be rebuilt. Unless you specify UPDATE GLOBAL INDEXES, all global indexes, or all partitions of partitioned global indexes, are marked UNUSABLE and must be rebuilt.

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 Oracle, and is dropped after its contents have been redistributed.

Indexes may be marked UNUSABLE as explained in the following table:

Table Type	Index Behavior
Regular (Heap)	■ 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. ■ Unless you specify UPDATE GLOBAL INDEXES, all global indexes, or all partitions of partitioned global indexes, are marked UNUSABLE and must be rebuilt.
Index-organized	■ Some local indexes are marked UNUSABLE as noted above. ■ All global indexes remain usable.

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 in "Adding a Subpartition" on page 17-22.

```
ALTER TABLE diving MODIFY PARTITION us_locations
     COALESCE SUBPARTITION;
```

Dropping Partitions

You can drop partitions from range, composite, or list-partitioned tables. For hash-partitioned tables, or hash subpartitions of composite-partitioned tables, you must perform a coalesce operation instead.

Dropping a Table Partition

Use the ALTER TABLE ... DROP PARTITION statement to drop a table partition. If you want to preserve the data in the partition, use the MERGE PARTITION statement instead of the DROP PARTITION statement.

If there are local indexes defined for the table, this statement also drops the matching partition or subpartitions from the local index. All global indexes, or all partitions of partitioned global indexes, are marked UNUSABLE unless either of the following are true:

- You specify UPDATE GLOBAL INDEXES (cannot be specified for index-organized tables)
- 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 that Contains Data and Global Indexes If the partition contains data and one or more global indexes are defined on the table, use one of the following methods to drop the table partition.

Method 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 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 require 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.

Method 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, to drop the first partition, which has a partition bound of 10000, 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.

Method 3:

Specify UPDATE GLOBAL INDEXES in the ALTER TABLE statement. This causes the global index to be updated at the time the partition is dropped.

```
ALTER TABLE sales DROP PARTITION dec98
     UPDATE GLOBAL INDEXES;
```

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.

Method 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.

Method 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 that you want to convert to partitions of a partitioned table. For example, you could already have partition views that you want to migrate into partitioned tables.

Exchanging partitions also facilitates high-speed data loading when used with transportable tablespaces.

When you exchange partitions, logging attributes are preserved. You can optionally specify if local indexes are also to be exchanged, and if rows are to be validated for proper mapping. Unless you specify `UPDATE GLOBAL INDEXES` (cannot be specified for index-organized tables), Oracle marks `UNUSABLE` the global indexes, or all global index partitions, on the table whose partition is being exchanged. Any global indexes, or global index partitions, on the table being exchanged are marked `UNUSABLE`.

See Also:

- "Converting a Partition View into a Partitioned Table" on page 17-46
- "Using Transportable Tablespaces" on page 11-42 for information about transportable tablespaces

Exchanging a Range, Hash, or List Partition

To exchange a partition of a range, hash, or list-partitioned table with a nonpartitioned table, or the reverse, use the `ALTER TABLE ... EXCHANGE PARTITION` statement. An example of converting a partition into a nonpartitioned table follows. In this example, table `stocks` can be range, hash, or list partitioned.

```
ALTER TABLE stocks
    EXCHANGE PARTITION p3 WITH stock_table_3;
```

Exchanging a Hash-Partitioned Table with a Composite Partition

In this example, 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 index 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

Use the ALTER TABLE ... MERGE PARTITIONS statement to merge the contents of two partitions into one partition. The two original partitions are dropped, as are any corresponding local indexes.

You cannot use this statement for a hash-partitioned table or for hash subpartitions of a composite-partitioned table.

Unless the involved partitions or subpartitions are empty, indexes may be marked UNUSABLE as explained in the following table:

Table Type	Index Behavior
Regular (Heap)	■ Oracle marks UNUSABLE all resulting corresponding local index partitions or subpartitions. ■ Unless you specify UPDATE GLOBAL INDEXES, all global indexes, or all partitions of partitioned global indexes, are marked UNUSABLE and must be rebuilt.
Index-organized	■ Oracle marks UNUSABLE all resulting corresponding local index partitions or subpartitions. ■ All global indexes remain usable.

Merging Range Partitions

You are allowed to merge the contents of two adjacent range partitions into one partition. Non adjacent range partitions cannot be merged. The resulting partition inherits the higher upper bound of the two merged partitions.

One reason for merging range partitions is 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.

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-apr-1998','dd-mon-yyyy'))
   TABLESPACE quarter_one,
PARTITION quarter_two
   VALUES LESS THAN ( TO_DATE('01-jul-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-jan-1999','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 List Partitions

When you merge list partitions, the partitions being merged can be any two partitions. They do not need to be adjacent, as for range partitions, since list partitioning does not assume any order for partitions. The resulting partition consists of all of the data from the original two partitions.

The statement below merges two partitions of a table partitioned using the list method into a partition that inherits all of its attributes from the table-level default attributes, except for PCTFREE and MAXEXTENTS, which are specified in the statement.

```
ALTER TABLE sales_by_region
   MERGE PARTITIONS sales_northwest, sales_southwest
   INTO PARTITION sales_west
      PCTFREE 50 STORAGE(MAXEXTENTS 20);
```

The value lists for the two original partitions were specified as:

```
PARTITION sales_northwest VALUES ('WA','OR','WY','MT')
PARTITION sales_southwest VALUES ('AZ','NM','CO')
```

The resulting sales_west partition's value list comprises the set that represents the union of these two partition value lists, or specifically:

```
('WA','OR','WY','MT','AZ','NM','CO')
```

Merging Range Composite Partitions

When you merge range composite partitions, the subpartitions are rehashed into either the number of subpartitions specified in a SUBPARTITIONS or SUBPARTITION clause, or, if no such clause is included, table-level defaults are used.

Note that the inheritance of properties is different when a range composite partition is split (discussed in "Splitting a Range Composite Partition" on page 17-41), verses when two range composite partitions are merged. When a partition is split, the new partitions can inherit properties from the original partition since there is only one parent. However, when partitions are merged, properties must be inherited from *table level* defaults because there are two parents and the new partition cannot inherit from either at the expense of the other.

The following example merges two range composite partitions:

```
ALTER TABLE all_seasons
     MERGE PARTITIONS quarter_1, quarter_2 INTO PARTITION quarter_2
     SUBPARTITIONS 8;
```

Modifying Default Attributes

You can modify the default attributes of a table, or for a partition of a composite-partitioned table. When you modify default attributes, the new attributes affect only future partitions, or subpartitions, that are created. The default values can still be specifically overridden when creating a new partition or subpartition.

Modifying Default Attributes of a Table

You modify the default attributes that will be inherited for range, list, 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 a Partition

To modify the default attributes inherited when creating subpartitions, use the ALTER TABLE ... MODIFY DEFAULT ATTRIBUTES FOR PARTITION. The following 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 or List 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 is performed for every subpartition of the specified partition.
- Likewise, changing any other attributes results in corresponding changes to those attributes of all the subpartitions for that partition. The partition level default attributes are 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 the following 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.

Modifying List Partitions: Adding or Dropping Values

List partitioning allows you the option of adding or dropping literal values from the defining value list.

Modifying Partitions: Adding Values

Use the MODIFY PARTITION ... ADD VALUES clause of the ALTER TABLE statement to extend the value list of an existing partition. Literal values being added must not have been included in any other partition's value list. The partition value list for any corresponding local index partition is correspondingly extended, and any global index, or global or local index partitions, remain usable.

The following statement adds a new set of state codes ('OK', 'KS') to an existing partition list.

```
ALTER TABLE sales_by_region
   MODIFY PARTITION region_east
      ADD VALUES ('OK', 'KS');
```

Modifying Partitions: Dropping Values

Use the MODIFY PARTITION ... DROP VALUES clause of the ALTER TABLE statement to remove literal values from the value list of an existing partition. The statement is always executed with validation, meaning that it checks to see if any rows exist in the partition that correspond to the set of values being dropped. If any such rows are found then Oracle returns an error message and the operation fails. When necessary, use a DELETE statement to delete corresponding rows from the table before attempting to drop values.

> **Note:** You cannot drop all literal values from the value list describing the partition. You must use the ALTER TABLE ... DROP PARTITION statement instead.

The partition value list for any corresponding local index partition reflects the new value list, and any global index, or global or local index partitions, remain usable.

The statement below drops a set of state codes ('OK' and 'KS') from an existing partition value list.

```
ALTER TABLE sales_by_region
   MODIFY PARTITION region_south
      DROP VALUES ('OK', 'KS');
```

Note: Since a query is executed to check for the existence of rows in the partition that correspond to the literal values being dropped, it is advisable to create a local prefixed index on the table. This speeds up the execution of the query and the overall operation.

Moving Partitions

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 using an ALTER TABLE/INDEX ... MODIFY PARTITION statement. However, there are some physical attributes, such as TABLESPACE, that you cannot modify using MODIFY PARTITION. In these cases, use the MOVE PARTITION clause.

Unless the partition being moved does not contain any data, indexes may be marked UNUSABLE according to the following table:

Table Type	Index Behavior
Regular (Heap)	■ The matching partition in each local index is marked UNUSABLE. You must rebuild these index partitions after issuing MOVE PARTITION. ■ Unless you specify UPDATE GLOBAL INDEXES, any global indexes, or all partitions of partitioned global indexes, are marked UNUSABLE.
Index-organized	Any local or global indexes defined for the partition being moved remain usable because they are primary-key based logical rowids. However, the guess information for these rowids becomes incorrect.

Moving Table Partitions

Use the MOVE PARTITION clause to move a partition. For example, to move the most active partition to a tablespace that resides on its own disk (in order to balance I/O) and to not log the action, 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 do not 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

The ALTER TABLE ... MOVE PARTITION statement for regular tables, marks 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

Some reasons for rebuilding index partitions include:

- 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 entire global index and re-create it.

> **Note:** This second method is more efficient because the table is scanned only once.

For most maintenance operations on partitioned tables with global indexes, you can optionally avoid the need to rebuild the global index by specifying UPDATE GLOBAL INDEXES on your DDL statement.

Rebuilding Local Index Partitions

Rebuild local indexes using either ALTER INDEX or ALTER TABLE as follows:

- 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. When you re-create the index, you can also choose to 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 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

Rename a range, hash, or list partition, using the ALTER TABLE ... RENAME PARTITION statement. For example:

```
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 an 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 of the ALTER TABLE or ALTER INDEX statement is used to redistribute the contents of a partition into two new partitions. Consider doing 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.

This clause cannot be used for hash partitions or subpartitions.

Unless the partition you are splitting does not contain any data, indexes may be marked UNUSABLE as explained in the following table:

Table Type	Index Behavior
Regular (Heap)	■ Oracle marks UNUSABLE the new partitions (there are two) in each local index. ■ Unless you specify UPDATE GLOBAL INDEXES, any global indexes, or all partitions of partitioned global indexes, are marked UNUSABLE and must be rebuilt.
Index-organized	■ Oracle marks UNUSABLE the new partitions (there are two) in each local index. ■ All global indexes remain usable.

Splitting a Partition of a Range-Partitioned Table

You split a range partition using the ALTER TABLE ... SPLIT PARTITION statement. You can 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, issue 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_P*n*. 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 Partition of a List-Partitioned Table

You split a list partition using the ALTER TABLE ... SPLIT PARTITION statement. The SPLIT PARTITION clause allows you to specify a value list of literal values for which rows with corresponding partitioning key values are inserted into the first new partition. The remaining rows of the original partition are inserted into the second partition.

You can optionally specify new attributes for the two partitions resulting from the split.

The following statement splits the partition region_east into 2 partitions:

```
ALTER TABLE sales_by_region
   SPLIT PARTITION region_east VALUES ('CT', 'VA', 'MD')
   INTO
    ( PARTITION region_east_1
         PCTFREE 25 TABLESPACE tbs2,
      PARTITION region_east_2
        STORAGE (NEXT 2M PCTINCREASE 25))
   PARALLEL 5;
```

The literal-value list for the original region_east partition was specified as:

```
PARTITION region_east VALUES ('CT','VA','MD','NY','NH','ME','VA','PA','NJ')
```

The two new partition's are:

- region_east_1 with a literal-value list of ('CT'. 'VA', 'MD')
- region_east_2 inheriting the remaining literal-value list of ('NY', 'NH', 'ME', 'VA', 'PA', 'NJ')

The individual partitions have new physical attributes specified at the partition level. The operation is executed with parallelism of degree 5.

Splitting a Range Composite Partition

This is the opposite of merging range composite partitions. When you split range composite partitions, the new subpartitions are rehashed into either the number of subpartitions specified in a SUBPARTITIONS or SUBPARTITION clause. Or, if no such clause is included, the new partitions inherit the number of subpartitions (and tablespaces) from the partition being split.

Note that the inheritance of properties is different when a range composite partition is split, verses when two range composite partitions are merged. When a partition is split, the new partitions can inherit properties from the original partition since there

is only one parent. However, when partitions are merged, properties must be inherited from *table level* defaults because there are two parents and the new partition cannot inherit from either at the expense of the other.

The following example splits a range composite partition:

```
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. However, you can split a global index partition as is done in the following example:

```
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 the resulting partitions do not require rebuilding, unless the original partition was previously marked UNUSABLE.

Truncating Partitions

Use the ALTER TABLE ... TRUNCATE PARTITION statement 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, if there are local indexes defined for the table, the ALTER TABLE TRUNCATE PARTITION statement truncates the matching partition in each local index. Unless you specify UPDATE GLOBAL INDEXES (cannot be specified for index-organized tables), any global indexes, or all partitions of partitioned global indexes, are marked UNUSABLE and must be rebuilt.

Truncating a Table Partition

Use the ALTER TABLE ... TRUNCATE PARTITION statement to remove all rows from a table partition, with or without reclaiming space.

Truncating Table Partitions Containing Data and Global Indexes If the partition contains data and global indexes, use one of the following methods to truncate the table partition.

Method 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 dec98;
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.

Method 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 logs.

For example, to truncate the first partition, which has a partition bound of 10000, issue the following statements:

```
DELETE FROM sales WHERE TRANSID < 10000;
ALTER TABLE sales TRUNCATE PARTITION dec98;
```

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.

Method 3:

Specify UPDATE GLOBAL INDEXES in the ALTER TABLE statement. This causes the global index to be truncated at the time the partition is truncated.

```
ALTER TABLE sales TRUNCATE PARTITION dec98
     UPDATE GLOBAL INDEXES;
```

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.

Method 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.

Method 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, and orders. Historical tables can also be **rollup** tables, which contain summary information derived from the base information using 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 transactions, and in turn allocate space for sets of rows that describe the most recent transactions. 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. These monthly 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. Some methods for doing this are:

- Bring down all user-level applications during a well-defined batch window.
- 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 AS
      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-JAN-1999'));
```

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 AS
    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;
```

Viewing Information About Partitioned Tables and Indexes

The following views display information specific to partitioned tables and indexes:

View	Description
DBA_PART_TABLES ALL_PART_TABLES USER_PART_TABLES	DBA view displays partitioning information for all partitioned tables in the database. ALL view displays partitioning information for all partitioned tables accessible to the user. USER view is restricted to partitioning information for partitioned tables owned by the user.
DBA_TAB_PARTITIONS ALL_TAB_PARTITIONS USER_TAB_PARTITIONS	Display partition-level partitioning information, partition storage parameters, and partition statistics determined by ANALYZE statements for partitions.
DBA_TAB_SUBPARTITIONS ALL_TAB_SUBPARTITIONS USER_TAB_SUBPARTITIONS	Display subpartition-level partitioning information, subpartition storage parameters, and subpartition statistics determined by ANALYZE operations for partitions.
DBA_PART_KEY_COLUMNS ALL_PART_KEY_COLUMNS USER_PART_KEY_COLUMNS	Display the partitioning key columns for partitioned tables.
DBA_SUBPART_KEY_COLUMNS ALL_SUBPART_KEY_COLUMNS USER_SUBPART_KEY_COLUMNS	Display the subpartitioning key columns for composite-partitioned tables (and local indexes on composite-partitioned tables).
DBA_PART_COL_STATISTICS ALL_PART_COL_STATISTICS USER_PART_COL_STATISTICS	Display column statistics and histogram information for the partitions of tables.
DBA_SUBPART_COL_STATISTICS ALL_SUBPART_COL_STATISTICS USER_SUBPART_COL_STATISTICS	Display column statistics and histogram information for subpartitions of tables.
DBA_PART_HISTOGRAMS ALL_PART_HISTOGRAMS USER_PART_HISTOGRAMS	Display the histogram data (end-points for each histogram) for histograms on table partitions.
DBA_SUBPART_HISTOGRAMS ALL_SUBPART_HISTOGRAMS USER_SUBPART_HISTOGRAMS	Display the histogram data (end-points for each histogram) for histograms on table subpartitions.
DBA_PART_INDEXES ALL_PART_INDEXES USER_PART_INDEXES	Display partitioning information for partitioned indexes.

View	Description
DBA_IND_PARTITIONS ALL_IND_PARTITIONS USER_IND_PARTITIONS	Display the following for index partitions: partition-level partitioning information, storage parameters for the partition, statistics collected by ANALYZE statements.
DBA_IND_SUBPARTITIONS ALL_IND_SUBPARTITIONS USER_IND_SUBPARTITIONS	Display the following for index subpartitions: partition-level partitioning information, storage parameters for the partition, statistics collected by ANALYZE statements.

See Also:

- *Oracle9i Database Reference* for complete descriptions of these views
- *Oracle9i Database Performance Methods* and *Oracle9i Database Performance Guide and Reference* for information about histograms and generating statistics for tables
- "Analyzing Tables, Indexes, and Clusters" on page 21-3

18

Managing Clusters

This chapter describes aspects of managing clusters. It contains the following topics relating to the management of indexed clusters, clustered tables, and cluster indexes:

- Guidelines for Managing Clusters
- Creating Clusters
- Altering Clusters
- Dropping Clusters
- Viewing Information About Clusters

See Also:

- Chapter 19, "Managing Hash Clusters" for a description of another type of cluster: a hash cluster
- Chapter 14, "Managing Space for Schema Objects" is recommended reading before attempting tasks described in this chapter.

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. The tables are grouped together because they share common columns and are often used together. For example, the `emp` and `dept` table share the `deptno` column. When you cluster the `emp` and `dept` tables (see Figure 18–1), Oracle physically stores all rows for each department from both the `emp` and `dept` tables in the same data blocks.

Because clusters store related rows of different tables together in the same data blocks, properly used clusters offer two primary benefits:

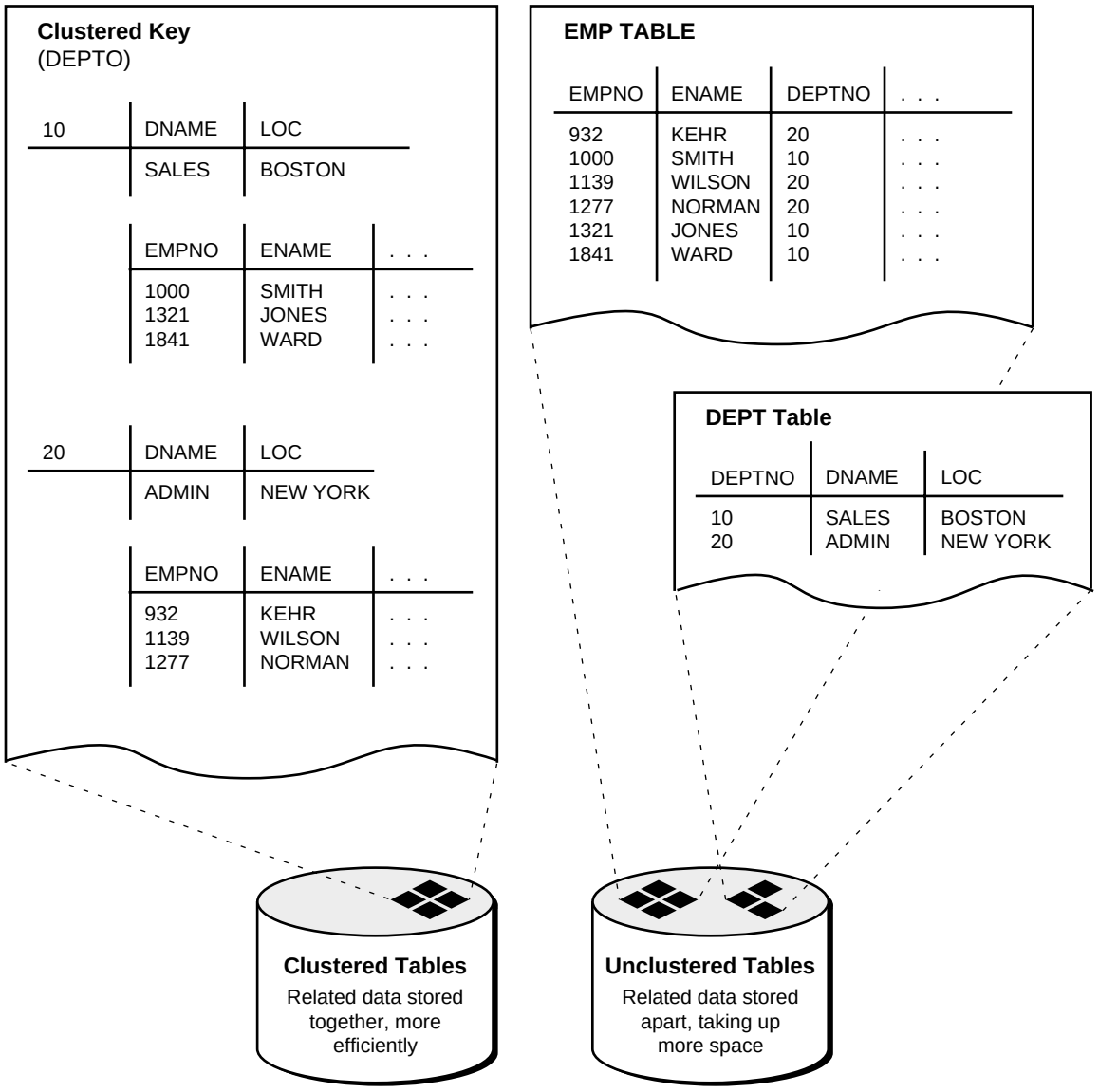
- Disk I/O is reduced and access time improves for joins of clustered tables.
- The **cluster key** is the column, or group of columns, that the clustered tables have in common. You specify the columns of the cluster key when creating the cluster. You subsequently specify the same columns when creating every table added to the cluster. Each cluster key value is stored only once each in the cluster and the cluster index, no matter how many rows of different tables contain the value.

  Therefore, less storage might be required to store related table and index data in a cluster than is necessary in non-clustered table format. For example, in Figure 18–1, notice how each cluster key (each `deptno`) is stored just once for many rows that contain the same value in both the `emp` and `dept` tables.

After creating a cluster, you can create tables in the cluster. However, before any rows can be inserted into the clustered tables, a cluster index must be created. Using clusters does not affect the creation of additional indexes on the clustered tables; they can be created and dropped as usual.

You should not use clusters for tables that are frequently accessed individually.

Figure 18–1 Clustered Table Data



The following sections describe guidelines to consider when managing clusters, and contains the following topics:

- Choose Appropriate Tables for the Cluster
- Choose Appropriate Columns for the Cluster Key
- Specify 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:

- *Oracle9i Database Concepts* for more information about clusters
- *Oracle9i Database Performance Guide and Reference* for guidelines on when to use clusters

Choose Appropriate Tables for the Cluster

Use clusters for tables for which the following conditions are true:

- The tables are primarily queried--that is, tables that are *not* predominantly inserted into or updated.
- Records from the tables are frequently queried together or joined.

Choose Appropriate Columns for the Cluster Key

Choose cluster key columns carefully. If multiple columns are used in queries that join the tables, make the cluster key a composite key. In general, the characteristics that indicate a good cluster index are the same as those for any index. For information about characteristics of a good index, see "Guidelines for Managing Indexes" on page 16-2.

A good cluster key has enough unique values so that the group of rows corresponding to each key value fills approximately one data block. Having too few rows for each cluster key value can waste space and result in negligible performance gains. Cluster keys that are so specific that only a few rows share a common value can cause wasted space in blocks, unless a small `SIZE` was specified at cluster creation time (see "Specify the Space Required by an Average Cluster Key and Its Associated Rows" on page 18-5).

Too many rows for each cluster key value can cause extra searching to find rows for that key. Cluster keys on values that are too general (for example, `male` and `female`) result in excessive searching and can result in worse performance than with no clustering.

A cluster index cannot be unique or include a column defined as `long`.

Specify 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. `PCTFREE` and `PCTUSED` parameters specified for tables created in a cluster are ignored; clustered tables automatically use the settings specified for the cluster.

> **See Also:** "Managing Space in Data Blocks" on page 14-2 for information about setting the `PCTFREE` and `PCTUSED` parameters

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 for each block is maintained as clustered tables are imported to other databases on other machines.

If all the rows for a given cluster key value cannot fit in one block, the blocks are chained together to speed access to all the values with the given key. The cluster index points to the beginning of the chain of blocks, each of which contains the cluster key value and associated rows. If the cluster `SIZE` is such that more than one key fits in a block, blocks can belong to more than one chain.

Specify the Location of Each Cluster and Cluster Index Rows

If you have the proper privileges and tablespace quota, you can create a new cluster and the associated cluster index in any tablespace that is currently online. Always specify the TABLESPACE 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

The 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.

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 19, "Managing Hash Clusters".

> **See Also:** *Oracle9i SQL Reference* for a more complete description of syntax, restrictions, and authorizations required for the SQL statements presented in this chapter

Creating Clustered Tables

To create a table in a cluster, you must have either the CREATE TABLE or CREATE ANY TABLE system privilege. You do not need a tablespace quota or the UNLIMITED TABLESPACE system privilege to create a table in a cluster.

You create a table in a cluster using the CREATE TABLE statement with the CLUSTER option. The emp and dept tables can be created in the emp_dept cluster using the following statements:

```
CREATE TABLE emp (
   empno NUMBER(5) PRIMARY KEY,
   ename VARCHAR2(15) NOT NULL,
   . . .
   deptno NUMBER(3) REFERENCES dept)
   CLUSTER emp_dept (deptno);

CREATE TABLE dept (
   deptno NUMBER(3) PRIMARY KEY, . . . )
   CLUSTER emp_dept (deptno);
```

Note: You can specify the schema for a clustered table in the CREATE TABLE statement. A clustered table can be in a different schema than the schema containing the cluster. Also, the names of the columns are not required to match, but their structure must match.

Creating Cluster Indexes

To create a cluster index, one of the following conditions must be true:

- Your schema contains the cluster.
- You have the CREATE ANY INDEX system privilege.

In either case, you must also have either a quota for the tablespace intended to contain the cluster index, or the UNLIMITED TABLESPACE system privilege.

A cluster index must be created before any rows can be inserted into any clustered table. The following statement creates a cluster index for the emp_dept cluster:

```
CREATE INDEX emp_dept_index
   ON CLUSTER emp_dept
   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 Oracle9*i* Real Application Clusters, you can allocate an extent of a cluster explicitly for a specific instance. You allocate a new extent for a cluster using the ALTER CLUSTER statement with the ALLOCATE EXTENT clause.

When you alter 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 and 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:** *Oracle9i Real Application Clusters Administration* for specific uses of the ALTER CLUSTER statement in an Oracle Real Application Clusters environment

Altering Clustered Tables

You can alter clustered tables using the ALTER TABLE statement. However, any data block space parameters, transaction entry parameters, or storage parameters you set in an ALTER TABLE statement for a clustered table generate an error message (ORA-01771, illegal option for a clustered table). 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 15-9.

Altering Cluster Indexes

You alter cluster indexes exactly as you do other indexes. See "Altering Indexes" on page 16-19.

Note: When estimating the size of cluster indexes, remember that the index is on each cluster key, not the actual rows. Therefore, each key appears only once in the index.

Dropping Clusters

A cluster can be dropped if the tables within the cluster are no longer 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 15-19.

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 16-22.

Viewing Information About Clusters

The following views display information about clusters:

View	Description
DBA_CLUSTERS ALL_CLUSTERS USER_CLUSTERS	DBA view describes all clusters in the database. ALL view describes all clusters accessible to the user. USER view is restricted to clusters owned by the user. Some columns in these views contain statistics that are generated by the DBMS_STATS package or ANALYZE statement.
DBA_CLU_COLUMNS USER_CLU_COLUMNS	These views map table columns to cluster columns

See Also: *Oracle9i Database Reference* for complete descriptions of these views

19

Managing Hash Clusters

This chapter describes how to manage hash clusters, and contains the following topics:

- When to Use Hash Clusters
- Creating Hash Clusters
- Altering Hash Clusters
- Dropping Hash Clusters
- Viewing Information About Hash Clusters

> **See Also:** Chapter 14, "Managing Space for Schema Objects" is recommended reading before attempting tasks described in this chapter.

When to 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 nonclustered 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 helps you decide when to use hash clusters by contrasting situations where hashing is most useful against situations where there is no advantage. If you find your decision is to use indexing rather than hashing, then you should consider whether to store a table individually or as part of a cluster.

Note: Even if you decide to use hashing, a table can still have separate indexes on any columns, including the cluster key.

See Also:

- *Oracle9i Database Concepts* for more information about hash clusters
- *Oracle9i Application Developer's Guide - Fundamentals* for additional recommendations on the use of hash clusters

Situations Where Hashing Is Useful

Hashing is useful when you have the following conditions:

- Most queries are equality queries on the cluster key:

  ```
  SELECT ... WHERE cluster_key = ...;
  ```

  In such cases, the cluster key in the equality condition is hashed, and the corresponding hash key is usually found with a single read. In comparison, for an indexed table the key value must first be found in the index (usually several reads), and then the row is read from the table (another read).

- The tables in the hash cluster are primarily static in size so that you can determine the number of rows and amount of space required for the tables in the cluster. If tables in a hash cluster require more space than the initial allocation for the cluster, performance degradation can be substantial because overflow blocks are required.

Situations Where Hashing Is Not Advantageous

Hashing is not advantageous in the following situations:

- Most queries on the table retrieve rows over a range of cluster key values. For example, in full table scans or queries such as the following, a hash function cannot be used to determine the location of specific hash keys. Instead, the equivalent of a full table scan must be done to fetch the rows for the query.

  ```
  SELECT . . . WHERE cluster_key < . . . ;
  ```

  With an index, key values are ordered in the index, so cluster key values that satisfy the `WHERE` clause of a query can be found with relatively few I/Os.

- The table is not static, but instead is continually growing. If a table grows without limit, the space required over the life of the table (its cluster) cannot be predetermined.

- Applications frequently perform full-table scans on the table and the table is sparsely populated. A full-table scan in this situation takes longer under hashing.

- You cannot afford to preallocate the space that the hash cluster will eventually need.

Creating Hash Clusters

A hash cluster is created using a CREATE CLUSTER statement, but you specify a HASHKEYS clause. The following example contains a statement to create a cluster named trial_cluster that stores the trial table, clustered by the trialno column (the cluster key); and another statement creating a table in the cluster.

```
CREATE CLUSTER trial_cluster (trialno NUMBER(5,0))
    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 18, "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

- Estimating Size Required by Hash Clusters

See Also:

- *Oracle9i Database Concepts* for a discussion of hash functions and specifying user-defined hash functions
- *Oracle9i SQL Reference* for a more complete description of syntax, restrictions, and authorizations required for the SQL statements CREATE CLUSTER and CREATE TABLE

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 (two cluster key values having the same hash value), 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 for each value), SIZE can be set to the average row size in the cluster.
- If the hash cluster is to contain multiple tables, SIZE can be set to the average amount of space required to hold all rows associated with a representative hash value.

Further, once you have determined a (preliminary) value for SIZE, consider the following. If the SIZE value is small (more than four hash keys can be assigned for each data block) you can use this value for SIZE in the CREATE CLUSTER statement. However, if the value of SIZE is large (four or fewer hash keys can be assigned for each data block), then you should also consider the expected frequency of collisions and whether performance of data retrieval or efficiency of space usage is more important to you.

- If the hash cluster does not use the internal hash function (if you specified HASH IS) and you expect few or no collisions, you can use your preliminary value of SIZE. No collisions occur and space is used as efficiently as possible.
- If you expect frequent collisions on inserts, the likelihood of overflow blocks being allocated to store rows is high. To reduce the possibility of overflow blocks and maximize performance when collisions are frequent, you should adjust SIZE as shown in the following chart.

Available Space for each Block/Calculated SIZE	Setting for SIZE
1	SIZE
2	SIZE + 15%
3	SIZE + 12%
4	SIZE + 8%
>4	SIZE

Overestimating the value of SIZE increases the amount of unused space in the cluster. If space efficiency is more important than the performance of data retrieval, disregard the above adjustments and use the original 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 for each data block. HASHKEYS can be set to the number of rows in the table, 10000. Oracle rounds this value up to the next highest prime number: 10007.

```
CREATE CLUSTER emp_cluster (empno
NUMBER)
. . .
SIZE 55
HASH IS empno HASHKEYS 10000;
```

Example 2 Conditions similar to the previous example exist. In this case, however, rows are usually retrieved by department number. At most, there are 1000 departments with an average of 10 employees for each department. Department numbers increment by 10 (0, 10, 20, 30, . . .).

In this case, deptno should be the cluster key. Since this column contains integers that are uniformly distributed, the internal hash function can be bypassed. A preliminary value of SIZE (the average amount of space required to hold all rows for each department) is 55 bytes * 10, or 550 bytes. Using this value for SIZE, only three hash keys can be assigned for each data block. If you expect some collisions and want maximum performance of data retrieval, slightly alter your estimated SIZE to prevent collisions from requiring overflow blocks. By adjusting SIZE by 12%, to 620 bytes (refer to "Setting SIZE" on page 19-6), there is more space for rows from expected collisions.

HASHKEYS can be set to the number of unique department numbers, 1000. Oracle rounds this value up to the next highest prime number: 1009.

```
CREATE CLUSTER emp_cluster (deptno NUMBER)
. . .
SIZE 620
HASH IS deptno HASHKEYS 1000;
```

Estimating Size Required by Hash Clusters

As with index clusters, it is important to estimate the storage required for the data in a hash cluster.

Oracle guarantees that the initial allocation of space is sufficient to store the hash table according to the settings SIZE and HASHKEYS. If settings for the storage parameters INITIAL, NEXT, and MINEXTENTS do not account for the hash table size, incremental (additional) extents are allocated until at least SIZE*HASHKEYS is reached. For example, assume that the data block size is 2K, the available data space for each block is approximately 1900 bytes (data block size minus overhead), and that the STORAGE and HASH parameters are specified in the CREATE CLUSTER statement as follows:

```
STORAGE (INITIAL 100K
    NEXT 150K
    MINEXTENTS 1
    PCTINCREASE 0)
SIZE 1500
HASHKEYS 100
```

In this example, only one hash key can be assigned for each data block. Therefore, the initial space required for the hash cluster is at least 100*2K or 200K. The settings for the storage parameters do not account for this requirement. Therefore, an initial extent of 100K and a second extent of 150K are allocated to the hash cluster.

Alternatively, assume the HASH parameters are specified as follows:

```
SIZE 500 HASHKEYS 100
```

In this case, three hash keys are assigned to each data block. Therefore, the initial space required for the hash cluster is at least 34*2K or 68K. The initial settings for the storage parameters are sufficient for this requirement (an initial extent of 100K is allocated to the hash cluster).

Altering Hash Clusters

You can alter a hash cluster with the ALTER CLUSTER statement:

```
ALTER CLUSTER emp_dept . . . ;
```

The implications for altering a hash cluster are identical to those for altering an index cluster, described in "Altering Clusters" on page 18-8. However, the SIZE, HASHKEYS, and HASH IS parameters cannot be specified in an ALTER CLUSTER statement. To change these parameters, you must re-create the cluster, then copy the data from the original cluster.

Dropping Hash Clusters

You can drop a hash cluster using the DROP CLUSTER statement:

```
DROP CLUSTER emp_dept;
```

A table in a hash cluster is dropped using the DROP TABLE statement. The implications of dropping hash clusters and tables in hash clusters are the same as those for dropping index clusters.

See Also: "Dropping Clusters" on page 18-10

Viewing Information About Hash Clusters

The following views display information about hash clusters:

View	Description
DBA_CLUSTERS ALL_CLUSTERS USER_CLUSTERS	DBA view describes all clusters (including hash clusters) in the database. ALL view describes all clusters accessible to the user. USER view is restricted to clusters owned by the user. Some columns in these views contain statistics that are generated by the DBMS_STATS package or ANALYZE statement.
DBA_CLU_COLUMNS USER_CLU_COLUMNS	These views map table columns to cluster columns.
DBA_CLUSTER_HASH_EXPRESSIONS ALL_CLUSTER_HASH_EXPRESSIONS USER_CLUSTER_HASH_EXPRESSIONS	These views list hash functions for hash clusters.

See Also: *Oracle9i Database Reference* for complete descriptions of these views

20

Managing Views, Sequences, and Synonyms

This chapter describes the management of views, sequences, and synonyms and contains the following topics:

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 contains the following topics:

- Creating Views
- Updating a Join View
- Altering Views
- Dropping Views
- Replacing Views

Creating Views

To create a view, you must meet the following requirements:

- To create a view in your schema, you must have the `CREATE VIEW` privilege. To create a view in another user's schema, you must have the `CREATE ANY VIEW` system privilege. You can acquire these privileges explicitly or through a role.
- The owner of the view (whether it is you or another user) must have been explicitly granted privileges to access all objects referenced in the view definition. The owner *cannot* have obtained these privileges through roles. Also, the functionality of the view 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.
- If the owner of the view intends to grant access to the view to other users, the owner must have received the object privileges to the base objects with the `GRANT OPTION` or the system privileges with the `ADMIN OPTION`.

You can create views using the `CREATE VIEW` statement. Each view is defined by a query that references tables, materialized views, or other views. As with all subqueries, the query that defines a view cannot contain the `FOR UPDATE` clause.

The following statement creates a view on a subset of data in the `emp` table:

```
CREATE VIEW sales_staff AS
      SELECT empno, ename, deptno
```

```
    FROM emp
    WHERE deptno = 10
WITH CHECK OPTION CONSTRAINT sales_staff_cnst;
```

The query that defines the `sales_staff` view references only rows in department 10. Furthermore, the `CHECK OPTION` creates the view with the constraint (named `sales_staff_cnst`) that `INSERT` and `UPDATE` statements issued against the view cannot result in rows that the view cannot select. For example, the following `INSERT` statement successfully inserts a row into the `emp` table by means of the `sales_staff` view, which contains all rows with department number 10:

```
INSERT INTO sales_staff VALUES (7584, 'OSTER', 10);
```

However, the following `INSERT` statement 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.

> **See Also:** *Oracle9i SQL Reference* for detailed syntax, restriction, and authorization information relating to creating and maintaining views

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 20-5 for further discussion.

Expansion of Defining Queries at View Creation Time

When a view is created, Oracle expands any wildcard (*) in a top-level view query into a column list. The resulting query is stored in the data dictionary; any subqueries are left intact. The column names in an expanded column list are enclosed in quote marks to account for the possibility that the columns of the base object were originally entered with quotes and require them for the query to be syntactically correct.

As an example, assume that the `dept` view is created as follows:

```
CREATE VIEW dept AS SELECT * FROM scott.dept;
```

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. In this case, the view is considered "created with errors." For example, when a view is created that refers to a nonexistent table or an invalid column of an existing table, or when the view owner does not have the required privileges, the view can be created anyway and entered into the data dictionary. However, the view is not yet usable.

To create a view with errors, you must include the `FORCE` 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 21-25.

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 can affect whether a join view is updatable. Specifics are listed in the description of the CREATE VIEW statement in the *Oracle9i SQL Reference.*

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 referencing views, see *Oracle9i Database Concepts* and *Oracle9i Database Performance Guide and Reference.*

There are data dictionary views that indicate whether the columns in a join view are updatable. See Table 20–1, "UPDATABLE_ COLUMNS Views" on page 20-9 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**. See "Key-Preserved Tables" on page 20-6 for a discussion of key-preserved tables. If the view is defined with the WITH CHECK OPTION clause, then all join columns and all columns of repeated tables are 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, DELETE, orINSERT statement on a join view can modify only one underlying base table. The following examples illustrate rules specific to UPDATE, DELETE, and INSERT statements.

UPDATE Statements The following example shows an UPDATE statement that successfully modifies the emp_dept view:

```
UPDATE emp_dept
     SET sal = sal * 1.10
     WHERE deptno = 10;
```

The following UPDATE statement would be disallowed on the emp_dept view:

```
UPDATE emp_dept
     SET loc = 'BOSTON'
     WHERE ename = 'SMITH';
```

This statement fails with an error (ORA-01779 cannot modify a column which maps to a non key-preserved table), because it attempts to

modify the base dept table, and the dept table is not key preserved in the emp_dept view.

In general, all updatable columns of a join view must map to columns of a key-preserved table. If the view is defined using the WITH CHECK OPTION clause, then all join columns and all columns taken from tables that are referenced more than once in the view are not modifiable.

So, for example, if the emp_dept view were defined using WITH CHECK OPTION, the following UPDATE statement would fail:

```
UPDATE emp_dept
     SET deptno = 10
     WHERE ename = 'SMITH';
```

The statement fails because it is trying to update a join column.

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, such as the following, would fail for the same reason that such an UPDATE on the base emp table would fail: the FOREIGN KEY integrity constraint on the emp table is violated (because there is no deptno 77).

```
INSERT INTO emp_dept (ename, empno, deptno)
   VALUES ('KURODA', 9010, 77);
```

The following INSERT statement would fail with an error (ORA-01776 cannot modify more than one base table through a 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 20–1 can assist you when modifying join views.

Table 20–1 UPDATABLE_COLUMNS Views

View Name	Description
DBA_UPDATABLE_COLUMNS	Shows all columns in all tables and views that are modifiable.
ALL_UPDATABLE_COLUMNS	Shows all columns in all tables and views accessible to the user that are modifiable.
USER_UPDATABLE_COLUMNS	Shows all columns in all tables and views in the user's schema that are modifiable.

The updatable columns in view emp_dept are shown below.

```
SELECT COLUMN_NAME, UPDATABLE
      FROM USER_UPDATABLE_COLUMNS
      WHERE TABLE_NAME = 'EMP_DEPT';

COLUMN_NAME                    UPD
------------------------------ ---
EMPNO                          YES
ENAME                          YES
DEPTNO                         YES
SAL                            YES
DNAME                          NO
LOC                            NO

6 rows selected.
```

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 20-10.

The ALTER VIEW statement allows you to locate recompilation errors before run time. To ensure that the alteration does not affect the view or other objects that depend on it, you can explicitly recompile a view after altering one of its base tables.

To use the ALTER VIEW statement, the view must be in your schema, or you must have the ALTER ANY TABLE system privilege.

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.

  Caution: When a view is dropped, all grants of corresponding object privileges are revoked from roles and users. After the view is re-created, privileges must be 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 21-25 for more information on how Oracle manages such dependencies.

Managing Sequences

Sequences are database objects from which multiple users can generate unique integers. You can use sequences to automatically generate primary key values. This section describes various aspects of managing sequences, and contains the following topics:

- Creating Sequences
- Altering Sequences

- Dropping Sequences

See Also:

- *Oracle9i Database Concepts* for more information about sequences
- *Oracle9i SQL Reference* for statement syntax

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 *Oracle9i Database Utilities* for details.

See Also:

- *Oracle9i Real Application Clusters Deployment and Performance* for information about how caching sequence numbers improves performance in an Oracle Real Application Clusters environment
- *Oracle9i Database Performance Guide and Reference* for performance information on caching sequence numbers

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 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 contains the following synonym management information:

- Creating Synonyms
- Dropping Synonyms

See Also:

- *Oracle9i Database Concepts* for more information about synonyms
- *Oracle9i SQL Reference* for statement syntax

Creating Synonyms

To create a private synonym in your own schema, you must have the CREATE SYNONYM privilege. To create a private synonym in another user's schema, you must have the CREATE ANY SYNONYM privilege. To create a public synonym, you must have the CREATE PUBLIC SYNONYM system privilege.

Create a synonym using the CREATE SYNONYM statement. The underlying schema object need not exist, nor do you need privileges to access the object. 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".

Viewing Information About Views, Synonyms, and Sequences

The following views display information about views, synonyms, and sequences:

View	Description
DBA_VIEWS ALL_VIEWS USER_VIEWS	DBA view describes all views in the database. ALL view is restricted to views accessible to the current user. USER view is restricted to views owned by the current user.
DBA_SYNONYMS ALL_SYNONYMS USER_SYNONYMS	These views describe synonyms.
DBA_SEQUENCES ALL_SEQUENCES USER_SEQUENCES	These views describe sequences.
DBA_UPDATABLE_COLUMNS ALL_UPDATABLE_COLUMNS USER_UPDATABLE_COLUMNS	These views describe all columns in join views that are updatable.

See Also: *Oracle9i Database Reference* for complete descriptions of these views

21

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:** *Oracle9i SQL Reference* for more information about syntax, authorizations, and restrictions for the SQL statements discussed in this chapter

Creating Multiple Tables and Views in a Single Operation

You can create several tables and views and grant privileges in one operation using the CREATE SCHEMA statement. The CREATE SCHEMA statement is useful if you want to guarantee the creation of several tables, views, and grants in one operation. If an individual table, view or grant fails, the entire statement is rolled back. None of the objects are created, nor are the privileges granted.

Specifically, the CREATE SCHEMA statement can include *only* CREATE TABLE, CREATE VIEW, and GRANT statements. You must have the privileges necessary to issue the included statements. You are not actually creating a schema, that is done when the user is created with a CREATE USER statement. Rather, you are populating the schema.

The following statement creates two tables and a view that joins data from the two tables:

```
CREATE SCHEMA AUTHORIZATION scott
    CREATE TABLE dept (
        deptno NUMBER(3,0) PRIMARY KEY,
        dname VARCHAR2(15),
        loc VARCHAR2(25)
    CREATE TABLE emp (
        empno NUMBER(5,0) PRIMARY KEY,
        ename VARCHAR2(15) NOT NULL,
        job VARCHAR2(10),
        mgr NUMBER(5,0),
        hiredate DATE DEFAULT (sysdate),
        sal NUMBER(7,2),
        comm NUMBER(7,2),
        deptno NUMBER(3,0) NOT NULL
        CONSTRAINT dept_fkey REFERENCES dept)
   CREATE VIEW sales_staff AS
        SELECT empno, ename, sal, comm
        FROM emp
        WHERE deptno = 30
        WITH CHECK OPTION CONSTRAINT sales_staff_cnst
        GRANT SELECT ON sales_staff TO human_resources;
```

The CREATE SCHEMA statement does not support Oracle extensions to the ANSI CREATE TABLE and CREATE VIEW statements, including the STORAGE clause.

Renaming Schema Objects

To rename an object, it must be in your schema. You can rename schema objects in either of the following ways:

- Drop and re-create the object
- Rename the object using the RENAME statement

If you drop and re-create an object, all privileges granted for that object are lost. Privileges must be regranted when the object is re-created.

Alternatively, a table, view, sequence, or a private synonym of a table, view, or sequence can be renamed using the RENAME statement. When using the RENAME statement, integrity constraints, indexes, and grants made for the object are carried forward for the new name. For example, the following statement renames the `sales_staff` view:

```
RENAME sales_staff TO dept_30;
```

> **Note:** You cannot use RENAME for stored PL/SQL program unit, public synonym, index, or cluster. To rename such an object, you must drop and re-create it.

Before renaming a schema object, consider the following effects:

- All views and PL/SQL program units dependent on a renamed object become invalid, and must be recompiled before next use.
- All synonyms for a renamed object return an error when used.

> **See Also:** "Managing Object Dependencies" on page 21-25 for more information about how Oracle manages object dependencies

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, Clusters, and Materialized Views
- Listing Chained Rows of Tables and Clusters

For information specific to analyzing index-organized tables, see "Analyzing Index-Organized Tables" on page 15-28.

> **See Also:** *Oracle9i Database Performance Guide and Reference* for more information about analyzing tables, indexes, and clusters for performance statistics

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 are always 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 for each key
- Average number of data blocks for each key
- Clustering factor

> **Note:** You 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 receive an error. You must drop and recreate the index that has been marked UNUSABLE for the ANALYZE statement to succeed. Optionally, you can specify a FOR clause that would cause the analyze operation 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 ALL_INDEXES 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 ALL_TABLES DBA_TABLES	This view contains descriptions of relational tables in the database, including the table statistics gathered by ANALYZE.

View	Description
USER_TAB_COLUMNS ALL_TAB_COLUMNS 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: *Oracle9i Database Reference* for more information about the data dictionary views containing statistics

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. Thus, 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 effectively allow you to 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 *Oracle9i Database Performance Guide and Reference*. For a description of procedures, syntax and exceptions, see *Oracle9i Supplied PL/SQL Packages and Types Reference*.

DBMS_UTILITY This package contains the ANALYZE_SCHEMA procedure that takes two arguments:

- The name of a schema
- 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 *Oracle9i Supplied PL/SQL Packages and Types 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
- An analysis method (COMPUTE, ESTIMATE, or DELETE).

It gathers statistics on the object.

For information on the DBMS_DDL package, see *Oracle9i Supplied PL/SQL Packages and Types Reference*.

Validating Tables, Indexes, Clusters, and Materialized Views

To verify the integrity of the structure of a table, index, cluster, or materialized view, use the ANALYZE statement with the VALIDATE STRUCTURE option. If the structure is valid, no error is returned. However, if the structure is corrupt, you receive an error message.

If a table, index, or cluster is corrupt, you should drop it and re-create it. If a materialized view is corrupt, perform a complete refresh and ensure that you have remedied the problem. If the problem is not corrected, drop and re-create the materialized view.

The following statement analyzes the emp table:

```
ANALYZE TABLE emp VALIDATE STRUCTURE;
```

You can validate an object and all related objects (for example, indexes) by including the CASCADE option. The following statement validates the emp table and all associated indexes:

```
ANALYZE TABLE emp VALIDATE STRUCTURE CASCADE;
```

You can specify that you want to perform structure validation online while DML is occurring against the object being validated. There can be a slight performance impact when validating with ongoing DML affecting the object, but this is offset by the flexibility of being able to perform ANALYZE online. The following statement validates the emp table and all associated indexes online:

```
ANALYZE TABLE emp VALIDATE STRUCTURE CASCADE ONLINE;
```

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 clause.

Creating a CHAINED_ROWS Table

To create the table to accept data returned by an ANALYZE ... LIST CHAINED ROWS statement, execute the UTLCHAIN.SQL or UTLCHN1.SQL script. These scripts are provided by Oracle. They create a table named CHAINED_ROWS in the schema of the user submitting the script.

Note: Your choice of script to execute for creating the CHAINED_ROWS table is dependent upon the compatibility level of your database and the type of table you are analyzing. See the following for more information:

- *Oracle9i SQL Reference*
- *Oracle9i Database Migration*

After a CHAINED_ROWS table is created, you specify it in the INTO clause of the ANALYZE statement. For example, the following statement inserts rows containing information about the chained rows in the emp_dept cluster into the CHAINED_ROWS table:

```
ANALYZE CLUSTER emp_dept LIST CHAINED ROWS INTO CHAINED_ROWS;
```

Eliminating Migrated or Chained Rows in a Table

You can use the information in the CHAINED_ROWS table to reduce or eliminate migrated and chained rows in an existing table. Use the following procedure.

1. Use the ANALYZE statement to collect information about migrated and chained rows.

   ```
   ANALYZE TABLE order_hist LIST CHAINED ROWS;
   ```

2. Query the output table:

   ```
   SELECT *
   FROM CHAINED_ROWS
   WHERE TABLE_NAME = 'ORDER_HIST';

   OWNER_NAME  TABLE_NAME  CLUST... HEAD_ROWID          TIMESTAMP
   ----------  ----------  -------- ------------------  ---------
   SCOTT       ORDER_HIST       ... AAAAluAAHAAAAA1AAA  04-MAR-96
   SCOTT       ORDER_HIST       ... AAAAluAAHAAAAA1AAB  04-MAR-96
   SCOTT       ORDER_HIST       ... AAAAluAAHAAAAA1AAC  04-MAR-96
   ```

   The output lists all rows that are either migrated or chained.

3. If the output table shows that you have many migrated or chained rows, then you can eliminate migrated rows by continuing through the following steps:

4. Create an intermediate table with the same columns as the existing table to hold the migrated and chained rows:

   ```
   CREATE TABLE int_order_hist
      AS SELECT *
         FROM order_hist
         WHERE ROWID IN
            (SELECT HEAD_ROWID
               FROM CHAINED_ROWS
               WHERE TABLE_NAME = 'ORDER_HIST');
   ```

5. Delete the migrated and chained rows from the existing table:

   ```
   DELETE FROM order_hist
      WHERE ROWID IN
         (SELECT HEAD_ROWID
            FROM CHAINED_ROWS
   ```

```
    WHERE TABLE_NAME = 'ORDER_HIST');
```

6. Insert the rows of the intermediate table into the existing table:

```
INSERT INTO order_hist
   SELECT *
   FROM int_order_hist;
```

7. Drop the intermediate table:

```
DROP TABLE int_order_history;
```

8. Delete the information collected in step 1 from the output table:

```
DELETE FROM CHAINED_ROWS
    WHERE TABLE_NAME = 'ORDER_HIST';
```

9. Use the ANALYZE statement again, and query the output table.
10. Any rows that appear in the output table are chained. You can eliminate chained rows only by increasing your data block size. It might not be possible to avoid chaining in all situations. Chaining is often unavoidable with tables that have a LONG column or long CHAR or VARCHAR2 columns.

Truncating Tables and Clusters

You can delete all rows of a table or all rows in a group of clustered tables so that the table (or cluster) still exists, but is completely empty. For example, consider a table that contains monthly data, and at the end of each month, you need to empty it (delete all rows) after archiving its data.

To delete all rows from a table, you have the following options:

- Use the DELETE statement.
- Use the DROP and CREATE statements.
- Use the TRUNCATE statement.

Each of these options are discussed in the following sections

Using DELETE

You can delete the rows of a table using the DELETE statement. For example, the following statement deletes all rows from the emp table:

```
DELETE FROM emp;
```

If there are many rows present in a table or cluster when using the DELETE statement, significant system resources are consumed as the rows are deleted. For example, CPU time, redo log space, and 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 affect the entire object.

Using DROP and CREATE

You can drop a table and then re-create the table. For example, the following statements drop and then re-create the emp table:

```
DROP TABLE emp;
CREATE TABLE emp ( ... );
```

When dropping and re-creating a table or cluster, all associated indexes, integrity constraints, and triggers are also dropped, and all objects that depend on the dropped table or clustered table are invalidated. Also, all grants for the dropped table or clustered table are dropped.

Using TRUNCATE

You can delete all rows of the table using the TRUNCATE statement. For example, the following statement truncates the emp table:

```
TRUNCATE TABLE emp;
```

Using the TRUNCATE statement provides a fast, efficient method for deleting all rows from a table or cluster. A TRUNCATE statement does not generate any 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 26, "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. 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)

This is not a complete list. See the *Oracle9i SQL Reference* for a full list of statements and database events that cause triggers to fire

Create triggers with the CREATE TRIGGER statement. They can be defined as firing BEFORE or AFTER the triggering event, or INSTEAD OF it. The following statement creates a trigger scott.emp_permit_changes on table scott.emp. The trigger fires before any of the specified statements are executed.

```
CREATE TRIGGER scott.emp_permit_changes
     BEFORE
     DELETE OR INSERT OR UPDATE
     ON scott.emp
     .
pl/sql block
     .
```

You can later remove a trigger from the database by issuing the DROP TRIGGER statement.

A trigger can be in either of two distinct modes:

- Enabled

  An enabled trigger executes its trigger body if a triggering statement is issued and the trigger restriction, if any, evaluates to true. By default, triggers are enabled when first created.

- Disabled

  A disabled trigger does not execute its trigger body, even if a triggering statement is issued and the trigger restriction (if any) evaluates to true.

To enable or disable triggers using the ALTER TABLE statement, you must own the table, have the ALTER object privilege for the table, or have the ALTER ANY TABLE system privilege. To enable or disable an individual trigger using the ALTER TRIGGER statement, you must own the trigger or have the ALTER ANY TRIGGER system privilege.

See Also:

- *Oracle9i Database Concepts* for a more detailed description of triggers
- *Oracle9i SQL Reference* for syntax, restrictions, and specific authorization requirements for the SQL statements used to create and manage triggers
- *Oracle9i Application Developer's Guide - Fundamentals* for information about creating and using triggers

Enabling Triggers

You enable a disabled trigger using the `ALTER TRIGGER` statement with the `ENABLE` option. To enable the disabled trigger named `reorder` on the `inventory` table, enter the following statement:

```
ALTER TRIGGER reorder ENABLE;
```

To enable all triggers defined for a specific table, use the `ALTER TABLE` statement with the `ENABLE ALL TRIGGERS` option. To enable all triggers defined for the `INVENTORY` table, enter the following statement:

```
ALTER TABLE inventory
    ENABLE ALL TRIGGERS;
```

Disabling Triggers

Consider temporarily disabling a trigger if one of the following conditions is true:

- An object that the trigger references is not available.
- You must perform a large data load and want it to proceed quickly without firing triggers.
- You are loading data into the table to which the trigger applies.

You disable a trigger using the `ALTER TRIGGER` statement with the `DISABLE` option. To disable the trigger `reorder` on the `inventory` table, enter the following statement:

```
ALTER TRIGGER reorder DISABLE;
```

You can disable all triggers associated with a table at the same time using the `ALTER TABLE` statement with the `DISABLE ALL TRIGGERS` option. For example,

to disable all triggers defined for the `inventory` table, enter the following statement:

```
ALTER TABLE inventory
    DISABLE ALL TRIGGERS;
```

Managing Integrity Constraints

Integrity constraints are rules that restrict the values for one or more columns in a table. Constraint clauses can appear in either `CREATE TABLE` or `ALTER TABLE` statements, and identify the column or columns affected by the constraint and identify the conditions of the constraint.

This section briefly discusses the concepts of constraints and identifies the SQL statements used to define and manage integrity constraints. The following topics are contained in this section:

- Integrity Constraint States
- Setting Integrity Constraints Upon Definition
- Modifying or Dropping Existing Integrity Constraints
- Deferring Constraint Checks
- Reporting Constraint Exceptions

See Also:

- *Oracle9i Database Concepts* for a more thorough discussion of integrity constraints
- *Oracle9i Application Developer's Guide - Fundamentals* for detailed information and examples of using integrity constraints in applications

Integrity Constraint States

You can specify that a constraint is enabled (`ENABLE`) or disabled (`DISABLE`). If a constraint is enabled, data is checked as it is entered or updated in the database, and data that does not conform to the constraint'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 *Oracle9i 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, consider temporarily disabling the integrity constraints of a table for the following performance reasons:

- When loading large amounts of data into a table
- When performing batch operations that make massive changes to a table (for example, changing every employee's number by adding 1000 to the existing number)
- When importing or exporting one table at a time

In all three cases, temporarily disabling integrity constraints can improve the performance of the operation, especially in data warehouse configurations.

It is possible to enter data that violates a constraint while that constraint is disabled. Thus, you should always enable the constraint after completing any of the operations listed in the 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 21-23. All rows violating constraints are noted in an `EXCEPTIONS` table, which you can examine.

Enable Novalidate Constraint State

When a constraint is in the enable novalidate state, all subsequent statements are checked for conformity to the constraint. However, any existing data in the table is not checked. A table with enable novalidated constraints can contain invalid data, but it is not possible to add new invalid data to it. Enabling constraints in the novalidated state is most useful in data warehouse configurations that are uploading valid OLTP data.

Enabling a constraint does not require validation. Enabling a constraint novalidate is much faster than enabling and validating a constraint. Also, validating a constraint that is already enabled does not require any DML locks during validation (unlike validating a previously disabled constraint). Enforcement guarantees that no violations are introduced during the validation. Hence, enabling without validating enables you to reduce the downtime typically associated with enabling a constraint.

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 is permitted.

Setting Integrity Constraints Upon Definition

When an integrity constraint is defined in a CREATE TABLE or ALTER TABLE statement, it can be enabled, disabled, or validated or not validated as determined by your specification of the ENABLE/DISABLE clause. If the ENABLE/DISABLE clause is not specified in a constraint'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 in the table that violate the integrity constraint. The definition of the constraint is allowed because its rule is not enforced.

Enabling Constraints Upon Definition

The following CREATE TABLE and ALTER TABLE statements both define and enable integrity constraints:

```
CREATE TABLE emp (
    empno NUMBER(5) CONSTRAINT emp.pk PRIMARY KEY,   . . . ;

ALTER TABLE emp
    ADD CONSTRAINT emp.pk PRIMARY KEY (empno);
```

An ALTER TABLE statement that defines and attempts to enable an integrity constraint can fail because rows of the table violate the integrity constraint. If this case, the statement is rolled back and the constraint definition is not stored and not enabled.

When you enable a UNIQUE or PRIMARY KEY constraint an associated index is created.

> **See Also:** "Creating an Index Associated with a Constraint" on page 16-11

Modifying or Dropping Existing Integrity Constraints

You can use the ALTER TABLE statement to enable, disable, modify, or drop a constraint. When Oracle is using a UNIQUE or PRIMARY KEY index to enforce a constraint, and constraints associated with that index are dropped or disabled, the index is dropped, unless you specify otherwise.

While enabled foreign keys reference a PRIMARY or UNIQUE key, you cannot disable or drop the PRIMARY or UNIQUE key constraint or the index.

Disabling Enabled Constraints

The following statements disable integrity constraints. The second statement specifies that the associated indexes are to be kept.

```
ALTER TABLE dept
    DISABLE CONSTRAINT dname_ukey;

ALTER TABLE dept
    DISABLE PRIMARY KEY KEEP INDEX,
    DISABLE UNIQUE (dname, loc) KEEP INDEX;
```

The following statements enable novalidate disabled integrity constraints:

```
ALTER TABLE dept
    ENABLE NOVALIDATE CONSTRAINT dname_ukey;

ALTER TABLE dept
    ENABLE NOVALIDATE PRIMARY KEY,
    ENABLE NOVALIDATE UNIQUE (dname, loc);
```

The following statements enable or validate disabled integrity constraints:

```
ALTER TABLE dept
    MODIFY CONSTRAINT dname_key VALIDATE;
ALTER TABLE dept
    MODIFY PRIMARY KEY ENABLE NOVALIDATE;
```

The following statements enable disabled integrity constraints:

```
ALTER TABLE dept
    ENABLE CONSTRAINT dname_ukey;
ALTER TABLE dept
    ENABLE PRIMARY KEY,
    ENABLE UNIQUE (dname, loc);
```

To disable or drop a UNIQUE key or PRIMARY KEY constraint and all dependent FOREIGN KEY constraints in a single step, use the CASCADE option of the DISABLE or DROP clauses. For example, the following statement disables a PRIMARY KEY constraint and any FOREIGN KEY constraints that depend on it:

```
ALTER TABLE dept
    DISABLE PRIMARY KEY CASCADE;
```

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. The second statement keeps the index associated with the PRIMARY KEY constraint:

```
ALTER TABLE dept
    DROP UNIQUE (dname, loc);

ALTER TABLE emp
    DROP PRIMARY KEY KEEP INDEX,
    DROP CONSTRAINT dept_fkey;
```

If FOREIGN KEYs reference a UNIQUE or PRIMARY KEY, you must include the CASCADE CONSTRAINTS clause in the DROP statement, or you cannot drop the constraint.

Deferring Constraint Checks

When 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.

Notes:

- You cannot issue a SET CONSTRAINT statement inside a trigger.
- Deferrable unique and primary keys must use nonunique indexes.

Set All Constraints Deferred

Within the application being used to manipulate the data, you must set all constraints deferred before you actually begin processing any data. Use the following DML statement to set all deferrable constraints deferred:

```
SET CONSTRAINTS ALL DEFERRED;
```

> **Note:** The SET CONSTRAINTS statement applies only to the current transaction. The defaults specified when you create a constraint remain as long as the constraint exists. The ALTER SESSION SET CONSTRAINTS statement applies for the current session only.

Check the Commit (Optional)

You can check for constraint violations before committing by issuing the SET CONSTRAINTS ALL IMMEDIATE statement just before issuing the COMMIT. If there are any problems with a constraint, this statement fails and the constraint causing the error is identified. If you commit while constraints are violated, the transaction is rolled back and you receive an error message.

Reporting Constraint Exceptions

If exceptions exist when a constraint is validated, an error is returned and the integrity constraint remains novalidated. When a statement is not successfully executed because integrity constraint exceptions exist, the statement is rolled back. If exceptions exist, you cannot validate the constraint until all exceptions to the constraint are either updated or deleted.

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.

You must create an appropriate exceptions report table to accept information from the EXCEPTIONS option of the ENABLE clause before enabling the constraint. You can create an exception table by executing the UTLEXCPT.SQL script or the UTLEXPT1.SQL script.

> **Note:** Your choice of script to execute for creating the EXCEPTIONS table is dependent upon the compatibility level of your database and the type of table you are analyzing. See the following for more information:
>
> - *Oracle9i SQL Reference*
> - *Oracle9i Database Migration*

Both of these scripts create a table named EXCEPTIONS. You can create additional exceptions tables with different names by modifying and resubmitting the script.

The following statement attempts to validate the PRIMARY KEY of the dept table, and if exceptions exist, information is inserted into a table named EXCEPTIONS:

```
ALTER TABLE dept ENABLE PRIMARY KEY EXCEPTIONS INTO EXCEPTIONS;
```

If duplicate primary key values exist in the dept table and the name of the PRIMARY KEY constraint on dept is sys_c00610, 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 to a null. After

the row in the master table is updated or deleted, the corresponding rows for the exception in the exception report table should be deleted to avoid confusion with later exception reports. The statements that update the master table and the exception report table should be in the same transaction to ensure transaction consistency.

To correct the exceptions in the previous examples, you might issue the following transaction:

```
UPDATE dept SET deptno = 20 WHERE dname = 'RESEARCH';
DELETE FROM EXCEPTIONS WHERE constraint = 'SYS_C00610';
COMMIT;
```

When managing exceptions, the goal is to eliminate all exceptions in your exception report table.

Note: While you are correcting current exceptions for a table with the constraint disabled, it is possible for other users to issue statements creating new exceptions. You can avoid this by enable novalidating the constraint before you start eliminating exceptions.

See Also: *Oracle9i Database Reference* for details about the `EXCEPTIONS` table

Managing Object Dependencies

This section describes the various object dependencies, and contains the following topics:

- Manually Recompiling Views
- Manually Recompiling Procedures and Functions
- Manually Recompiling Packages

First, review Table 21–1, which shows how objects are affected by changes to other objects on which they depend.

Table 21–1 Operations that Affect Object Status

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, MODIFY columns) 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|PROCEDURE][2]	VALID if there are no errors; INVALID if there are syntax or authorization errors	INVALID
REVOKE *object privilege*[3] ON *object* TO|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] **Can cause dependent objects to be made** INVALID**, if object did not exist earlier.**

[2] **Standalone 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 standalone 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 standalone 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 statement recompiles just the body of the package acct_mgmt:

```
ALTER PACKAGE acct_mgmt COMPILE BODY;
```

The next example compiles both the body and specification of the package acct_mgmt:

```
ALTER PACKAGE acct_mgmt COMPILE PACKAGE;
```

Managing Object Name Resolution

Object names referenced in SQL statements can consist of several pieces, separated by periods. The following describes how Oracle resolves an object name.

1. 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. 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. 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 an 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

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 could require 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 has sufficient space. To remedy this situation, you can change the storage parameters of the underlying data dictionary tables, just as you can change the storage settings for user-created segments. This allows the data dictionary tables to be allocated more extents. For example, you can adjust the values of NEXT or PCTINCREASE for a data dictionary table.

Caution: 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. At that point you will not be able to create any more users or roles without exporting, re-creating, and importing the entire database.

This section describes aspects of changing data dictionary storage parameters, and contains the following topics:

- Structures in the Data Dictionary
- Errors that Require Changing Data Dictionary Storage

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 following error message indicates this kind of problem.

```
ORA-1653 unable to extend table name by num in tablespace name
```

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-1653` 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$` or `C_COBJ#` cannot be allocated another extent. To do this, query `DBA_SEGMENTS`. If another extent cannot be allocated, consider changing the storage parameters for `CON$` or `C_COBJ#`. See "Example 7: Displaying Segments that Cannot Allocate Additional Extents" on page 21-37.

Displaying Information About Schema Objects

Oracle provides data dictionary views and PL/SQL packages that allow you to display information about schema objects. Views and packages that are unique to a particular schema object are described in the chapter of this book associated with that object. This section describes views and packages that are generic in nature and apply to multiple schema objects.

Using PL/SQL Packages to Display Information About Schema Objects

These Oracle supplied PL/SQL packages provide information about schema objects:

Package and Procedure/Function	Description
`DBMS_METADATA.GET_DDL`	Use to obtain metadata (in the form of DDL used to create the object) about a schema object.
The following package procedures provide information about space usage and free blocks in schema objects:	
`DBMS_SPACE.UNUSED_SPACE`	Returns information about unused space in an object (table, index, or cluster).

Package and Procedure/Function	Description
DBMS_SPACE.FREE_BLOCKS	Returns information about free data blocks in an object (table, index, or cluster) whose segment free space is managed by free lists (segment space management is MANUAL).
DBMS_SPACE.SPACE_USAGE	Returns information about free data blocks in an object (table, index, or cluster) whose segment space management is AUTO.

The following sections contain examples of using some of these packages.

> **See Also:** *Oracle9i Supplied PL/SQL Packages and Types Reference* for a description of PL/SQL packages

Example 1: Using the DBMS_METADATA Package

The DBMS_METADATA package is a powerful tool for obtaining the complete definition of a schema object. It enables you to obtain all of the attributes of an object in one pass. The object is described as DDL that can be used to (re)create it.

In this example the GET_DDL function is used to fetch the DDL for all tables in the current schema, filtering out nested tables and overflow segments. The SET_TRANSFORM_PARAM (with the handle value equal to DBMS_METADATA.SESSION_TRANSFORM meaning "for the current session") is used to specify that storage clauses are not to be returned in the SQL DDL. Afterwards, the session-level transform parameters are reset to their defaults. Once set, transform parameter values remain in effect until specifically reset to their defaults.

```
EXECUTE DBMS_METADATA.SET_TRANSFORM_PARAM(
     DBMS_METADATA.SESSION_TRANSFORM,'STORAGE',false);
SELECT DBMS_METADATA.GET_DDL('TABLE',u.table_name)
     FROM USER_ALL_TABLES u
     WHERE u.nested='NO'
     AND (u.iot_type is null or u.iot_type='IOT');
EXECUTE DBMS_METADATA.SET_TRANSFORM_PARAM(
     DBMS_METADATA.SESSION_TRANSFORM,'DEFAULT');
```

> **See Also:** *Oracle9i Application Developer's Guide - XML* for detailed information and further examples relating to the use of the DBMS_METADATA package

Example 2: Using DBMS_SPACE.UNUSED_SPACE

The following SQL*Plus example uses the DBMS_SPACE package to obtain unused space information.

```
SQL> VARIABLE total_blocks NUMBER
SQL> VARIABLE total_bytes NUMBER
SQL> VARIABLE unused_blocks NUMBER
SQL> VARIABLE unused_bytes NUMBER
SQL> VARIABLE lastextf NUMBER
SQL> VARIABLE last_extb NUMBER
SQL> exec DBMS_SPACE.UNUSED_SPACE('SCOTT', 'EMP', 'TABLE', :total_blocks, -
>    :total_bytes,:unused_blocks, :unused_bytes, :lastextf, -
>    :last_extb, :lastusedblock);

PL/SQL procedure successfully completed.

SQL> PRINT

TOTAL_BLOCKS
------------
           5

TOTAL_BYTES
-----------
      10240

...

LASTUSEDBLOCK
-------------
            3
```

Using Views to Display Information About Schema Objects

These views display information about schema objects:

View	Description
DBA_OBJECTS ALL_OBJECTS USER_OBJECTS	DBA view describes all schema objects in the database. ALL view describes objects accessible to current user. USER view describes objects owner by the current user.

View	Description
DBA_CATALOG ALL_CATALOG USER_CATALOG	List the name, type, and owner (USER view does not display owner) for all tables, views, synonyms, and sequences in the database.
DBA_DEPENDENCIES ALL_DEPENDENCIES USER_DEPENDENCIES	Describe all dependencies between procedures, packages, functions, package bodies, and triggers, including dependencies on views without any database links.
The following views contain information about segments of the database:	
DBA_SEGMENTS USER_SEGMENTS	Describe storage allocated for all database segments, or for segments for the current user.
The following views contain information about extents of the database:	
DBA_EXTENTS USER_EXTENTS	Describe extents comprising all segments either in the database, or segments for the current user.
DBA_FREE_SPACE USER_FREE_SPACE	List free extents in all tablespaces, or tablespaces owned by the current user.

The following sections contain examples of using some of these views.

> **See Also:** *Oracle9i Database Reference* for a complete description of data dictionary views

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. 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 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 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 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 as free extents in each tablespace:

```
SELECT TABLESPACE_NAME, FILE_ID, BYTES, BLOCKS
    FROM 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 satisfy any of the above criteria:

```
SELECT a.SEGMENT_NAME, a.SEGMENT_TYPE, a.TABLESPACE_NAME, a.OWNER
    FROM DBA_SEGMENTS a
    WHERE a.NEXT_EXTENT >= (SELECT MAX(b.BYTES)
        FROM DBA_FREE_SPACE b
        WHERE b.TABLESPACE_NAME = a.TABLESPACE_NAME)
    OR a.EXTENTS = a.MAX_EXTENTS
    OR a.EXTENTS = 'data_block_size' ;
```

Note: When you use this query, replace *data_block_size* with the data block size for your system.

Once you have identified a segment that cannot allocate additional extents, you can solve the problem in either of two ways, depending on its cause:

- If the tablespace is full, add datafiles to the tablespace.
- If the segment has too many extents, and you cannot increase `MAXEXTENTS` for the segment, perform the following steps.

  1. Export the data in the segment
  2. Drop and re-create the segment, giving it a larger `INITIAL` setting so that it does not need to allocate so many extents
  3. Import the data back into the segment.

22

Detecting and Repairing Data Block Corruption

This chapter explains using the DBMS_REPAIR PL/SQL package to repair data block corruption in database schema objects. It contains the following topics:

- Options for Repairing Data Block Corruption
- About the DBMS_REPAIR Package
- Using the DBMS_REPAIR Package
- DBMS_REPAIR Examples

> **Note:** If you are not familiar with the DBMS_REPAIR package, it is recommended that you work with an Oracle Support Services analyst when performing any of the repair procedures included in this package.

Options for Repairing Data Block Corruption

Oracle 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. 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. Thus, you must 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: *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information on the syntax, restrictions, and exceptions for the DBMS_REPAIR procedures

DBMS_REPAIR Procedures

The following table lists the procedures included in the DBMS_REPAIR package.

Procedure Name	Description
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 software corrupt

Procedure Name	Description
DUMP_ORPHAN_KEYS	Reports index entries (into an orphan key table) that point to rows in corrupt data blocks
REBUILD_FREELISTS	Rebuilds an object's free lists
SEGMENT_FIX_STATUS	Provides the capability to fix the corrupted state of a bitmap entry when segment space management is AUTO
SKIP_CORRUPT_BLOCKS	When used, ignores blocks marked corrupt during table and index scans. If not used, you get error ORA-1578 when encountering blocks marked corrupt.
ADMIN_TABLES	Provides administrative functions (create, drop, purge) for repair or orphan key tables. **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 22-8.

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 approach is recommended when considering DBMS_REPAIR for addressing data block corruption:

Task 1: Detect and Report Corruptions

Task 2: Evaluate the Costs and Benefits of Using DBMS_REPAIR

Task 3: Make Objects Usable

Task 4: Repair Corruptions and Rebuild Lost Data

These tasks are discussed in succeeding sections.

Task 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 22–1 describes the different detection methodologies.

Table 22–1 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.

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:** *Oracle9i Database Utilities* for more information about DB_VERIFY

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, drop and re-create the object.

> **See Also:** *Oracle9i SQL Reference* for more information about the ANALYZE statement

DB_BLOCK_CHECKING (Block Checking Initialization Parameter)

You can set block checking for instances using 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:** *Oracle9i Database Reference* for more information about the DB_BLOCK_CHECKING initialization parameter

Task 2: Evaluate the Costs and Benefits of Using DBMS_REPAIR

Before using DBMS_REPAIR you must weigh the benefits of its use in relation to the liabilities. You should also examine other options available for addressing corrupt objects.

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? Consider the following:

- Assuming the data is available from another source, drop, re-create and re-populate the object.
- Issue the CREATE TABLE ... AS SELECT statement from the corrupt table to create a new one.
- Ignore the corruption by excluding corrupt rows from select statements.
- Perform media recovery.

3. What logical corruptions or side effects are introduced when you use DBMS_REPAIR to make an object usable? Can these be addressed? What is the effort required to do so?

   It is possible that you do not have access to rows in blocks marked corrupt. However, a block could be marked corrupt even though there are still rows that you can validly access.

   It is also possible that referential integrity constraints are broken when blocks are marked corrupt. If this occurs, disable and re-enable the constraint; any inconsistencies are reported. After fixing all problems, you should be able to successfully re-enable the constraint.

   Logical corruption can 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 can become inaccessible. If a corrupt block is at the head or tail of a free list, space management reinitializes the free list. There then can be blocks that should be on a free list, but are not. You can address this by running the REBUILD_FREELISTS procedure.

   Indexes and tables are 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.

Task 3: Make Objects Usable

In this task 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 skips 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 can 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 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 producing different results.

Task 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

Use this procedure if free space in segments is being managed using free lists (`SEGMENT SPACE MANAGEMENT MANUAL`).

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 distributing blocks in an equitable fashion, one block at a time. Any blocks marked "corrupt" in the object are ignored during the rebuild.

Fix Segment Bitmaps Using the SEGMENT_FIX_STATUS Procedure

Use this procedure if free space in segments is being managed using bitmaps (`SEGMENT SPACE MANAGEMENT AUTO`).

This procedure either recalculates the state of a bitmap entry based on the corresponding block's current contents, or you can specify that a bitmap entry be set to a specific value. Usually, the state is recalculated correctly and there is no need to force a setting.

DBMS_REPAIR Examples

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

Using ADMIN_TABLES to Build a Repair Table or Orphan Key Table

A repair table provides information about 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 for the users tablespace.

```
BEGIN
DBMS_REPAIR.ADMIN_TABLES (
     TABLE_NAME => 'REPAIR_TABLE',
     TABLE_TYPE => dbms_repair.repair_table,
     ACTION     => dbms_repair.create_action,
     TABLESPACE => 'USERS');
END;
/
```

For each repair or orphan key table, a view is also created that eliminates any rows that pertain to objects that no longer exist. The name of the view corresponds to the name of the repair or orphan key table, 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 for the `users` tablespace.

```
BEGIN
DBMS_REPAIR.ADMIN_TABLES (
     TABLE_NAME => 'ORPHAN_KEY_TABLE',
     TABLE_TYPE => dbms_repair.orphan_table,
     ACTION     => dbms_repair.create_action,
     TABLESPACE => 'USERS');
END;
/
```

The orphan key table is described in the following query:

```
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 is skipped.

Here is an example of executing the CHECK_OBJECT procedure for the scott.dept table.

```
SET SERVEROUTPUT ON
DECLARE num_corrupt INT;
BEGIN
num_corrupt := 0;
DBMS_REPAIR.CHECK_OBJECT (
     SCHEMA_NAME => 'SCOTT',
     OBJECT_NAME => 'DEPT',
     REPAIR_TABLE_NAME => 'REPAIR_TABLE',
     CORRUPT_COUNT =>  num_corrupt);
DBMS_OUTPUT.PUT_LINE('number corrupt: ' || TO_CHAR (num_corrupt));
END;
/
```

SQL*PLUS outputs the following line, indicating one corruption:

```
number corrupt: 1
```

Querying the repair table produces information describing the corruption and suggesting a repair action.

```
SELECT OBJECT_NAME, BLOCK_ID, CORRUPT_TYPE, MARKED_CORRUPT,
       CORRUPT_DESCRIPTION, REPAIR_DESCRIPTION
     FROM REPAIR_TABLE;

OBJECT_NAME                     BLOCK_ID CORRUPT_TYPE MARKED_COR
------------------------------ ---------- ------------ ----------
CORRUPT_DESCRIPTION
--------------------------------------------------------------------------------
REPAIR_DESCRIPTION
--------------------------------------------------------------------------------
DEPT                                    3            1 FALSE
kdbchk: row locked by non-existent transaction
        table=0   slot=0
        lockid=32   ktbbhitc=1
mark block software corrupt
```

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.

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. This guarantees that 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 IV

Database Security

Part IV addresses issues of user and privilege management affecting the security of the database. It includes the following chapters:

23

Establishing Security Policies

This chapter provides guidelines for developing security policies for database operation, and contains the following topics:

System Security Policy

This section describes aspects of system security policy, and contains 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.

User authentication and how it is specified is discussed in "User Authentication Methods" on page 24-7.

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:** Your operating system specific Oracle documentation contains more information about operating system security issues

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 is determined primarily by the level of security you want to establish for the data in your database. For example, it may be acceptable to have little data security in a database when you want 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 want 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 25, "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 20, "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 enables 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:

- *Oracle9i Application Developer's Guide - Fundamentals*
- *Oracle9i Supplied PL/SQL Packages and Types Reference*

The above manuals contain information about implementing fine-grained access control and an application context.

User Security Policy

This section describes aspects of user security policy, and contains 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 define a policy for end-user security. If a database has many users, the security administrator can decide which groups of users can be categorized into user groups, and then create user roles for these groups. The security administrator can 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 they contain the object privileges necessary to execute those applications.

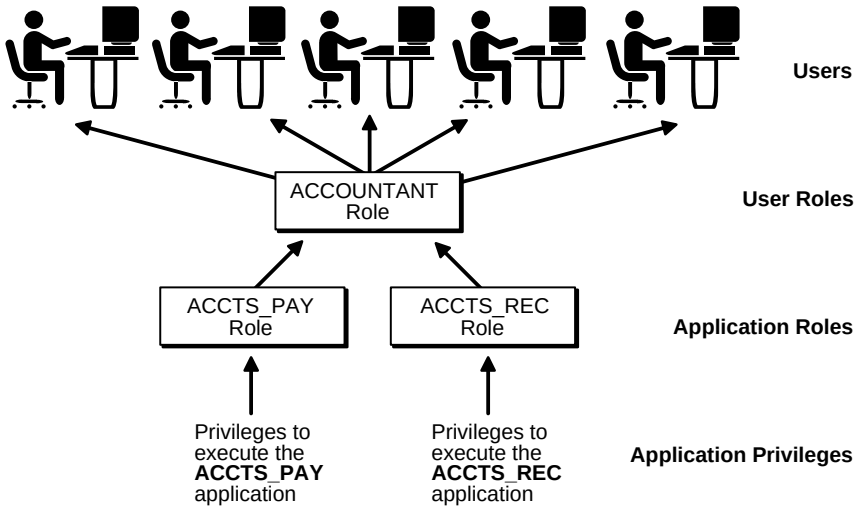
The following actions, performed by the database or security administrator, address this simple security situation:

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 23–1.

Figure 23–1 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.

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 the *Oracle Advanced Security Administrator's Guide* for information about this functionality.

Administrator Security

Security administrators should have a policy addressing database 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.

> **See Also:** Chapter 1, "The Oracle Database Administrator" contains a more thorough discussion of administrator security

Protection for Connections as SYS and SYSTEM

After database creation, *immediately* change the passwords for the SYS and SYSTEM administrative usernames to prevent unauthorized access to the database. Connecting as SYS or SYSTEM gives a user powerful privileges to modify a database in many ways. Connecting as SYS allows a user to alter data dictionary tables. The privileges associated with these usernames are extremely sensitive, and should only be available to select database administrators.

If you have installed options that have caused other administrative usernames to be created, such username accounts are initially created locked. To unlock these accounts, use the ALTER USER statement. The ALTER USER statement should also be used to change the associated passwords for these accounts.

The passwords for these accounts can be modified using the procedures described in "Altering Users" on page 24-20.

Protection for Administrator Connections

Only database administrators should have the capability to connect to a database with administrative privileges. For example:

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

Connecting as SYSOPER gives a user the ability to perform basic operational tasks (such as STARTUP, SHUTDOWN, and recovery operations). Connecting as SYSDBA gives the user these abilities plus unrestricted privileges to do anything to a database or the objects within a database (including, 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 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:

- Object creation and maintenance
- Database tuning and performance
- Creation of new users and granting roles and privileges to database users
- Routine database operation (for example: STARTUP, SHUTDOWN, and backup and recovery operations)
- Emergency situations, such as database recovery

There are also 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. Define six roles 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. Grant each role the appropriate privileges.
3. Grant each type of database administrator 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 could grant the privileges to create necessary objects to application developers. Or, alternatively, the privileges to create objects could be granted only to a database administrator, who then 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 is 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 because granting object privileges through 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 24-20.

Application Administrator Security

In large database systems with many database applications, you might consider assigning 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 an application. However, an application administrator could be any individual familiar with the database application.

Password Management Policy

Database security systems that are dependent on passwords require that passwords be kept secret at all times. But, 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 and security officers through user profiles.

You use the CREATE PROFILE statement to create a user profile. The profile is assigned to a user with the CREATE USER or ALTER USER statement. Details of creating and altering database users are not discussed in this section. This section is concerned with the password parameters that can be specified using the CREATE PROFILE (or ALTER PROFILE) statement.

This section contains the following topics relating to password management:

- Password Aging and Expiration
- Password History
- Password Complexity Verification

See Also:

- "Managing Resources with Profiles" on page 24-22
- "Managing Oracle Users" on page 24-16
- *Oracle9i SQL Reference* for syntax and specific information about SQL statements discussed in this section

Account Locking

When a particular user exceeds a designated number of failed login attempts, the server automatically locks that user's account. You specify the permissible number of failed login attempts using the CREATE PROFILE statement. You can 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 four, 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 you do not specify a time interval for unlocking the account, PASSWORD_LOCK_TIME assumes the value specified in a default profile. If you specify PASSWORD_LOCK_TIME as UNLIMITED, the account must be explicitly unlocked using an ALTER USER statement. For example, assuming that PASSWORD_LOCK_TIME UNLIMITED is specified for ashwini, then the following statement must be used to unlock the account:

```
ALTER USER ashwini ACCOUNT UNLOCK;
```

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, and only the security officer should unlock the account. The `CREATE USER` or `ALTER USER` statements are used to explicitly lock or unlock user accounts. For example, the following statement locks user account `susan`:

```
ALTER USER susan ACCOUNT LOCK;
```

Password Aging and Expiration

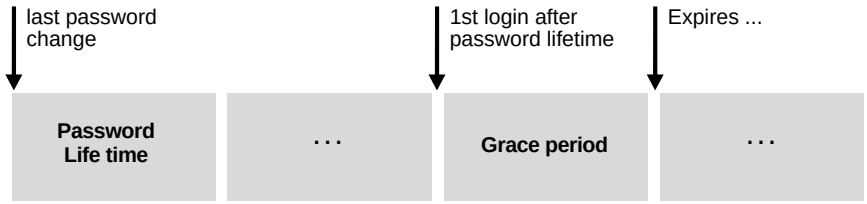
Use the `CREATE PROFILE` statement to specify a maximum lifetime for passwords. When the specified amount of time passes and the password expires, the user or DBA must change the password. The following statements create and assign a profile to user `ashwini`, and the `PASSWORD_LIFE_TIME` clause specifies 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;
```

You can also specify a grace period for password expiration. 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, thereafter users are prompted for a new password each time an attempt is made to access their accounts. Access to an account is denied until a new password is supplied.

Figure 23–2 shows the chronology of the password lifetime and grace period.

Figure 23–2 Chronology of Password Lifetime and Grace Period



In the following example, the profile assigned to `ashwini` includes the specification of a grace period: `PASSWORD_GRACE_TIME = 3`. The first time `ashwini` tries to log in to the database after 90 days (this can be *any* day after the 90th day; that is, the 70th day, 100th day, or another day), she receives a warning message that her password will expire in three days. If three days pass, and she does not change her password, the password expires. Thereafter, she receives a prompt to change her password on any attempt to log in, and cannot log in until she does so.

```
CREATE PROFILE prof LIMIT
   FAILED_LOGIN_ATTEMPTS 4
   PASSWORD_LOCK_TIME 30
   PASSWORD_LIFE_TIME 90
   PASSWORD_GRACE_TIME 3;
ALTER USER ashwini PROFILE prof;
```

Oracle provides a means of explicitly expiring a password. The `CREATE USER` and `ALTER USER` statements provide this functionality. The following statement creates a user with an expired password. This setting forces the user to change the password before the user can log in to the database.

```
CREATE USER jbrown
     IDENTIFIED BY zX83yT
     ...
     PASSWORD EXPIRE;
```

Password History

Use the `CREATE PROFILE` statement to specify a time interval during which users cannot reuse a password. In the following statement, a profile is defined where the `PASSWORD_REUSE_TIME` clause specifies that the user cannot reuse the password for 60 days.

```
CREATE PROFILE prof LIMIT
```

```
   PASSWORD_REUSE_TIME 60
   PASSWORD_REUSE_MAX UNLIMITED;
```

In the next statement, the PASSWORD_REUSE_MAX clause specifies that the number of password changes the user must make before the current password can be used again is three.

```
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 four.
- The password is not the same as the username.
- The password has at least one alpha, one numeric, and one punctuation mark character.
- The password is not a simple or obvious word, such as welcome, account, database, or user.
- The password differs from the previous password by at least 3 characters.

> **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

You can enhance the existing password verification complexity routine or create other password verification routines using PL/SQL or third-party tools.

The 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.

Sample Password Verification Routine

You can use this sample password verification routine as a model when developing your own complexity checks for a new password.

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 26, "Auditing Database Use".

A Security Checklist

Information security and privacy and protection of corporate assets and data are of pivotal importance in any business. Oracle9*i* comprehensively addresses the need for information security by offering cutting-edge security features such as deep data protection, auditing, scalable security, secure hosting and data exchange.

The Oracle9*i* database server leads the industry in security. However, in order to fully maximize the security features offered by Oracle9*i* in any business environment, it is imperative that Oracle9*i* itself is well-protected. Furthermore, proper use of its security features and adherence to basic security practices will help protect against database-related threats and attacks and provide a much more secure operating environment for the Oracle9*i* database.

This security checklist provides guidance on configuring Oracle9*i* in a secure manner by adhering to and recommending industry-standard "best security practices" for operational database deployments.

Details on specific database-related tasks and actions can be found throughout the Oracle documentation set.

1. INSTALL ONLY WHAT IS REQUIRED

The Oracle9*i* CD pack contains a host of options and products in addition to the database server. Install additional products and options only as necessary. Or, following a typical installation (if avoiding a custom installation), deinstall options and products that are not necessary. There is no need to maintain the additional products and options if they are not being used. They can always be properly and easily reinstalled as required.

2. LOCK AND EXPIRE DEFAULT USER ACCOUNTS

Oracle9*i* installs with a number of default (preset) database server user accounts. The Database Client Administration tool (DBCA) automatically locks and expires all default database user accounts except the following upon successful installation of the database server:

- SYS
- SYSTEM
- SCOTT
- DBSNMP
- OUTLN
- The three JSERV users

If a manual (not utilizing DBCA) installation of Oracle9*i* is performed, none of the default database users are locked upon successful installation of the database server. If left open in their default states, these user accounts can be exploited to gain unauthorized access to data or disrupt database operations. *Lock* and *expire* all default database user accounts except SYS, SYSTEM, SCOTT, DBSNMP, OUTLN and the three JSERV database users after performing any kind of initial installation that does not utilize DBCA. Oracle9*i* provides SQL to perform such operations.

Provided below is the table of database users after a typical Oracle9*i* installation utilizing DBCA.

USERNAME	ACCOUNT_STATUS
ADAMS	EXPIRED & LOCKED
AURORAJISUTILITY$	OPEN
AURORAORBUNAUTHENTICATED	OPEN

USERNAME	ACCOUNT_STATUS
BLAKE	EXPIRED & LOCKED
CLARK	EXPIRED & LOCKED
CTXSYS	EXPIRED & LOCKED
DBSNMP	OPEN
HR	EXPIRED & LOCKED
JONES	EXPIRED & LOCKED
LBACSYS	EXPIRED & LOCKED
MDSYS	EXPIRED & LOCKED
OE	EXPIRED & LOCKED
OLAPDBA	EXPIRED & LOCKED
OLAPSVR	EXPIRED & LOCKED
OLAPSYS	EXPIRED & LOCKED
ORDPLUGINS	EXPIRED & LOCKED
ORDSYS	EXPIRED & LOCKED
OSE$HTTP$ADMIN	OPEN
OUTLN	OPEN
PM	EXPIRED & LOCKED
QS	EXPIRED & LOCKED
QS_ADM	EXPIRED & LOCKED
QS_CB	EXPIRED & LOCKED
QS_CBADM	EXPIRED & LOCKED
QS_CS	EXPIRED & LOCKED
QS_ES	EXPIRED & LOCKED
QS_OS	EXPIRED & LOCKED
QS_WS	EXPIRED & LOCKED
SCOTT	OPEN
SH	EXPIRED & LOCKED
SYS	OPEN

USERNAME	ACCOUNT_STATUS
SYSTEM	OPEN

If any default database server user account other the ones left open is required for any reason, a database administrator (DBA) need simply unlock and activate that account with a new, meaningful password.

3. CHANGE DEFAULT USER PASSWORDS

The most trivial method by which Oracle9*i* can be compromised is a default database server user account which still has a default password associated with it *even after installation*.

a. Change default passwords of administrative users

In Oracle9*i*, SYS installs with a default password of CHANGE_ON_INSTALL and SYSTEM installs with a default password of MANAGER. Change the default passwords associated with users SYS and SYSTEM immediately upon installation of the database server.

b. Change default passwords of all users

In Oracle9*i*, SCOTT installs with default password TIGER and the three JSERV accounts (AURORAJISUTILITY$, AURORA$ORB$UNAUTHENTICATED and OSE$HTTP$ADMIN) each install with randomly-generated passwords. Each of the other accounts install with a default password that is exactly the same as that user account (for example, user MDSYS installs with password MDSYS).

Change the passwords for SCOTT, DBSNMP, OUTLN and the three JSERV user accounts immediately upon installation as well. If any of the other default user accounts that were locked and expired upon installation need to be activated, assign a new meaningful password to that user account.

Even though Oracle does not explicitly mandate changing the default password for user SCOTT, Oracle nevertheless recommends that this user account also be locked unless it is being actively used.

c. Enforce password management

Oracle recommends that basic password management rules (such as password length, history, complexity, and so forth) as provided by the database be applied to all user passwords and that all users be required to change their passwords periodically.

Oracle also recommends, if possible, utilizing Oracle Advanced Security (an option to the Enterprise Edition of Oracle9*i*) with network authentication services (such as Kerberos), token cards, smart cards or X.509 certificates. These services enable strong authentication of users to provide better protection against unauthorized access to Oracle9*i*.

4. ENABLE DATA DICTIONARY PROTECTION

Oracle recommends that customers implement data dictionary protection to prevent users having the ANY system privileges from using such privileges on the data dictionary.

To enable dictionary protection, set the O7_DICTIONARY_ACCESSIBILITY initialization parameter, in the following manner:

```
O7_DICTIONARY_ACCESSIBILITY = FALSE
```

By doing so, only those authorized users making DBA-privileged (for example CONNECT / AS SYSDBA) connections can use the ANY system privilege on the data dictionary. If this parameter is not set to the value recommended above, any user with a DROP ANY TABLE (for example) system privilege will be able to maliciously drop parts of the data dictionary.

However, if a user requires view access to the data dictionary, it is permissible to grant that user the SELECT ANY DICTIONARY system privilege.

Note that in Oracle9*i*, O7_DICTIONARY_ACCESSIBILITY = FALSE by default; in Oracle8i, the parameter is set to TRUE by default and must specifically be changed to FALSE to enable this security feature.

5. PRACTICE PRINCIPLE OF LEAST PRIVILEGE

a. Grant necessary privileges only

Do not provide database users more privileges than are necessary. In other words, *principle of least privilege* is that a user be given only those privileges that are actually required to efficiently and succinctly perform his or her job.

To implement least privilege, restrict: 1) the number of SYSTEM and OBJECT privileges granted to database users, and 2) the number of SYS-privileged connections to the database as much as possible. For example, there is generally no need to grant CREATE ANY TABLE to any non DBA-privileged user.

b. Revoke unnecessary privileges from PUBLIC

Revoke all unnecessary privileges and roles from the database server user group PUBLIC. PUBLIC acts as a default role granted to every user in an Oracle database. Any database user can exercise privileges that are granted to PUBLIC. Such privileges include EXECUTE on various PL/SQL packages that may permit a minimally privileged user to access and execute packages that he may not directly be permitted to access. The more powerful packages that may potentially be misused are listed in the following table:

Package	Description
UTL_SMPT	This package permits arbitrary mail messages to be sent from one arbitrary user to another arbitrary user. Granting this package to PUBLIC may permit unauthorized exchange of mail messages.
UTL_TCP	This package permits outgoing network connections to be established by the database server to any receiving (or waiting) network service. Thus, arbitrary data may be sent between the database server and any waiting network service.
UTL_HTTP	This package allows the database server to request and retrieve data using HTTP. Granting this package to PUBLIC may permit data to be sent using HTML forms to a malicious web site.
UTL_FILE	If configured improperly, this package allows text level access to any file on the host operating system. Even when properly configured, this package does not distinguish between its calling applications with the result that one application with access to UTL_FILE may write arbitrary data into the same location that is written to by another application.
DBMS_RANDOM	This package can be used to encrypt stored data. Generally, most users should not have the privilege to encrypt data since encrypted data may be non-recoverable if the keys are not securely generated, stored, and managed.

These packages are extremely useful to some applications that need them and require proper configuration and usage. These packages may not be suitable for other applications. Thus, unless absolutely necessary, revoke them from PUBLIC.

c. Restrict permissions on run-time facilities

Do not assign "all permissions" to any database server run-time facility such as the Oracle Java Virtual Machine (OJVM). Grant specific permissions to the explicit document root file paths for such facilities that may execute files and packages outside the database server.

An example of a vulnerable run-time call:

```
call dbms_java.grant_permission('SCOTT',
'SYS:java.io.FilePermission','<<ALL FILES>>','read');
```

An example of a better (more secure) run-time call:

```
call dbms_java.grant_permission('SCOTT',
'SYS:java.io.FilePermission','<<actual directory path>>','read');
```

6. ENFORCE ACCESS CONTROLS EFFECTIVELY

a. Authenticate clients properly

Remote authentication is a security feature provided by Oracle9*i* such that if turned on (TRUE), it defers authentication of users to the remote client connecting to an Oracle database. Thus, the database implicitly trusts any client to have authenticated itself properly. Note that clients, in general, such as PCs, are not trusted to perform operating system authentication properly and therefore, it is very poor security practice to turn on this feature.

In a more secure configuration where this feature is turned off (FALSE), it enforces proper, server-based authentication of clients connecting to an Oracle database.

To restrict remote authentication and thereby defer client trust to the database, set the REMOTE_OS_AUTHENT initialization parameter in the following manner:

```
REMOTE_OS_AUTHENT = FALSE
```

b. Limit the number of operating system users

Limit the number of users with operating system accounts (administrative, root-privileged or minimally privileged) on the Oracle9*i* host (physical machine) to the least number possible.

Oracle also recommends that neither any privileged operating system user nor the Oracle owner be permitted to modify the default file and directory permissions within and on the Oracle9*i* home (installation) directory unless instructed otherwise by Oracle Corporation.

7. RESTRICT NETWORK ACCESS

a. Utilize a firewall

Keep the database server behind a firewall. Oracle9*i*'s network infrastructure, Oracle Net (formerly known as Net8 and SQL*Net), offers support for a variety of firewalls from various vendors. Supported proxy-enabled firewalls include Network Associates' Gauntlet and Axent's Raptor. Supported packet-filtered firewalls include Cisco's PIX Firewall and supported stateful inspection firewalls (more sophisticated packet-filtered firewalls) include CheckPoint's Firewall-1.

b. Never poke a hole through a firewall

If Oracle9*i* is behind a firewall, do not, under any circumstances, poke a hole through the firewall; for example, do not leave open Oracle Listener's 1521 port to make a connection to the Internet or vice versa.

Doing so will introduce a number of significant security vulnerabilities including more port openings through the firewall, multi-threaded operating system server issues and revelation of crucial information on database(s) behind the firewall. Furthermore, an Oracle Listener running without an established password may be probed for critical details about the database(s) on which it is listening such as trace and logging information, banner information and database descriptors and service names.

Such a plethora of information and the availability of an ill-configured firewall will provide an attacker ample opportunity to launch malicious attacks on the target database(s).

c. Prevent unauthorized administration of the Oracle Listener

Always establish a meaningful, well-formed password for the Oracle Listener to prevent remote configuration of the Oracle Listener. Additionally, set the `listener.ora` (Oracle Listener control file) security configuration parameter in the following manner:

```
ADMIN_RESTRICTIONS_listener_name = ON
```

Doing so will also prevent unauthorized administration of the Oracle Listener.

d. Check network IP addresses

Utilize the Oracle Net "valid node checking" security feature to allow or deny access to Oracle server processes from network clients with specified IP addresses. To use this feature, set the following `protocol.ora` (Oracle Net configuration file) parameters:

```
tcp.validnode_checking = YES

tcp.excluded_nodes = {list of IP addresses}

tcp.invited_nodes = {list of IP addresses}
```

The first parameter turns on the feature whereas the latter two parameters respectively deny or allow specific client IP addresses from making connections to the Oracle Listener (and thereby preventing potential Denial of Service attacks).

e. Encrypt network traffic

If possible, utilize Oracle Advanced Security to encrypt network traffic between clients, databases and application servers. (Note that Oracle Advanced Security is available only with the Enterprise Edition of the Oracle database).

f. Harden the operating system

Harden the host operating system by disabling all unnecessary operating system services. Both UNIX and Windows platforms provide a variety of operating system services, most of which are not necessary for most deployments. Such services include FTP, TFTP, TELNET, and so forth. Be sure to close both the UDP and TCP ports for each service that is being disabled. Disabling one type of port and not the other does not make the operating system more secure.

8. APPLY ALL SECURITY PATCHES AND WORKAROUNDS

Always apply all relevant and current security patches for both the operating system on which Oracle9*i* resides and Oracle9*i* itself, and for all installed Oracle9*i* options and components thereof.

Periodically check the security site on Oracle Technology Network for details on security alerts released by Oracle Corporation.

```
http://otn.oracle.com/deploy/security/alerts.htm

http://technet.oracle.com/deploy/security/alerts.htm
```

Also check Oracle Worldwide Support Service's site, Metalink, for details on available and upcoming security-related patches.

```
http://metalink.oracle.com
```

9. CONTACT ORACLE SECURITY PRODUCTS

If you believe that you have found a security vulnerability in Oracle9*i*, submit an iTAR to Oracle Worldwide Support Services using Metalink, or e-mail a complete description of the problem, including product version and platform, together with any exploit scripts and/or examples to the following address:

secalert_us@oracle.com

24

Managing Users and Resources

This chapter describes how to control access to an Oracle database, and contains the following topics:

- Session and User Licensing
- User Authentication Methods
- Managing Oracle Users
- Managing Resources with Profiles
- Viewing Information About Database Users and Profiles

See Also:

- Chapter 23, "Establishing Security Policies"
- Chapter 25, "Managing User Privileges and Roles"

Session and User Licensing

Oracle helps you ensure that your site complies with its Oracle database 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`

To use the licensing facility, you must know which type of licensing agreement your site has, and what the maximum number of sessions or named users is. Your site can 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 contains the following topics:

- Concurrent Usage Licensing
- Named User Limits
- Viewing Licensing Limits and Current Values

See Also: *Oracle9i Database Reference* for the description and syntax of the `LICENSE_MAX_SESSIONS`, `LICENSE_SESSIONS_WARNING`, and `LICENSE_MAX_USERS` initialization parameters

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. You can also change the maximum number of concurrent sessions while the database is running.

> **See Also:** Chapter 2, "Creating an Oracle Database" describes setting a limit on the number of concurrent sessions as part of the initial database creation process

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.

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" to help you determine if your Oracle license needs to be reviewed.

For instances running Oracle Real Application Clusters, 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.

Caution: 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: "Viewing Licensing Limits and Current Values" on page 24-6 for information about Oracle licensing limit upgrades

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 initialization parameter file used to start the instance. In the following example a warning message is written to the alert file for each new connection starting with the 60th.

```
LICENSE_SESSIONS_WARNING = 60
```

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.

Caution: 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: *Oracle9i SQL Reference* for more information about using the `ALTER SYSTEM` statement to change the value of initialization parameters

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 user name, and that there are no shared user names. If you use named user licensing, do not allow multiple users to connect using the same user name.

Setting User Limits

To limit the number of users created in a database, set the LICENSE_MAX_USERS initialization parameter in the database's initialization 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.

For instances running Oracle Real Application Clusters, all instances connected to the same database should have the same named user limit.

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 initialization parameter file.

To change the maximum named users limit, you must have the ALTER SYSTEM privilege.

Caution: 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

The V$LICENSE data dictionary view allows you to see the current limits of all of the license settings, the current number of user sessions, and the highest number of concurrent user sessions since the instance started. An example is shown below. 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:** *Oracle9i Database Reference* for a complete description of the V$LICENSE view

User Authentication Methods

Oracle provides several means for users to be authenticated 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 **globally** 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 middle-tier server. The middle-tier server authenticates and assumes the identity of the user and is

allowed to enable specific roles for the user. This is called **proxy authentication** and authorization.

These means of authentication are discussed in the following sections:

- Database Authentication
- External Authentication
- Global Authentication and Authorization
- Proxy Authentication and Authorization

> **See Also:** "Managing Oracle Users" on page 24-16 for a discussion of other attributes to consider when creating users for your database

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 multibyte 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.

> **See Also:** "Password Management Policy" on page 23-12

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:** *Oracle9i SQL Reference* for more information about valid passwords, and how to specify the `IDENTIFIED BY` clause in the `CREATE USER` and `ALTER USER` statements

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 Oracle Net.

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 user names. 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 user name with the Oracle user names in the database when a user attempts to connect.

For example, assume that `OS_AUTHENT_PREFIX` is set as follows:

```
OS_AUTHENT_PREFIX=OPS$
```

> **Note:** The text of the `OS_AUTHENT_PREFIX` initialization parameter is case sensitive on some operating systems. See your operating system specific Oracle documentation for more information about this initialization parameter.

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 user names exactly match operating system user names.

After you set OS_AUTHENT_PREFIX, it should remain the same for the life of a database. If you change the prefix, any database user name that includes the old prefix cannot be used to establish a connection, unless you alter the user name 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 by 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:** *Oracle Advanced Security Administrator's Guide* for more information about external authentication

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 Oracle Net. This means the user cannot connect using a shared server configuration, since this connection uses Oracle Net. 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 initialization 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 user name received over a nonsecure connection and use it for account access. The change take effect the next time you start the instance and mount the database.

Generally, user authentication through the host operating system offers the following benefits:

- Users can connect to Oracle faster and more conveniently without specifying a separate database user name or password.
- User entries in the database and operating system audit trails correspond.

Network Authentication

Network authentication is performed using Oracle Advanced Security, which can 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 enables 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 (**distinguished name,** or **DN**) meaningful to the enterprise directory.

In this case, `scott` is truly a global user. But, the disadvantage 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 Windows 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:

- *Oracle Advanced Security Administrator's Guide*
- *Oracle Internet Directory Administrator's Guide*

The above books contain additional information about global authentication and authorization, and enterprise users and roles.

Proxy Authentication and Authorization

It is possible to design a middle-tier server to proxy clients in a secure fashion.

Oracle provides three forms of proxy authentication:

- The middle-tier server authenticates itself with the database server and a client, in this case an application user or another application, authenticates itself with the middle-tier server. Client identities can be maintained all the way through to the database.
- The client, in this case a database user, is not authenticated by the middle-tier server. The clients identity and database password are passed through the middle-tier server to the database server for authentication.
- The client, in this case a global user, is authenticated by the middle-tier server, and passes one of the following through the middle tier for retrieving the client's user name.
  - Distinguished name (DN)
  - Certificate

In all cases, the middle-tier server must be authorized to act on behalf of the client by the administrator.

To authorize a middle-tier server to proxy a client use the `GRANT CONNECT THROUGH` clause of the `ALTER USER` statement. You can also specify roles that the middle tier is permitted to activate when connecting as the client.

Operations done on behalf of a client by a middle-tier server can be audited.

The `PROXY_USERS` data dictionary view can be queried to see which users are currently authorized to connect through a middle tier.

Use the `REVOKE CONNECT THROUGH` clause of `ALTER USER` to disallow a proxy connection.

See Also:

- *Oracle Call Interface Programmer's Guide* and *Oracle9i Application Developer's Guide - Fundamentals* for details about designing a middle-tier server to proxy users
- *Oracle9i SQL Reference* for a description and syntax of the proxy clause for `ALTER USER`
- "Auditing in a Multi-Tier Environment" on page 26-10 for details of auditing operations done on behalf of a user by a middle tier

Authorizing a Middle Tier to Proxy and Authenticate a User

The following statement authorizes the middle-tier server `appserve` to connect as user `bill`. It uses the `WITH ROLE` clause to specify that `appserve` activate all roles associated with `bill`, except `payroll`.

```
ALTER USER bill
    GRANT CONNECT THROUGH appserve
    WITH ROLE ALL EXCEPT payroll;
```

To revoke the middle-tier server's (`appserve`) authorization to connect as user `bill`, the following statement is used:

```
ALTER USER bill REVOKE CONNECT THROUGH appserve;
```

Authorizing a Middle Tier to Proxy a User Authenticated by Other Means

Use the `AUTHENTICATED USING` clause of the `ALTER USER ... GRANT CONNECT THROUGH` statement to authorize a user to be proxied, but not authenticated, by a middle tier. Currently, `PASSWORD` is the only means supported.

The following statement illustrates this form of authentication:

```
ALTER USER mary
    GRANT CONNECT THROUGH midtier
    AUTHENTICATED USING PASSWORD;
```

In the above statement, middle-tier server `midtier` is authorized to connect as `mary`, and `midtier` must also pass `mary`'s password to the database server for authorization.

Authorizing a Middle Tier to Proxy a User Identified by a Distinguished Name

In this case, the following statement authorizes the middle-tier server `WebDB` to present the distinguished name for global user `jeff` to the database server. The distinguished name is used to retrieve the user name. User `jeff` has been authenticated by the middle-tier server `WebDB`.

```
ALTER USER jeff
     GRANT CONNECT THROUGH WebDB
     AUTHENTICATED USING DISTINGUISHED NAME;
```

Optionally, the middle-tier server can be authorized to present an entire certificate (containing the distinguished name). This is illustrated in the following statement:

```
ALTER USER jeff
     GRANT CONNECT THROUGH WebDB
```

```
    AUTHENTICATED USING CERTIFICATE;
```

Passing the entire certificate costs time in authentication. However, some applications use other information contained in the certificate.

Managing 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 user name defined in the database. This section explains how to manage users for a database, and contains the following topics:

- Creating Users
- Altering Users
- Dropping Users

> **See Also:** *Oracle9i SQL Reference* for more information about SQL statements used for managing users

Creating Users

You create a user with the CREATE USER statement.To create a database user, you must have the CREATE USER system privilege. Because it is a powerful privilege, a DBA or security administrator is normally the only user who has the CREATE USER system privilege.

The following example creates a user and specifies that user's password, default tablespace, temporary tablespace where temporary segments are created, tablespace quotas, and profile.

```
CREATE USER jward
    IDENTIFIED BY aZ7bC2
    DEFAULT TABLESPACE data_ts
    QUOTA 100M ON test_ts
    QUOTA 500K ON data_ts
    TEMPORARY TABLESPACE temp_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.

This section refers to the above example as it discusses the following aspects of creating a user:

- Specifying a Name
- Setting a User's Authentication
- Assigning a Default Tablespace
- Assigning Tablespace Quotas
- Assigning a Temporary Tablespace
- Specifying a Profile
- Setting Default Roles

See Also: "Granting System Privileges and Roles" on page 25-11

Specifying a Name

Within each database a user name must be unique with respect to other user names 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.

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, and has no privileges to do so, this default setting is fine. However, if a user creates any type of object, you should specifically assign the user a default tablespace. Using a tablespace other than `SYSTEM` reduces contention between data dictionary objects and user objects for the same datafiles. In general, it is not advisable for user data to be stored in the `SYSTEM` tablespace.

You can set a user's default tablespace during user creation, and change it later with the ALTER USER statement. Changing the user's default tablespace affects only objects created after the setting is changed.

When you specify the user's default tablespace, also specify a quota on that tablespace.

In the previous CREATE USER statement, jward's default tablespace is data_ts, and his quota on that tablespace is 500K.

Assigning Tablespace Quotas

You can assign each user a tablespace quota for any tablespace (except 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 can 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 Users Ability to Create Objects in a Tablespace You can revoke a user's ability to create objects in a tablespace by changing the user's current quota to zero. After a quota of zero is assigned, the user's objects in the tablespace remain, but new objects cannot be created and existing 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.

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. 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.

In the previous CREATE USER statement, jward's temporary tablespace is temp_ts, a tablespace created explicitly to contain only temporary segments. Such a tablespace is created using the CREATE TEMPORARY TABLESPACE statement.

If a user's temporary tablespace is not explicitly set, the user is assigned the default temporary tablespace that was specified at database creation, or by an ALTER DATABASE statement at a later time. If there is no default temporary tablespace, the default is the SYSTEM tablespace. Just as for a user's default tablespace discussed earlier, it is not advisable for user data to be stored in the SYSTEM tablespace. Also, assigning a tablespace to be used specifically as a temporary tablespace eliminates file contention among temporary segments and other types of segments.

You can set a user's temporary tablespace at user creation, and change it later using the ALTER USER statement. Do not set a quota for temporary tablespaces.

See Also:

- "Temporary Tablespaces" on page 11-11
- "Creating a Default Temporary Tablespace" on page 2-21

Specifying a Profile

You also specify a profile when you create a user. A profile is a set of limits on database resources and password access to the database. If no profile is specified, the user is assigned a default profile.

See Also:

- "Managing Resources with Profiles" on page 24-22
- "Password Management Policy" on page 23-12

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 Also: "Specifying Default Roles" on page 25-18

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 ALTER USER statement. 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 and a form of external authentication. Usually, only an administrator has 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.

> **See Also:** Chapter 25, "Managing User Privileges and Roles" for information about changing users' default 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.

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. 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;
```

See Also: "Terminating Sessions" on page 5-22 for more information about terminating sessions

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 contains the following topics:

- Enabling and Disabling Resource Limits
- Creating Profiles

- Assigning Profiles
- Altering Profiles
- Using Composite Limits
- Dropping Profiles

> **See Also:** *Oracle9i SQL Reference.*for more information about the SQL statements used for managing profiles

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 initialization 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 initialization 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 parameters.

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 with the `CREATE USER` and `ALTER USER` statements.

See Also:

- "Creating Users" on page 24-16
- "Altering Users" on page 24-20

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

In addition to being able to use the `CREATE` or `ALTER PROFILE` statements to assign resource limits to specific resources, you can limit the total resource cost for a session by using composite limits. A composite limit is expressed as a weighted sum, measured in **service units**, of certain resources.

You can set a profile's composite limit using the `COMPOSITE_LIMIT` clause of a `CREATE PROFILE` or `ALTER PROFILE` statement. The following `CREATE PROFILE` statement specifies 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:** *Oracle9i SQL Reference* for information on how to calculate the composite limit

Setting Resource Costs

Each Oracle database server environment has its own characteristics. Some system resources can be more valuable in one environment than another. Oracle enables you to assign the following resources a weight, which then affects their contribution to a total resource cost:

- CPU_PER_SESSION
- LOGICAL_READS_PER_SESSION
- CONNECT_TIME
- PRIVATE_SGA.

If you do not assign a weight to a resource, its weight defaults to 0, and the use of the resource does not contribute to the total resource cost.

Oracle calculates the total resource cost by first multiplying the amount of each resource used in the session by the resource's weight, and then summing the products for all four resources. For any session, this cost is limited by the value of the COMPOSITE_LIMIT parameter in the user's profile. Both the products and the total cost are expressed in units called service units.

To set weights for resources, use the ALTER RESOURCE COST statement.You must have the ALTER RESOURCE system privilege.The following example assigns

weights to the CPU_PER_SESSION and LOGICAL_READS_PER_SESSION resources.

```
ALTER RESOURCE COST
    CPU_PER_SESSION 1
    LOGICAL_READS_PER_SESSION 50;
```

The weights establish this cost formula for a session:

```
cost = (1 * CPU_PER_SESSION) + (50 * LOGICAL_READS_PER_SESSION)
```

where the values of CPU_PER_SESSION and LOGICAL_READS_PER_SESSION are either values in the DEFAULT profile or in the profile of the user of the session.

Because the above statement assigns no weight to the resources CONNECT_TIME and PRIVATE_SGA, these resources do not appear in the formula.

See Also:

- *Oracle9i SQL Reference*
- Your operating system specific Oracle documentation

The above sources provide additional information and recommendations on setting resource costs

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. 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.

Viewing Information About Database Users and Profiles

The following data dictionary views contain information about database users and profiles:

View	Description
DBA_USERS ALL_USERS USER_USERS	DBA view describes all users of the database. ALL view lists users visible to the current user, but does not describe them. USER view describes only the current user.
DBA_TS_QUOTAS USER_TS_QUOTAS	Describes tablespace quotas for users.
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_USERS	Describes users who can assume the identity of other users.

The following sections present some example of using these views, and 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;
```

> **See Also:** *Oracle9i SQL Reference* for complete descriptions of the above data dictionary and dynamic performance views

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 is 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 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 is always 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 is 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 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     UNLIMITED
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 for Each User Session

The following query lists all current sessions, showing the Oracle user and current UGA (user global area) memory use for each 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'`.

25

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 discussed:

- 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
- Viewing Privilege and Role Information

See Also:

- Chapter 24, "Managing Users and Resources" for information about controlling access to a database
- Chapter 23, "Establishing Security Policies" for suggested general database security policies

Identifying User Privileges

This section describes Oracle user privileges, and contains 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.

Caution: System privileges can be very powerful, and should be granted only when necessary to roles and trusted users of the database.

For the complete list, including descriptions, of system privileges, see the *Oracle9i 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, ensure that the `O7_DICTIONARY_ACCESSIBILITY` initialization parameter is set 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 Oracle8*i* and higher releases. 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 for O7_DICTIONARY_ACCESSIBILITY is FALSE.
>
> When this parameter is not set to FALSE, the ANY privilege applies to the data dictionary, and a malicious user with ANY privilege could access or alter data dictionary tables.
>
> See the *Oracle9i Database Reference* for more information on the O7_DICTIONARY_ACCESSIBILITY initialization parameter and *Oracle9i Database Migration* to understand its usage.

If you enable dictionary protection (O7_DICTIONARY_ACCESSIBILITY is FALSE), access to objects in the SYS schema (dictionary objects) is restricted to users with the SYS schema. These users are SYS and those 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 Objects in the SYS Schema

Users with explicit object privileges or with administrative privileges (SYSDBA) can access objects in the SYS schema. Another means of allowing access to objects in the SYS schema is by granting users any of the following roles:

- SELECT_CATALOG_ROLE

  This role can be granted to users to allow SELECT privileges on all data dictionary views.

- EXECUTE_CATALOG_ROLE

  This role can be granted to users to allow EXECUTE privileges for packages and procedures in the data dictionary.

- DELETE_CATALOG_ROLE

  This role can be granted to users to allow them to delete records from the system audit table (AUD$).

Additionally, the following system privilege can be granted to users who require access to tables created in the SYS schema:

- SELECT ANY DICTIONARY

  This system privilege allows query access to any object in the SYS schema, including tables created in that schema. It must be granted individually to each user requiring the privilege. It is not included in GRANT ALL PRIVILEGES, nor can it be granted through a role.

> **Caution:** You should grant these roles and the SELECT ANY DICTIONARY system privilege with extreme care, since the integrity of your system can be compromised by their misuse.

Object Privileges

Each type of object has different privileges associated with it. For a detailed list of objects and associated privileges, see the *Oracle9i 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. A role must be enabled for a user before it can be used by the user.

This section describes aspects of managing roles, and contains the following topics:

- Predefined Roles

- Creating a Role
- Specifying the Type of Role Authorization
- Dropping Roles

See Also: *Oracle9i Database Concepts* for additional information about roles

Predefined Roles

The roles listed in Table 25–1 are automatically defined for Oracle databases when you run the standard scripts that are part of database creation. You can grant privileges and roles to, and revoke privileges and roles from, these predefined roles, much the way you do with any role you define.

Table 25–1 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.

Table 25–1 Predefined Roles **(Page 2 of 2)**

Role Name	Created By (Script)	Description
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	Provides DELETE privilege on the system audit table (AUD$)
EXECUTE_CATALOG_ROLE	SQL.BSQ	Provides EXECUTE privilege on objects in the data dictionary. Also, HS_ADMIN_ROLE.
SELECT_CATALOG_ROLE	SQL.BSQ	Provides SELECT privilege on objects in the data dictionary. 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 release 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 multibyte character set, Oracle recommends that each role name contain at least one single-byte character. If a role name contains only multibyte 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 how the user must be authorized 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 using a password
- An application using a specified package
- Externally by the operating system, network, or other external source
- Globally by an enterprise directory service

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 specify that the user must have been authorized by an external source before enabling the role:

```
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:** *Oracle9i SQL Reference* for syntax, restrictions, and authorization information about the SQL statements used to manage roles and privileges

Specifying the Type of Role Authorization

The methods of authorizing roles are presented in this section. A role must be enabled for you to use it.

> **See Also:** "When Do Grants and Revokes Take Effect?" on page 25-17 for a discussion about enabling roles

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. However, if the role is made a default role and enabled at connect time, the user is not required to enter a password.

The following statement creates a role `manager`. When it is enabled, the password `morework` must be supplied.

```
CREATE ROLE manager IDENTIFIED BY morework;
```

Note: In a database that uses a multibyte character set, passwords for roles must include only singlebyte characters. Multibyte characters are not accepted in passwords. See the *Oracle9i SQL Reference* for information about specifying valid passwords.

Role Authorization by an Application

The `INDENTIFIED USING` *`package_name`* clause lets you create an application role, which is a role that can be enabled only by applications using an authorized package. Application developers do not need to secure a role by embedding passwords inside applications. Instead, they can create an application role and specify which PL/SQL package is authorized to enable the role.

The following example indicates that the role `admin_role` is an application role and the role can only be enabled by any module defined inside the PL/SQL package `hr.admin`.

```
CREATE ROLE admin_role IDENTIFIED USING hr.admin;
```

When enabling the user's default roles at login as specified in the user's profile, no checking is performed for application roles.

Role Authorization by an External Source

The following statement creates a role named `accts_rec` and requires that the user be authorized by an external source before it can be enabled:

```
CREATE ROLE accts_rec IDENTIFIED EXTERNALLY;
```

Role Authorization by the Operating System Role authentication through 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.

> **See Also:** "Granting Roles Using the Operating System or Network" on page 25-19 for more information about roles granted by the operating system

Role Authorization and Network Clients If users connect to the database over Oracle Net, by default their roles cannot be authenticated by the operating system. This includes connections through a shared server configuration, as this connection requires Oracle Net. 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 initialization parameter `REMOTE_OS_ROLES` in the database's initialization 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.

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 24-11.

See Also:

Oracle Advanced Security Administrator's Guide

Oracle Internet Directory Administrator's Guide

Both of these books contain information about enterprise user management and how to implement it.

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 through 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 contains 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 "Proxy Authentication and Authorization" on page 24-13.

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 both of the following are true, the grantee can create views on the table and grant the corresponding privileges on the views to any user or role in the database.
  - The grantee receives object privileges for the table with the GRANT OPTION.
  - The grantee has the CREATE VIEW or CREATE ANY VIEW system privilege.

The GRANT OPTION is not valid when granting an object privilege to a role. Oracle prevents the propagation of object privileges through 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.

> **Caution:** 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 contains the following topics:

- Revoking System Privileges and Roles
- Revoking Object Privileges and Roles
- Cascading 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 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 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, 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 clause is specified.

Cascading 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. If SELECT ANY TABLE is revoked from a user, then all procedures contained in the users schema relying on this privilege will fail until the privilege is reauthorized.

Object Privileges

Revoking an object privilege can 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.
- 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.

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.

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 and revoking DML-related privileges to PUBLIC.

> **See Also:** "Managing Object Dependencies" on page 21-25 for more information about object dependencies

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.

Caution: When you create a role (other than a user role), it is granted to you implicitly and added as a default role. You receive 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.

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 for each 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 through your operating system or network, and contains 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.

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, such as the following situation:

- MVS Oracle administrators want RACF groups to identify a database user's roles.
- UNIX Oracle administrators want UNIX groups to identify a database user's roles.
- VMS Oracle administrators 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 shared 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 25-22.

Note: The features described in this section are available only on some operating systems. See your operating system specific Oracle documentation to determine if you can use these features.

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 has a definition that 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.

- ROLE is the name of the database role.
- d is an optional character that indicates this role is to be a default role of the database user.
- a is an optional character that indicates 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 using 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. This still applies, even if the role was defined to require a password or operating system authorization. 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 initialization parameter MAX_ENABLED_ROLES.

Using Network Connections with Operating System Role Management

If you choose to have the operating system to manage roles, by default users cannot connect to the database through the shared 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 shared server, or any other network connection, set the initialization parameter REMOTE_OS_ROLES in the database's initialization 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.

Viewing Privilege and Role Information

To access information about grants of privileges and roles, you can query the following data dictionary views:

View	Description
DBA_COL_PRIVS ALL_COL_PRIVS USER_COL_PRIVS	DBA view describes all column object grants in the database. ALL view describes all column object grants for which the current user or PUBLIC is the object owner, grantor, or grantee. USER view describes column object grants for which the current user is the object owner, grantor, or grantee.
ALL_COL_PRIVS_MADE USER_COL_PRIVS_MADE	ALL view lists column object grants for which the current user is object owner or grantor. USER view describes column object grants for which the current user is the grantor.
ALL_COL_PRIVS_RECD USER_COL_PRIVS_RECD	ALL view describes column object grants for which the current user or PUBLIC is the grantee. USER view describes column object grants for which the current user is the grantee.
DBA_TAB_PRIVS ALL_TAB_PRIVS USER_TAB_PRIVS	DBA view lists all grants on all objects in the database. ALL view lists the grants on objects where the user or PUBLIC is the grantee. USER view lists grants on all objects where the current user is the grantee.
ALL_TAB_PRIVS_MADE USER_TAB_PRIVS_MADE	ALL view lists the all object grants made by the current user or made on the objects owned by the current user. USER view lists grants on all objects owned by the current user.
ALL_TAB_PRIVS_RECD USER_TAB_PRIVS_RECD	ALL view lists object grants for which the user or PUBLIC is the grantee. USER view lists object grants for which the current user is the grantee.
DBA_ROLES	This view lists all roles that exist in the database.
DBA_ROLE_PRIVS USER_ROLE_PRIVS	DBA view lists roles granted to users and roles. USER view lists roles granted to the current user.

View	Description
DBA_SYS_PRIVS USER_SYS_PRIVS	DBA view lists system privileges granted to users and roles. USER view lists system privileges granted to the current user.
ROLE_ROLE_PRIVS	This view describes roles granted to other roles. Information is provided only about roles to which the user has access.
ROLE_SYS_PRIVS	This view contains information about system privileges granted to roles. Information is provided only about roles to which the user has access.
ROLE_TAB_PRIVS	This view contains information about object privileges granted to roles. Information is provided only about roles to which the user has access.
SESSION_PRIVS	This view lists the privileges that are currently enabled for the user.
SESSION_ROLES	This view lists the roles that are currently enabled to the user.

Some examples of using these views follow. For these examples, assume the following statements have been 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: *Oracle9i Database Reference* for a detailed description of these data dictionary views

Listing All System Privilege Grants

The following query returns all system privilege grants made to roles and users:

```
SELECT * FROM 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 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 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 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 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
```

26

Auditing Database Use

This chapter describes how to use the Oracle database server's auditing facilities, and contains these topics:

- Guidelines for Auditing
- Managing Audit Trail Information
- Fine-Grained Auditing
- Viewing Database Audit Trail Information

Guidelines for Auditing

This section describes guidelines for auditing and contains the following topics:

- Decide Whether to Use the Database or Operating System Audit Trail
- Keep Audited Information Manageable
- Guidelines for Auditing Suspicious Database Activity
- Guidelines for Auditing Normal Database Activity

Decide Whether to Use the Database or Operating System Audit Trail

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:** 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 minimizes 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.

Guidelines for 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.

See Also: "Protecting the Audit Trail" on page 26-15

Guidelines for 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.

Managing Audit Trail Information

This section describes various aspects of managing audit trail information, and contains the following topics:

What Information is Contained in the Audit Trail?

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:

- Operating system login user name
- 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

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 *Oracle9i Database Error Messages*.

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 using fine-grained auditing methods.

> **See Also:** "Fine-Grained Auditing" on page 26-16 for more information about methods of fine-grained auditing

Events Audited by Default

Regardless of whether database auditing is enabled, Oracle always audits 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 operating system 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 operating system audit trail because the database audit trail is not available until after startup has successfully completed. Recording the state of database auditing at startup helps detect when an administrator has restarted a database with database auditing disabled (thus enabling the administrator to perform unaudited actions).

- Instance shutdown

  An audit record is generated that lists the operating system user shutting down the instance, the user's terminal identifier, and the date and time stamp.

- Connections to the database with administrator privileges

  An audit record is generated that lists the operating system user connecting to Oracle as SYSOPER or SYSDBA. This provides for accountability of users with administrative 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.

Setting Auditing Options

You specify auditing options using the AUDIT statement. The AUDIT statement allows you to set audit options at three levels:

Level	Effect
Statement	Causes auditing of specific SQL statements or groups of statements that affect a particular type of database object. For example, AUDIT TABLE audits the CREATE TABLE, TRUNCATE TABLE, COMMENT ON TABLE, and DELETE [FROM] TABLE statements.
Privilege	Audits SQL statements that are authorized by the specified system privilege. For Example, AUDIT CREATE ANY TRIGGER audits statements issued using the CREATE ANY TRIGGER system privilege.
Object	Audits specific statements on specific objects, such as ALTER TABLE on the emp table

To use the AUDIT statement 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.

When setting auditing options, you can also specify the following conditions for auditing:

- BY SESSION/BY ACCESS

  BY SESSION causes Oracle to write a singe record for all SQL statements of the same type issued in the same session. BY ACCESS causes Oracle to write one record for each access.

- WHENEVER SUCCESSFUL/WHENEVER NOT SUCCESSFUL

  WHENEVER SUCCESSFUL chooses auditing only for statements that succeed. WHENEVER NOT SUCCESSFUL chooses auditing only for statements that fail or result in errors.

The implications of your choice of auditing option and specification of AUDIT statement clauses is discussed in subsequent sections.

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 continue using the audit options in place at session creation.

Caution: 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 initialization parameter AUDIT_TRAIL as described in "Enabling and Disabling Database Auditing" on page 26-12.

See Also: *Oracle9i SQL Reference* for a complete description of the AUDIT statement

Specifying Statement Auditing

Valid statement audit options that can be included in AUDIT and NOAUDIT statements are listed in the *Oracle9i SQL Reference*.

Two special cases of statement auditing are discussed in the following sections.

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.

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;
```

Auditing Statements That Fail Because an Object Does Not Exist The NOT EXISTS statement option specifies auditing of all SQL statements that fail because the target object does not exist.

Specifying Privilege Auditing

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 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 *Oracle9i SQL Reference*.

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.

Specifying Object Auditing

The *Oracle9i SQL Reference* lists valid object audit options and the schema object types for which each option is available.

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 option. Normally, the security administrator is the only user granted the AUDIT ANY privilege.

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;
```

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:** *Oracle9i Database Concepts* and *Oracle9i Application Developer's Guide - Fundamentals* for more information on proxies and multi-tier applications

Turning Off 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* or BY *proxy* 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.

Caution: 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, set the initialization parameter AUDIT_TRAIL in the database's initialization parameter file as described in "Enabling and Disabling Database Auditing" on page 26-12.

See Also: *Oracle9i SQL Reference* for a complete syntax listing of the NOAUDIT statement

Turning Off 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 statement turns off all statement audit options:

```
NOAUDIT ALL;
```

The following statement turns off all privilege audit options:

```
NOAUDIT ALL PRIVILEGES;
```

To disable statement or privilege auditing options, you must have the AUDIT SYSTEM system privilege.

Turning Off 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;
```

To turn off all default object audit options, enter the following statement:

```
NOAUDIT ALL
   ON DEFAULT;
```

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 initialization 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 initialization parameter file, restart the database instance to enable or disable database auditing as intended. These parameters are not dynamic.

> **See Also:** *Oracle9i Database Reference* for more information about the AUDIT_TRAIL and AUDIT_FILE_DEST initialization parameters

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:
  - 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.
  - 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: Your operating system specific Oracle documentation for more information about managing the operating system audit trail when you are directing audit records to that location

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: *Oracle9i Database Utilities* for information about exporting tables

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 by following these 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 a user 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, ensure that any operation performed while connected with administrator privileges is audited in the operating system audit trail, if available.

> **See Also:** Your operating system specific Oracle documentation for more information about the availability of an operating system audit trail and possible uses

Fine-Grained Auditing

In the auditing methods discussed so far, a fixed set of facts is recorded in the audit trail. Additionally, audit options can only be set to monitor access of objects or privileges. No support has been discussed for obtaining more specific information about the environment or query results, nor any mechanism to specify audit conditions in order to minimize false audits. For these purposes, Oracle offers fine-grained auditing.

Fine-grained auditing allows the monitoring of data access based on content. For example, a central tax authority needs to track access to tax returns to guard against employee snooping. Enough detail is wanted to be able to determine what data was accessed, not just that SELECT privilege was used by a specific user on a particular table. Fine-grained auditing provides this functionality.

In general, fine-grained auditing policy is based on simple user-defined SQL predicates on table objects as conditions for selective auditing. During fetching, whenever policy conditions are met for a returning row, the query is audited. Later, Oracle executes user-defined audit event handlers using autonomous transactions to process the event.

Fine-grained auditing can be implemented in user applications using the DBMS_FGA package or by using database triggers.

> **See Also:** *Oracle9i Application Developer's Guide - Fundamentals* for information about using fine-grained auditing

Viewing Database Audit Trail Information

The database audit trail (SYS.AUD$) is a single table in each Oracle database's data dictionary. To help you meaningfully view auditing information in this table, several predefined views are available. They must be created by you. You can later delete them if you decide not to use auditing.

Creating the Audit Trail Views

The following views (except STMT_AUDIT_OPTION_MAP) are created by the CATALOG.SQL and CATAUDIT.SQL scripts:

View	Description
STMT_AUDIT_OPTION_MAP	Contains information about auditing option type codes. Created by the SQL.BSQ script at CREATE DATABASE time.
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
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.

View	Description
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 NOT EXISTS
The following views are used for fine-grained auditing:	
DBA_AUDIT_POLICIES	Shows all the auditing policies on the system.
DBA_FGA_AUDIT_TRAIL	Lists audit trail records for value-based auditing.

See Also: *Oracle9i Database Reference* for more detailed descriptions of the Oracle provided predefined views

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.

Using Audit Trail Views to Investigate Suspicious Activities

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 display the information relevant to your investigation that can be viewed 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 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 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 whose name starts with the characters emp and which are contained in scott's schema:

```
SELECT * FROM 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 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 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
```

Part V

Database Resource Management

Part V discusses database resource management. It includes the following chapter:

- Chapter 27, "Using the Database Resource Manager"

27

Using the Database Resource Manager

Oracle provides database resource management capability through its Database Resource Manager. This chapter introduces you to its use.

The following topics are discussed:

Note: This chapter discusses the use of the Oracle supplied `DBMS_RESOURCE_MANAGER` and `DBMS_RESOURCE_MANAGER_PRIVS` packages to administer the Database Resource Manager. You can more easily administer the Database Resource Manager through the Oracle Enterprise Manager (OEM). It provides an easy to use graphical interface for administering the Database Resource Manager.

See the Oracle Enterprise Manager documentation set for more information.

What Is the Database Resource Manager?

The main goal of the Database Resource Manager is to give the Oracle database server more control over resource management decisions, thus circumventing problems resulting from inefficient operating system management.

This section contains the following topics:

What Problems Does the Database Resource Manager Address?

When database resource allocation decisions are left to the operating system, you may encounter the following problems:

- Excessive overhead

  Excessive overhead results from operating system context switching between Oracle server processes when the number of server processes is high.

- Inefficient scheduling

  The operating system deschedules Oracle database servers while they hold latches, which is inefficient.

- Inappropriate allocation of resources

  The operating system distributes resources equally among all active processes and is unable to prioritize one task over another.

- Inability to manage database-specific resources, such as parallel slaves and active sessions

How Does the Database Resource Manager Address These Problems?

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 (relational on-line analytical processing) applications than to batch jobs.
- Limit the degree of parallelism of any operation performed by members of a group of users
- Create an **active session pool**. This pool consists of a specified maximum number of user sessions allowed to be concurrently active within a group of users. Additional sessions beyond the maximum are queued for execution, but you can specify a timeout period, after which queued jobs will abort.
- Allow **automatic switching** of users from one group to another group based on administrator defined criteria. If a member of a particular group of users creates a session that executes for longer than a specified amount of time, that session can be automatically switched to another group of users with different resource requirements.
- Prevent the execution of operations that are estimated to run for a longer time than a predefined limit
- Create an **undo pool**. This pool consists of the amount of undo space that can be consumed in by a group of users.
- Configure an instance to use a particular method of allocating resources. You can dynamically change the method, for example, from a daytime setup to a nighttime setup, without having to shut down and restart the instance.

What are the Elements of the Database Resource Manager?

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.
Resource plan	Contains directives that specify how resources are allocated to resource consumer groups.

Element	Description
Resource allocation method	The method / policy used by the Database Resource Manager when allocating for a particular resource; used by resource consumer groups and resource plans. Oracle provides the resource allocation methods that are available, but you determine which method to use.
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 later sections of this chapter.

Understanding Resource Plans

This section briefly introduces the concept of resource plans. Included are some illustrations of simple resource plans. More complex plans are included in the examples presented later ("Putting It All Together: Database Resource Manager Examples" on page 27-25), after it has been explained how to build and maintain the elements of the Database Resource Manager.

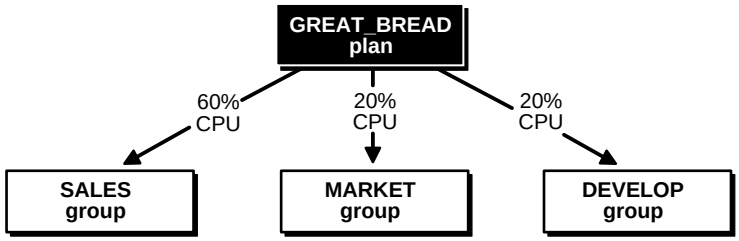
Resource plans specify the resource consumer groups belonging to the plan and contain directives for how resources are to be allocated among these groups. You use the `DBMS_RESOURCE_MANAGER` package to create and maintain these elements of the Database Resource Manager: resource plans, resource consumer groups, and resource plan directives. Plan information is stored in tables in the data dictionary. Several views are available for viewing plan data.

> **See Also:** *Oracle9i Database Concepts* for an in depth discussion of the Database Resource Manager

A Single-Level Resource Plan

The first illustration, shown in Figure 27–1, 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` is allotted 20%, and `develop` receives the remaining 20%.

Figure 27–1 A Simple Resource Management Plan

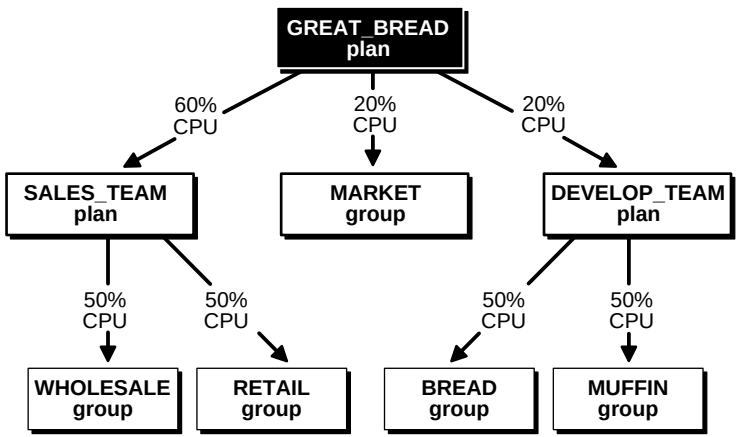


Oracle provides a procedure (`CREATE_SIMPLE_PLAN`) that enables you to quickly create a simple resource plan. This procedure is discussed in "Creating a Simple Resource Plan" on page 27-10.

A Multilevel Resource 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 27–2.

Figure 27–2 A Multilevel 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 `develop_team`, who in turn allocate resources to consumer groups. Figure 27–2

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.

Resource Consumer Groups

Resource consumer groups are groups of users, or sessions, that are grouped together based on their processing needs. Resource plan directives, discussed next, specify how resources are allocated among consumer groups and subplans in a plan schema.

Resource Plan Directives

How resources are allocated to resource consumer groups is specified in resource allocation directives. The Database Resource Manager provides several means of allocating resources.

CPU Method This method enables you to specify how CPU resources are to be allocated among consumer groups or subplans. The multiple levels of CPU resource allocation (up to eight levels) 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. 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.

Active Session Pool with Queuing You can control the maximum number of concurrently active sessions allowed within a consumer group. This maximum designates the active session pool. When a session cannot be initiated because the pool is full, the session is placed into a queue. When an active session completes, the first session in the queue can then be scheduled for execution. You can also specify a timeout period after which a job in the execution queue (waiting for execution) will timeout, causing it to abort with an error.

An entire parallel execution session is counted as one active session.

Degree of Parallelism Limit Specifying a parallel degree limit enables you to control the maximum degree of parallelism for any operation within a consumer group.

Automatic Consumer Group Switching This method enables you to control resources by specifying criteria that, if met, causes the automatic switching of sessions to another consumer group. The criteria used to determine switching are:

- Switch group—specifies the consumer group to which this session is switched if the other (following) criteria are met.
- Switch time—specifies the length of time that a session can execute before it is switched to another consumer group.
- Use estimate—specifies whether Oracle is to use its own estimate of how long an operation will execute.

The Database Resource Manager switches a running session to *switch group* if the session is active for more than *switch time* seconds. Active means that the session is running and consuming resources, not waiting idly for user input or waiting for CPU cycles. The session is allowed to continue running, even if the active session pool for the new group is full. Under these conditions a consumer group can have more sessions running than specified by its active session pool. Once the session finishes its operation and becomes idle, it is switched back to its original group.

If *use estimate* is set to TRUE, the Database Resource Manager uses a predicted estimate of how long the operation will take to complete. If Oracle's predicted estimate is longer than the value specified as the switch time, then Oracle switches the session before execution starts. If this parameter is not set, the operation starts normally and only switches groups when other switch criteria are met.

Execution Time Limit You can specify a maximum execution time allowed for an operation. If Oracle estimates that an operation will run longer than the specified maximum execution time, the operation is terminated with an error. This error can be trapped and the operation rescheduled.

Undo Pool You can specify an undo pool for each consumer group. An undo pool controls the amount of total undo that can be generated by a consumer group. When the total undo generated by a consumer group exceeds it's undo limit, the current DML statement generating the redo is terminated. No other members of the consumer group can perform further data manipulation until undo space is freed from the pool.

See Also: *Oracle9i Database Concepts* for additional conceptual information about the Database Resource Manager.

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 the following table, and their use is explained in succeeding sections of this chapter.

Procedure	Description
CREATE_SIMPLE_PLAN	Creates a simple resource plan, containing up to eight consumer groups, in one step. This is the quickest way to get started when you use this package.
CREATE_PLAN	Creates a resource plan and specifies its allocation methods.
UPDATE_PLAN	Updates a resource plan's comment information.
DELETE_PLAN	Deletes a resource plan and its directives.
DELETE_PLAN_CASCADE	Deletes a resource plan and all of its descendents.
CREATE_CONSUMER_GROUP	Creates a resource consumer group.
UPDATE_CONSUMER_GROUP	Updates a consumer group's comment information.
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.

Procedure	Description
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.

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 the table below.

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 from 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 can execute all of the procedures in the DBMS_RESOURCE_MANAGER package, but scott cannot use the GRANT_SYSTEM_PRIVILEGE procedure to grant the administrative privilege to others.

```
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 or revoked through the SQL GRANT or REVOKE statements.

The other procedures in the DBMS_RESOURCE_MANAGER_PRIVS package are discussed in "Managing the Switch Privilege" on page 27-22.

> **See Also:** *Oracle9i Supplied PL/SQL Packages and Types Reference.* contains detailed information about the Database Resource Manager packages:
>
> - DBMS_RESOURCE_MANAGER
> - DBMS_RESOURCE_MANAGER_PRIVS

Creating a Simple Resource Plan

You can quickly create a simple resource plan that will be adequate for many situations using the CREATE_SIMPLE_PLAN procedure. This procedure enables you to create consumer groups and allocate resources to them by executing a single statement. Using this procedure, you are not required to invoke the procedures that are described in succeeding sections for creating a pending area, creating each consumer group individually, and specifying resource plan directives.

You can specify the following parameters for the CREATE_SIMPLE_PLAN procedure:

Parameter	Description
SIMPLE_PLAN	Name of the plan
CONSUMER_GROUP1	Consumer group name for first group
GROUP1_CPU	CPU resource allocated to this group
CONSUMER_GROUP2	Consumer group name for second group
GROUP2_CPU	CPU resource allocated to this group
CONSUMER_GROUP3	Consumer group name for third group
GROUP3_CPU	CPU resource allocated to this group
CONSUMER_GROUP4	Consumer group name for fourth group
GROUP4_CPU	CPU resource allocated to this group
CONSUMER_GROUP5	Consumer group name for fifth group
GROUP5_CPU	CPU resource allocated to this group
CONSUMER_GROUP6	Consumer group name for sixth group
GROUP6_CPU	CPU resource allocated to this group

Parameter	Description
CONSUMER_GROUP7	Consumer group name for seventh group
GROUP7_CPU	CPU resource allocated to this group
CONSUMER_GROUP8	Consumer group name for eighth group
GROUP8_CPU	CPU resource allocated to this group

Up to eight consumer groups can be specified using this procedure and the only plan directive that can be specified is for CPU. Each consumer group specified in the plan is allocated its CPU percentage at level 2. Also included in the plan are SYS_GROUP (an Oracle defined groups that is the initial consumer group for the users SYS and SYSTEM) and OTHER_GROUPS.

Example: Using the CREATE_SIMPLE_PLAN Procedure

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_SIMPLE_PLAN(SIMPLE_PLAN => 'simple_plan1',
   CONSUMER_GROUP1 => 'mygroup1', GROUP1_CPU => 80,
   CONSUMER_GROUP2 => 'mygroup2', GROUP2_CPU => 20);
END;
```

Executing the above statements creates the following plan:

Consumer Group	Level 1	Level 2	Level 3
SYS_GROUP	100%		
mygroup1		80%	
mygroup2		20%	
OTHER_GROUPS			100%

Creating Complex Resource Plans

This section describes the actions and DBMS_RESOURCE_MANAGER procedures that you can use when your situation requires that you create more complex resource plans. It contains the following sections:

- Using the Pending Area for Creating Plan Schemas
- Creating Resource Plans
- Creating Resource Consumer Groups

- Specifying Resource Plan Directives

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 Viewing Database Resource Manager Information on page 27-31.

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.

5. A plan that is currently being used as a top plan by an active instance cannot be deleted.
6. The following plan directive parameters can appear only in plan directives that refer to resource consumer groups (not other resource plans):
   - PARALLEL_DEGREE_LIMIT_P1
   - ACTIVE_SESS_POOL_P1
   - QUEUEING_P1
   - SWITCH_GROUP
   - SWITCH_TIME
   - SWITCH_ESTIMATE
   - MAX_EST_EXEC_TIME
   - UNDO_POOL
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 which is not part of any of the consumer groups included in 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 violated. You can then make changes to fix any problems and call the validate procedure again.

It is possible to create "orphan" consumer groups that have no plan directives referring to them. This allows the creation of consumer groups that will not currently be used, but may be part of some plan to be implemented in the future.

Submitting Changes

After you have validated your changes, 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. No changes are submitted (made active) until validation is successful on all of the changes in the pending area.

The SUBMIT_PENDING_AREA procedure clears (deactivates) the pending area after successfully validating and committing the changes.

> **Note:** A call to SUBMIT_PENDING_AREA 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. This field is optional.
The following parameters are not required to be specified. The defaults are appropriate and the only values allowed at this time.	
CPU_MTH	CPU resource allocation method. EMPHASIS is the default and the only CPU method allowed at the resource plan level.

Parameter	Description
ACTIVE_SESS_POOL_MTH	Active session pool resource allocation method. Controls maximum concurrent users. ACTIVE_SESS_POOL_ABSOLUTE is the default and only method available.
PARALLEL_DEGREE_LIMIT_MTH	Resource allocation method for specifying a limit on the degree of parallelism of any operation. PARALLEL_DEGREE_LIMIT_ABSOLUTE is the default and only method available.
QUEUEING_MTH	Queuing resource allocation method. Controls order in which queued sessions will execute. FIFO_TIMEOUT is the default and only method available.

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 27-28.

> **See Also:** *Oracle9i Database Concepts* contains detailed descriptions of the resource allocation methods

Creating a Plan

You create a plan using the CREATE_PLAN procedure. The following creates a plan called great_bread. You choose to use the default resource allocation methods.

```
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:

- 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 "Managing the Switch Privilege" on page 27-22).

- OTHER_GROUPS

  This consumer group cannot can be explicitly assigned to a user. OTHER_GROUPS must have a resource directive specified in the schema of any active plan. This group applies collectively to all sessions that belong to a consumer group that is not part of the currently active plan schema, including DEFAULT_CONSUMER_GROUP.

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 27-28.

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 can 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. Default is NULL for all CPU parameters.
CPU_P2	Specifies CPU percentage at the second level.

Parameter	Description
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.
ACTIVE_SESS_POOL_P1	Specifies maximum number of concurrently active sessions for a consumer group. Default is UNLIMITED.
QUEUEING_P1	Specified time (in seconds) after which a job in the execution queue (waiting for execution) will timeout. Default is UNLIMITED.
PARALLEL_DEGREE_LIMIT_P1	Specifies a limit on the degree of parallelism for any operation. Default is UNLIMITED.
SWITCH_GROUP	Specifies consumer group to which this session is switched if other switch criteria is met. Default is NULL.
SWITCH_TIME	Specifies time (in seconds) that a session can execute before it is switched to another consumer group. Default in UNLIMITED.
SWITCH_ESTIMATE	If TRUE, tells Oracle to use its execution time estimate to automatically switch the consumer group of an operation prior to beginning its execution. Default is FALSE.
MAX_EST_EXEC_TIME	Specifies the maximum execution time (in seconds) allowed for a session. Default is UNLIMITED.
UNDO_POOL	Sets a maximum in kilobytes (K) on the total amount of undo generated by a consumer group. Default is UNLIMITED.

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 27–1, 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 of 4 for any operation, 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

How Resource Plan Directives Interact

If there are multiple resource plan directives that refer to the same consumer group, then the following rules apply for specific cases:

1. The parallel degree limit for the consumer group will be the *minimum* of all the incoming values.

2. The active session pool for the consumer group will be the *sum* of all the incoming values and the queue timeout will be the *minimum* of all incoming timeout values.
3. If there is more than one switch group and more than one switch time, the Database Resource Manager will choose the *most restrictive* of all incoming values. Specifically:
   - `SWITCH_TIME = min` (all incoming over_switch_time values)
   - `SWITCH_ESTIMATE = TRUE` overrides `SWITCH_ESTIMATE = FALSE`

   Note: If both plan directives specify the same switch time, but different switch group's, then the choice as to which group to switch to will be statically, yet arbitrarily, decided by the Database Resource Manager.
4. If a session is switched to another consumer group because it exceeds its switch time, that session will execute even if the active session pool for the new consumer group is full.
5. The maximum estimated execution time will be the most restrictive of all incoming values. Specifically:
   - max_estimated_exec_time = min (all incoming max_estimated_exec_time values)

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. The user's initial consumer group is automatically set to DEFAULT_CONSUMER_GROUP when the user is created.

A user (or PUBLIC) must be granted permission to switch to a specific consumer group before that consumer group can become the user's initial consumer group. This permission is called the switch privilege, and is explained in "Managing the Switch Privilege" on page 27-22. The switch privilege to an 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, which are part of the DBMS_RESOURCE_MANAGER package, that allow administrators to change the resource consumer group of running sessions. Both of these procedures can also change the consumer group of any parallel query slave sessions associated with the coordinator's session. The changes made by these procedures pertain to current sessions only; they are not persistent. They also do not change the initial consumer groups for users.

Instead of killing a session of a user who is using excessive CPU, an administrator can instead change that user's consumer group to one that is allowed less CPU. Or, this switching can be enforced automatically, using automatic consumer group switching resource plan directives.

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');
```

The SID, session serial number, and current resource consumer group for a session are viewable using the V$SESSION data dictionary view.

Switching Sessions for a User

The SWITCH_CONSUMER_GROUP_FOR_USER procedure changes the resource consumer group for all sessions with a given user name.

```
EXEC DBMS_RESOURCE_MANAGER.SWITCH_CONSUMER_GROUP_FOR_USER ('scott', -
    'low_group');
```

Managing 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 enables 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);
```

User 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 through that role will not be able to subsequently switch to that consumer group.

If you revoke switch privileges to a consumer group from PUBLIC, then any users other than those who are explicitly assigned switch privileges either directly or through 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 to which the user is switching.
OLD_CONSUMER_GROUP	An output parameter. Stores the name of the consumer group from which the user switched. Can be used to switch back later.

Parameter	Description
INITIAL_GROUP_ON_ERROR	Controls behavior if a switching error occurs. If TRUE, in the event of an error, the user is switched to the initial consumer group. If FALSE, raise an error.

The following example illustrates switching to a new consumer group. By printing the value of the output parameter old_group, we illustrate how the old consumer group name has been saved.

```
SET serveroutput on
DECLARE
    old_group varchar2(30);
BEGIN
DBMS_SESSION.SWITCH_CURRENT_CONSUMER_GROUP('sales', old_group, FALSE);
DBMS_OUTPUT.PUT_LINE('OLD GROUP = ' || old_group);
END;
```

The following line is output:

```
OLD GROUP = DEFAULT_CONSUMER_GROUP
```

The DBMS_SESSION package can be used from within a PL/SQL application, thus allowing the application to change consumer groups, or effectively priority, dynamically.

> **Note:** The Database Resource Manager also works in environments where a generic database user name is used to log on to an application. The DBMS_SESSION package can be called to switch a session's consumer group assignment at session startup, or as particular modules are called.

> **See Also:** *Oracle9i Supplied PL/SQL Packages and Types Reference* for additional examples and more information about the DBMS_SESSION package

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. The following example activates the Database Resource Manager and assigns the top plan as `mydb_plan`.

```
RESOURCE_MANAGER_PLAN = mydb_plan
```

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.

To deactivate the Database Resource Manager, issue the following statement:

```
ALTER SYSTEM SET RESOURCE_MANAGER_PLAN = '';
```

Putting It All Together: Database Resource Manager Examples

This section provides some examples of resource plan schemas. The following examples are presented:

- Multilevel Schema Example
- Example of Using Several Resource Allocation Methods
- An Oracle Supplied Plan

Multilevel Schema Example

The following statements create a multilevel schema as illustrated in Figure 27–3. They use default plan and resource consumer group methods.

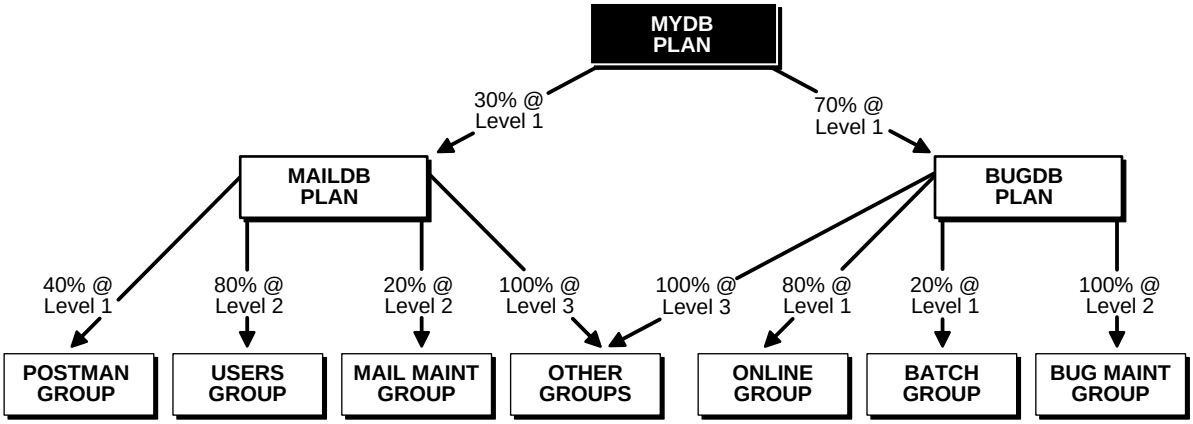
```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_PENDING_AREA();
DBMS_RESOURCE_MANAGER.CREATE_PLAN(PLAN => 'bugdb_plan',
   COMMENT => 'Resource plan/method for bug users sessions');
DBMS_RESOURCE_MANAGER.CREATE_PLAN(PLAN => 'maildb_plan',
   COMMENT => 'Resource plan/method for mail users sessions');
DBMS_RESOURCE_MANAGER.CREATE_PLAN(PLAN => '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 27–3 Multilevel Schema



Example of Using Several Resource Allocation Methods

The example presented here could represent a plan for a database supporting a packaged ERP (Enterprise Resource Planning) or CRM (Customer Relationship Management). The work in such an environment can be highly varied. There may be a mix of short transactions and quick queries, in combination with longer running batch jobs that include large parallel queries. The goal is to give good response time to OLTP (Online Transaction Processing), while allowing batch jobs to run in parallel.

The plan is summarized in the following table.

Group	CPU Resource Allocation %	Active Session Pool Parameters	Automatic Switching Parameters	Max Estimated Execution Time	Undo Pool
oltp	Level 1: 80%		Switch to group: batch Switch time: 3 Use estimate: TRUE		Size: 200K

Group	CPU Resource Allocation %	Active Session Pool Parameters	Automatic Switching Parameters	Max Estimated Execution Time	Undo Pool
batch	Level 2: 100%	Pool size: 5 Timeout: 600		Time: 3600	
OTHER_GROUPS	Level 3: 100%				

The following statements create the above plan, which is named erp_plan:

```
BEGIN
DBMS_RESOURCE_MANAGER.CREATE_PENDING_AREA();
DBMS_RESOURCE_MANAGER.CREATE_PLAN(PLAN => 'erp_plan',
  COMMENT => 'Resource plan/method for ERP Database');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'oltp',
  COMMENT => 'Resource consumer group/method for OLTP jobs');
DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP(CONSUMER_GROUP => 'batch',
  COMMENT => 'Resource consumer group/method for BATCH jobs');
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'erp_plan',
  GROUP_OR_SUBPLAN => 'oltp', COMMENT => 'OLTP sessions', CPU_P1 => 80,
  SWITCH_GROUP => 'batch', SWITCH_TIME => 3,SWITCH_ESTIMATE => TRUE,
  UNDO_POOL => 200);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'erp_plan',
  GROUP_OR_SUBPLAN => 'batch', COMMENT => 'BATCH sessions', CPU_P2 => 100,
  ACTIVE_SESS_POOL_P1 => 5, QUEUEING_P1 => 600,
  MAX_EST_EXEC_TIME => 3600);
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE(PLAN => 'erp_plan',
  GROUP_OR_SUBPLAN => 'OTHER_GROUPS', COMMENT => 'mandatory', CPU_P3 => 100);
DBMS_RESOURCE_MANAGER.VALIDATE_PENDING_AREA();
DBMS_RESOURCE_MANAGER.SUBMIT_PENDING_AREA();
END;
```

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%

	CPU Resource Allocation		
Resource Consumer Group	**Level 1**	**Level 2**	**Level 3**
LOW_GROUP	0%	0%	100%

The Oracle provided groups in this plan are:

- SYS_GROUP is the initial consumer group for the users SYS and SYSTEM.
- OTHER_GROUPS applies collectively to all sessions that belong to a consumer group that is not part of the currently active plan schema.
- 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.

Monitoring and Tuning the Database Resource Manager

To effectively monitor and tune the Database Resource Manager, you must design a representative environment. The Database Resource Manager works best in large production environments in which system utilization is high. If a test places insufficient load on the system, measured CPU allocations can be very different from the allocations specified in the active resource plan.

Creating the Environment

To create a representative environment, there must be sufficient load (demand for CPU resources) to make CPU resources scarce. If the following rules are followed, the test environment should generate actual (measured) resource allocations that match those specified in the active resource plan.

1. Create the minimum number of concurrently running processes required to generate sufficient load. This is the larger of:
   - Four processes for each consumer group
   - 1.5 * (number of processors) for each consumer group. If the result is not an integer, round up.

2. Each and every process must be capable of consuming all of the CPU resources allocated to the consumer group in which it runs. Write resource intensive programs that continue to spin no matter what happens. This can be as simple as:

```
BEGIN
DECLARE
    m NUMBER;
  BEGIN
    FOR i IN 1..100000 LOOP
      FOR j IN 1..100000 LOOP
        m := sqrt(4567);
      END LOOP;
    END LOOP;
  END;
END;
/
```

Why Is This Necessary to Produce Expected Results?

When every group can secure as much CPU resources as it demands, the Database Resource Manager first seeks to maximize system throughput, not to enforce allocation percentages. For example, consider the following conditions:

- There is only one process available to run for each consumer group.
- Each process runs continuously.
- There are four CPUs.

In this case, the measured CPU allocation to each consumer group will be 25%, no matter what the allocations specified in the active resource plan.

Another factor determines the calculation in (1) above. Processor affinity scheduling at the operating system level can distort CPU allocation on underutilized systems. This is explained in the following paragraphs.

Until the number of concurrently running processes reaches a certain level, typical operating system scheduling algorithms will prevent full utilization. The Database Resource Manager controls CPU usage by restricting the number of running processes. By deciding which processes are allowed to run and for what duration, the Database Resource Manager controls CPU resource allocation. When a CPU has resources available, and other processors are fully utilized, the operating system migrates processes to the underutilized processor, but not immediately.

With processor affinity, the operating system waits (for a time) to migrate processes, "hoping" that another process will be dispatched to run instead of forcing process migration from one CPU to another. On a fully loaded system with enough processes waiting, this strategy will work. In large production environments, processor affinity increases performance significantly, because invalidating the current CPU cache and then loading the new one is quite expensive. Since processes have processor affinity on most platforms, more processes than CPUs for each consumer group must be run. Otherwise, full system utilization is not possible.

Monitoring Results

Use the V$RSRC_CONSUMER_GROUP view to monitor CPU usage. It provides the cumulative amount of CPU time consumed by all sessions in each consumer group. It also provides a number of other measures helpful for tuning.

```
SQL> SELECT NAME, CONSUMED_CPU_TIME FROM V$RSRC_CONSUMER_GROUP;

NAME                             CONSUMED_CPU_TIME
-------------------------------- -----------------
OTHER_GROUPS                                14301
TEST_GROUP                                   8802
TEST_GROUP2                                     0

3 rows selected.
```

Viewing Database Resource Manager Information

The following table lists views that are associated with Database Resource Manager:

View	Description
DBA_RSRC_CONSUMER_GROUP_PRIVS USER_RSRC_CONSUMER_GROUP_PRIVS	DBA view lists all resource consumer groups and the users and roles to which they have been granted. USER view lists all resource consumer groups granted to the user.
DBA_RSRC_CONSUMER_GROUPS	Lists all resource consumer groups that exist in the database.
DBA_RSRC_MANAGER_SYSTEM_PRIVS USER_RSRC_MANAGER_SYSTEM_PRIVS	DBA view lists all users and roles that have been granted Database Resource Manager system privileges. USER view lists all the users that are granted system privileges for the DBMS_RESOURCE_MANAGER package.
DBA_RSRC_PLAN_DIRECTIVES	Lists all resource plan directives that exist in the database.
DBA_RSRC_PLANS	List all resource plans that exist in the database.

View	Description
DBA_USERS USERS_USERS	DBA view 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 view contains information about the current user, and specifically, for the Database Resource Manager, it contains the current user's initial resource consumer group.
V$ACTIVE_SESS_POOL_MTH	Displays all available active session pool resource allocation methods.
V$PARALLEL_DEGREE_LIMIT_MTH	Displays all available parallel degree limit resource allocation methods.
V$QUEUEING	Displays all available queuing resource allocation methods.
V$RSRC_CONSUMER_GROUP	Displays information about active resource consumer groups. This view can be used for tuning.
V$RSRC_CONSUMER_GROUP_CPU_MTH	Displays all available CPU resource allocation methods for resource consumer groups.
V$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 privileges, viewing plan schemas, or you can monitor them to gather information for tuning the Database Resource Manager. Some examples of their use follow.

> **See Also:** *Oracle9i Database Reference* for detailed information about the contents of each of these views

Viewing Consumer Groups Granted to Users or Roles

The DBA_RSRC_CONSUMER_GROUP_PRIVS view displays the consumer groups granted to users or roles. Specifically, it displays the groups to which a user or role is allowed to belong or be switched. For example, in the view shown below, user scott can belong to the consumer groups market or sales, he has the ability to assign (grant) other users to the sales group but not the market group. Neither group is his initial consumer group.

```
SQL> SELECT * FROM DBA_RSRC_CONSUMER_GROUP_PRIVS;

GRANTEE                        GRANTED_GROUP                  GRA INI
------------------------------ ------------------------------ --- ---
PUBLIC                         DEFAULT_CONSUMER_GROUP         YES YES
PUBLIC                         LOW_GROUP                      NO  NO
SCOTT                          MARKET                         NO  NO
SCOTT                          SALES                          YES NO
SYSTEM                         SYS_GROUP                      NO  YES
```

Scott was granted the ability to switch to these groups using the DBMS_RESOURCE_MANAGER_PRIVS package.

Viewing Plan Schema Information

This example shows using the DBA_RSRC_PLANS view to display all of the resource plans defined in the database. All of the plans displayed are active, meaning they are not staged in the pending area

```
SQL> SELECT PLAN,COMMENTS,STATUS FROM DBA_RSRC_PLANS;

PLAN         COMMENTS                                                  STATUS
-----------  --------------------------------------------------------  ------
SYSTEM_PLAN  Plan to give system sessions priority                     ACTIVE
BUGDB_PLAN   Resource plan/method for bug users sessions              ACTIVE
MAILDB_PLAN  Resource plan/method for mail users sessions             ACTIVE
MYDB_PLAN    Resource plan/method for bug and mail users sessions     ACTIVE
GREAT_BREAD  Great plan for great bread                               ACTIVE
ERP_PLAN     Resource plan/method for ERP Database                    ACTIVE

6 rows selected.
```

Viewing Current Consumer Groups for Sessions

You can use the V$SESSION view to display the consumer groups that are currently assigned to sessions.

```
SQL> SELECT SID,SERIAL#,USERNAME,RESOURCE_CONSUMER_GROUP FROM V$SESSION;

SID    SERIAL#  USERNAME                 RESOURCE_CONSUMER_GROUP
-----  -------  -----------------------  -------------------------------
.
.
.
   11       136 SYS                      SYS_GROUP
```

```
   13     16570 SCOTT                     SALES

10 rows selected.
```

Viewing the Currently Active Plans

This example sets `mydb_plan`, as created by the statements shown earlier in "Multilevel Schema Example" on page 27-25, as the top level plan. The `V$RSRC_PLAN` view is queried to display the currently active plans.

```
SQL> ALTER SYSTEM SET RESOURCE_MANAGER_PLAN = mydb_plan;

System altered.

SQL> SELECT * FROM V$RSRC_PLAN;

NAME
--------------------------------
MYDB_PLAN
MAILDB_PLAN
BUGDB_PLAN
```

Part VI

Distributed Database Management

Part VI discusses the management of a distributed database environment. It contains the following sections:

28

Distributed Database Concepts

This chapter describes the basic concepts and terminology of Oracle's distributed database architecture. It contains the following topics:

Distributed Database Architecture

A **distributed database system** allows applications to access data from local and remote databases. In a **homogenous distributed database system**, each database is an Oracle database. In a **heterogeneous distributed database system**, at least one of the databases is a non-Oracle database. Distributed databases use a **client/server** architecture to process information requests.

This section contains the following topics:

- Homogenous Distributed Database Systems
- Heterogeneous Distributed Database Systems
- Client / Server Database Architecture

Homogenous Distributed Database Systems

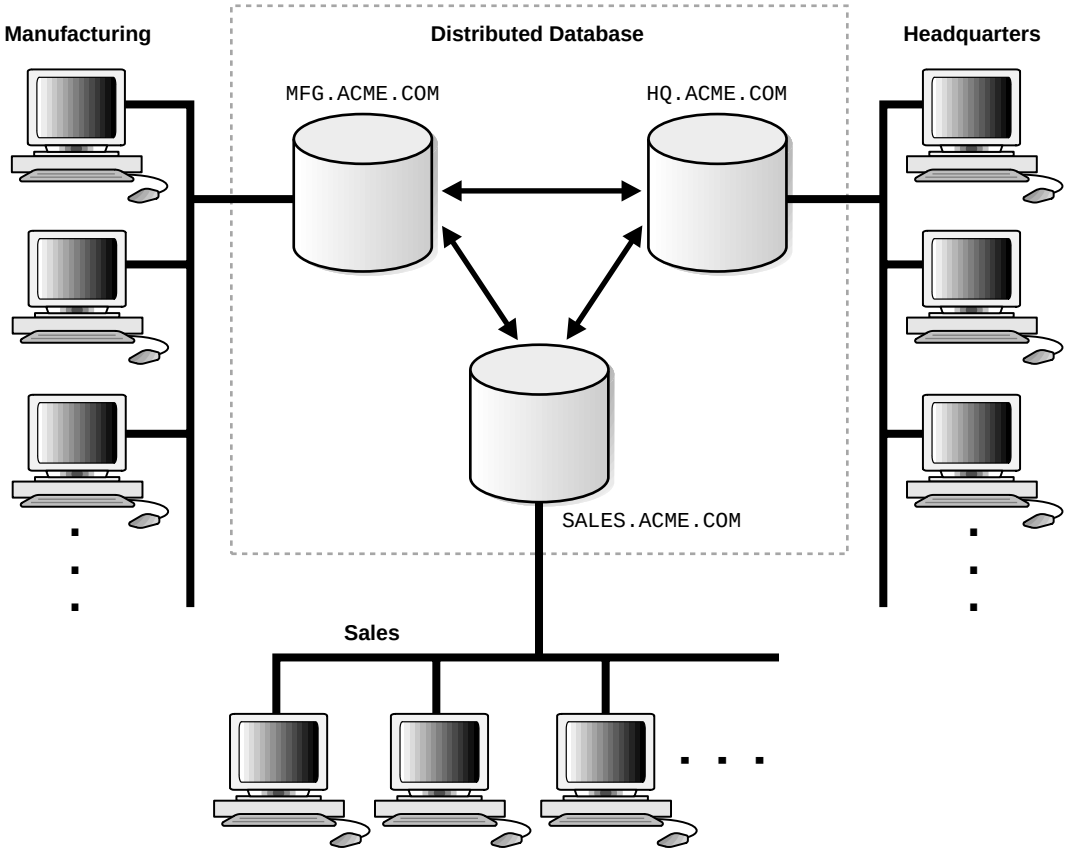
A homogenous distributed database system is a network of two or more Oracle databases that reside on one or more machines. Figure 28–1 illustrates a distributed system that connects three databases: `hq`, `mfg`, and `sales`. An application can simultaneously access or modify the data in several databases in a single distributed environment. For example, a single query from a Manufacturing client on local database `mfg` can retrieve joined data from the `products` table on the local database and the `dept` table on the remote `hq` database.

For a client application, the location and platform of the databases are transparent. You can also create **synonyms** for remote objects in the distributed system so that users can access them with the same syntax as local objects. For example, if you are connected to database `mfg` but want to access data on database `hq`, creating a synonym on `mfg` for the remote `dept` table enables you to issue this query:

```
SELECT * FROM dept;
```

In this way, a distributed system gives the appearance of native data access. Users on `mfg` do not have to know that the data they access resides on remote databases.

Figure 28–1 Homogeneous Distributed Database



An Oracle distributed database system can incorporate Oracle databases of different versions. All supported releases of Oracle can participate in a distributed database system. Nevertheless, the applications that work with the distributed database must understand the functionality that is available at each node in the system. A distributed database application cannot expect an Oracle7 database to understand the SQL extensions that are only available with Oracle9*i*.

Distributed Databases Versus Distributed Processing

The terms **distributed database** and **distributed processing** are closely related, yet have distinct meanings.

Distributed database	A set of databases in a distributed system that can appear to applications as a single data source.
Distributed processing	The operations that occurs when an application distributes its tasks among different computers in a network. For example, a database application typically distributes front-end presentation tasks to client computers and allows a back-end database server to manage shared access to a database. Consequently, a distributed database application processing system is more commonly referred to as a client/server database application system.

Oracle distributed database systems employ a distributed processing architecture. For example, an Oracle database server acts as a client when it requests data that another Oracle database server manages.

Distributed Databases Versus Replicated Databases

The terms distributed database system and **database replication** are related, yet distinct. In a **pure** (that is, not replicated) distributed database, the system manages a single copy of all data and supporting database objects. Typically, distributed database applications use distributed transactions to access both local and remote data and modify the global database in real-time.

Note: This book discusses only pure distributed databases.

The term **replication** refers to the operation of copying and maintaining database objects in multiple databases belonging to a distributed system. While replication relies on distributed database technology, database replication offers applications benefits that are not possible within a pure distributed database environment.

Most commonly, replication is used to improve local database performance and protect the availability of applications because alternate data access options exist. For example, an application may normally access a local database rather than a remote server to minimize network traffic and achieve maximum performance. Furthermore, the application can continue to function if the local server experiences a failure, but other servers with replicated data remain accessible.

> **See Also:** *Oracle9i Replication* for more information about Oracle's replication features

Heterogeneous Distributed Database Systems

In a heterogeneous distributed database system, at least one of the databases is a non-Oracle system. To the application, the heterogeneous distributed database system appears as a single, local, Oracle database. The local Oracle database server hides the distribution and heterogeneity of the data.

The Oracle database server accesses the non-Oracle system using Oracle Heterogeneous Services in conjunction with an **agent**. If you access the non-Oracle data store using an Oracle Transparent Gateway, then the agent is a system-specific application. For example, if you include a Sybase database in an Oracle distributed system, then you need to obtain a Sybase-specific transparent gateway so that the Oracle databases in the system can communicate with it.

Alternatively, you can use **generic connectivity** to access non-Oracle data stores so long as the non-Oracle system supports the ODBC or OLE DB protocols.

Note: Other than the introductory material presented in this chapter, this book does not discuss Oracle Heterogeneous Services.

See *Oracle9i Heterogeneous Connectivity Administrator's Guide* for more detailed information about Heterogeneous Services.

Heterogeneous Services

Heterogeneous Services (HS) is an integrated component within the Oracle database server and the enabling technology for the current suite of Oracle Transparent Gateway products. HS provides the common architecture and administration mechanisms for Oracle gateway products and other heterogeneous access facilities. Also, it provides upwardly compatible functionality for users of most of the earlier Oracle Transparent Gateway releases.

Transparent Gateway Agents

For each non-Oracle system that you access, Heterogeneous Services can use a transparent gateway agent to interface with the specified non-Oracle system. The agent is specific to the non-Oracle system, so each type of system requires a different agent.

The transparent gateway agent facilitates communication between Oracle and non-Oracle databases and uses the Heterogeneous Services component in the Oracle database server. The agent executes SQL and transactional requests at the non-Oracle system on behalf of the Oracle database server.

See Also: Your Oracle supplied gateway-specific documentation for information about transparent gateways

Generic Connectivity

Generic connectivity enables you to connect to non-Oracle data stores by using either a Heterogeneous Services ODBC agent or a Heterogeneous Services OLE DB agent—both are included with your Oracle product as a standard feature. Any data source compatible with the ODBC or OLE DB standards can be accessed using a generic connectivity agent.

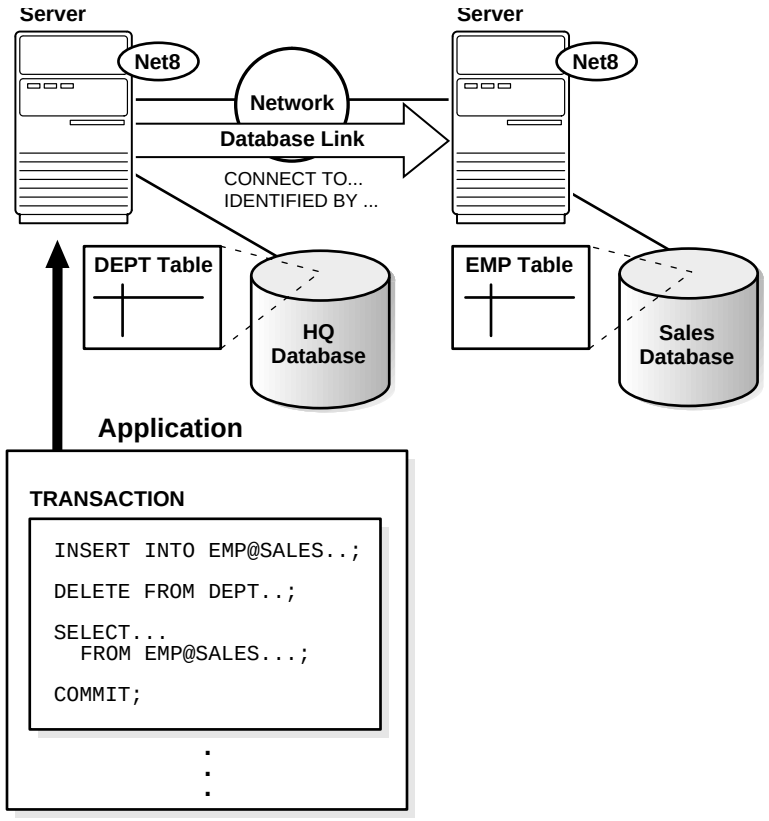
The advantage to generic connectivity is that it may not be required for you to purchase and configure a separate system-specific agent. You use an ODBC or OLE DB driver that can interface with the agent. However, some data access features are only available with transparent gateway agents.

Client/Server Database Architecture

A database server is the Oracle software managing a database, and a client is an application that requests information from a server. Each computer in a network is a node that can host one or more databases. Each node in a distributed database system can act as a client, a server, or both, depending on the situation.

In Figure 28–2, the host for the `hq` database is acting as a database server when a statement is issued against its local data (for example, the second statement in each transaction issues a statement against the local `dept` table), but is acting as a client when it issues a statement against remote data (for example, the first statement in each transaction is issued against the remote table `emp` in the `sales` database).

Figure 28–2 An Oracle Distributed Database System



A client can connect **directly** or **indirectly** to a database server. A direct connection occurs when a client connects to a server and accesses information from a database contained on that server. For example, if you connect to the `hq` database and access the `dept` table on this database as in Figure 28–2, you can issue the following:

```
SELECT * FROM dept;
```

This query is direct because you are not accessing an object on a remote database.

In contrast, an indirect connection occurs when a client connects to a server and then accesses information contained in a database on a different server. For example, if you connect to the `hq` database but access the `emp` table on the remote `sales` database as in Figure 28–2, you can issue the following:

```
SELECT * FROM emp@sales;
```

This query is indirect because the object you are accessing is not on the database to which you are directly connected.

Database Links

The central concept in distributed database systems is a **database link**. A database link is a connection between two physical database servers that allows a client to access them as one logical database.

This section contains the following topics:

What Are Database Links?

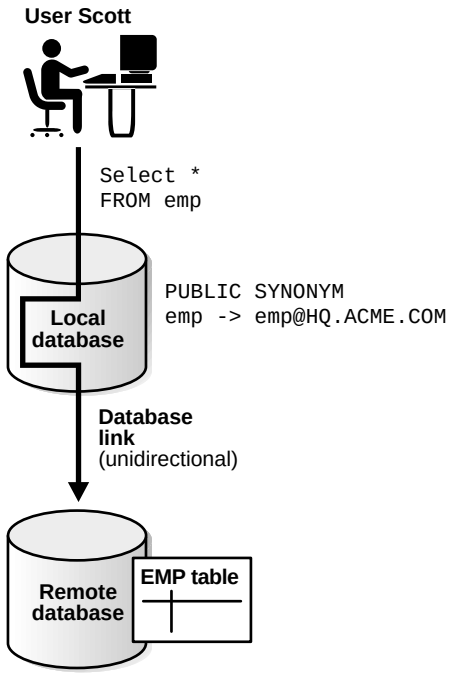
A database link is a pointer that defines a one-way communication path from an Oracle database server to another database server. The link pointer is actually defined as an entry in a data dictionary table. To access the link, you must be connected to the local database that contains the data dictionary entry.

A database link connection is one-way in the sense that a client connected to local database A can use a link stored in database A to access information in remote database B, but users connected to database B cannot use the same link to access data in database A. If local users on database B want to access data on database A, then they must define a link that is stored in the data dictionary of database B.

A database link connection allows local users to access data on a remote database. For this connection to occur, each database in the distributed system must have a unique **global database name** in the network domain. The global database name uniquely identifies a database server in a distributed system.

Figure 28–3 shows an example of user `scott` accessing the `emp` table on the remote database with the global name `hq.acme.com`:

Figure 28–3 Database Link



Database links are either private or public. If they are private, then only the user who created the link has access; if they are public, then all database users have access.

One principal difference among database links is the way that connections to a remote database occur. Users access a remote database through the following types of links:

Connected user link Users connect as themselves, which means that they must have an account on the remote database with the same username as their account on the local database.

Fixed user link Users connect using the username and password referenced in the link. For example, if Jane uses a fixed user link that connects to the `hq` database with the username and password `scott/tiger`, then she connects as `scott`, Jane has all the privileges in `hq` granted to `scott` directly, and all the default roles that `scott` has been granted in the `hq` database.

Current user link A user connects as a global user. A local user can connect as a global user in the context of a stored procedure—without storing the global user's password in a link definition. For example, Jane can access a procedure that Scott wrote, accessing Scott's account and Scott's schema on the `hq` database. Current user links are an aspect of Oracle Advanced Security.

Create database links using the `CREATE DATABASE LINK` statement. After a link is created, you can use it to specify schema objects in SQL statements.

See Also:

- *Oracle9i SQL Reference* for syntax of the `CREATE DATABASE` statement
- *Oracle Advanced Security Administrator's Guide* for information about Oracle Advanced Security

What Are Shared Database Links?

A shared database link is a link between a local server process and the remote database. The link is shared because multiple client processes can use the same link simultaneously.

When a local database is connected to a remote database through a database link, either database can run in dedicated or shared server mode. The following table illustrates the possibilities:

Local Database Mode	Remote Database Mode
Dedicated	Dedicated
Dedicated	Shared server
Shared server	Dedicated

Local Database Mode	Remote Database Mode
Shared server	Shared server

A shared database link can exist in any of these four configurations. Shared links differ from standard database links in the following ways:

- Different users accessing the same schema object through a database link can share a network connection.
- When a user needs to establish a connection to a remote server from a particular server process, the process can reuse connections already established to the remote server. The reuse of the connection can occur if the connection was established on the same server process with the same database link—possibly in a different session. In a non-shared database link, a connection is not shared across multiple sessions.
- When you use a shared database link in a shared server configuration, a network connection is established directly out of the shared server process in the local server. For a non-shared database link on a local shared server, this connection would have been established through the local dispatcher, requiring context switches for the local dispatcher, and requiring data to go through the dispatcher.

> **See Also:** *Oracle Net Services Administrator's Guide* for information about shared server

Why Use Database Links?

The great advantage of database links is that they allow users to access another user's objects in a remote database so that they are bounded by the privilege set of the object's owner. In other words, a local user can access a link to a remote database without having to be a user on the remote database.

For example, assume that employees submit expense reports to Accounts Payable (A/P), and further suppose that a user using an A/P application needs to retrieve information about employees from the hq database. The A/P users should be able to connect to the hq database and execute a stored procedure in the remote hq database that retrieves the desired information. The A/P users should not need to be hq database users to do their jobs; they should only be able to access hq information in a controlled way as limited by the procedure.

Database links allow you to grant limited access on remote databases to local users. By using current user links, you can create centrally managed global users whose

password information is hidden from both administrators *and* non-administrators. For example, A / P users can access the `hq` database as `scott`, but unlike fixed user links, `scott`'s credentials are not stored where database users can see them.

By using fixed user links, you can create non-global users whose password information is stored in unencrypted form in the `LINK$` data dictionary table. Fixed user links are easy to create and require low overhead because there are no SSL or directory requirements, but a security risk results from the storage of password information in the data dictionary.

See Also:

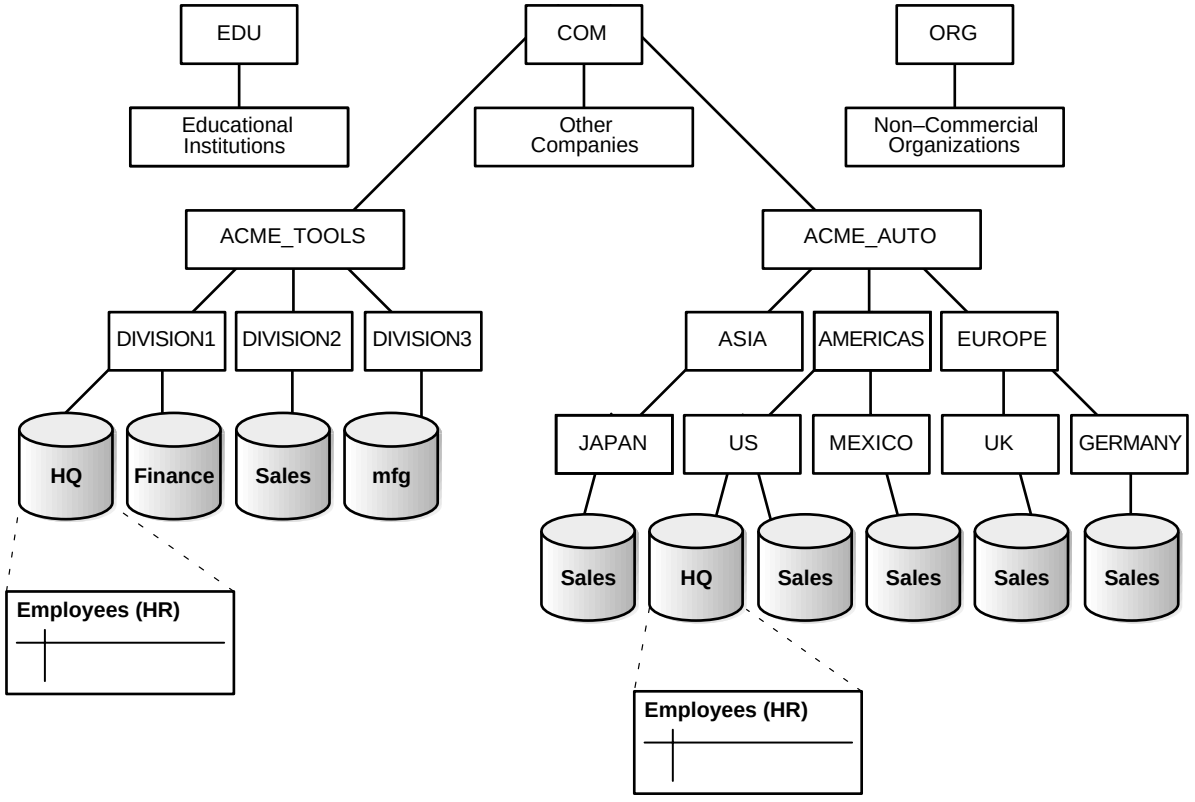
- "Users of Database Links" on page 28-16 for an explanation of database link users
- "Viewing Information About Database Links" for an explanation of how to hide passwords from non-administrators

Global Database Names in Database Links

To understand how a database link works, you must first understand what a global database name is. Each database in a distributed database is uniquely identified by its global database name. Oracle forms a database's global database name by prefixing the database's network domain, specified by the `DB_DOMAIN` initialization parameter at database creation, with the individual database name, specified by the `DB_NAME` initialization parameter.

For example, Figure 28–4 illustrates a representative hierarchical arrangement of databases throughout a network.

Figure 28–4 Hierarchical Arrangement of Networked Databases



The name of a database is formed by starting at the leaf of the tree and following a path to the root. For example, the `mfg` database is in `division3` of the `acme_tools` branch of the `com` domain. The global database name for `mfg` is created by concatenating the nodes in the tree as follows:

```
mfg.division3.acme_tools.com
```

While several databases can share an individual name, each database must have a unique global database name. For example, the network domains `us.americas.acme_auto.com` and `uk.europe.acme_auto.com` each contain a `sales` database. The global database naming system distinguishes the `sales` database in the `americas` division from the `sales` database in the `europe` division as follows:

```
sales.us.americas.acme_auto.com
sales.uk.europe.acme_auto.com
```

> **See Also:** "Managing Global Names in a Distributed System" on page 29-2 to learn how to specify and change global database names

Names for Database Links

Typically, a database link has the same name as the global database name of the remote database that it references. For example, if the global database name of a database is `sales.us.oracle.com`, then the database link is also called `sales.us.oracle.com`.

When you set the initialization parameter `GLOBAL_NAMES` to `TRUE`, Oracle ensures that the name of the database link is the same as the global database name of the remote database. For example, if the global database name for `hq` is `hq.acme.com`, and `GLOBAL_NAMES` is `TRUE`, then the link name must be called `hq.acme.com`. Note that Oracle checks the domain part of the global database name as stored in the data dictionary, *not* the `DB_DOMAIN` setting in the initialization parameter file (see "Changing the Domain in a Global Database Name" on page 29-4).

If you set the initialization parameter `GLOBAL_NAMES` to `FALSE`, then you are not required to use global naming. You can then name the database link whatever you want. For example, you can name a database link to `hq.acme.com` as `foo`.

Note: Oracle Corporation recommends that you use global naming because many useful features, including Replication, require global naming.

After you have enabled global naming, database links are essentially transparent to users of a distributed database because the name of a database link is the same as the global name of the database to which the link points. For example, the following statement creates a database link in the local database to remote database `sales`:

```
CREATE PUBLIC DATABASE LINK sales.division3.acme.com USING 'sales1';
```

> **See Also:** *Oracle9i Database Reference* for more information about specifying the initialization parameter `GLOBAL_NAMES`

Types of Database Links

Oracle lets you create **private**, **public**, and **global** database links. These basic link types differ according to which users are allowed access to the remote database:

Type	Owner	Description
Private	User who created the link. View ownership data through: ■ DBA_DB_LINKS ■ ALL_DB_LINKS ■ USER_DB_LINKS	Creates link in a specific schema of the local database. Only the owner of a private database link or PL/SQL subprograms in the schema can use this link to access database objects in the corresponding remote database.
Public	User called PUBLIC. View ownership data through views shown above.	Creates a database-wide link. All users and PL/SQL subprograms in the database can use the link to access database objects in the corresponding remote database.
Global	User called PUBLIC. View ownership data through views shown above.	Creates a network-wide link. When an Oracle network uses Oracle Names, the names servers in the system automatically create and manage global database links for every Oracle database in the network. Users and PL/SQL subprograms in any database can use a global link to access objects in the corresponding remote database.

Determining the type of database links to employ in a distributed database depends on the specific requirements of the applications using the system. Consider these advantages and disadvantages:

Private Database Link — This link is more secure than a public or global link, because only the owner of the private link, or subprograms within the same schema, can use the link to access the remote database.

Public Database Link — When many users require an access path to a remote Oracle database, you can create a single public database link for all users in a database.

Global Database Link — When an Oracle network uses Oracle Names, an administrator can conveniently manage global database links for all databases in the system. Database link management is centralized and simple.

See Also:

- "Specifying Link Types" on page 29-9 to learn how to create different types of database links
- "Viewing Information About Database Links" on page 29-21 to learn how to access information about links

Users of Database Links

When creating the link, you determine which user should connect to the remote database to access the data. The following table explains the differences among the categories of users involved in database links:

User Type	Meaning	Sample Link Creation Syntax
Connected user	A local user accessing a database link in which no fixed username and password have been specified. If SYSTEM accesses a public link in a query, then the connected user is SYSTEM, and Oracle connects to the SYSTEM schema in the remote database. **Note:** A connected user does not have to be the user who created the link, but is any user who is accessing the link.	`CREATE PUBLIC DATABASE LINK hq USING 'hq';`
Current user	A global user in a CURRENT_USER database link. The global user must be authenticated by an X.509 certificate (an SSL-authenticated enterprise user) or a password (a password-authenticated enterprise user), and be a user on both databases involved in the link. Current user links are an aspect of the Oracle Advanced Security option. See *Oracle Advanced Security Administrator's Guide* for information about global security	`CREATE PUBLIC DATABASE LINK hq CONNECT TO CURRENT_USER using 'hq';`
Fixed user	A user whose username/password is part of the link definition. If a link includes a fixed user, then the fixed user's username and password are used to connect to the remote database.	`CREATE PUBLIC DATABASE LINK hq CONNECT TO jane IDENTIFIED BY doe USING 'hq';`

See Also: "Specifying Link Users" on page 29-11 to learn how to specify users where creating links

Connected User Database Links

Connected user links have no connect string associated with them. The advantage of a connected user link is that a user referencing the link connects to the remote

database as the same user. Furthermore, because no connect string is associated with the link, no password is stored in clear text in the data dictionary.

Connected user links have some disadvantages. Because these links require users to have accounts and privileges on the remote databases to which they are attempting to connect, they require more privilege administration for administrators. Also, giving users more privileges than they need violates the fundamental security concept of least privilege: users should only be given the privileges they need to perform their jobs.

The ability to use a connected user database link depends on several factors, chief among them whether the user is authenticated by Oracle using a password, or externally authenticated by the operating system or a network authentication service. If the user is externally authenticated, then the ability to use a connected user link also depends on whether the remote database accepts remote authentication of users, which is set by the REMOTE_OS_AUTHENT initialization parameter.

The REMOTE_OS_AUTHENT parameter operates as follows:

If REMOTE_OS_AUTHENT is...	Then...
TRUE for the remote database	An externally-authenticated user can connect to the remote database using a connected user database link.
FALSE for the remote database	An externally-authenticated user cannot connect to the remote database using a connected user database link unless a secure protocol or a network authentication service supported by the Oracle Advanced Security option is used.

Fixed User Database Links

A benefit of a fixed user link is that it connects a user in a primary database to a remote database with the security context of the user specified in the connect string. For example, local user joe can create a public database link in joe's schema that specifies the fixed user scott with password tiger. If jane uses the fixed user link in a query, then jane is the user on the local database, but she connects to the remote database as scott/tiger.

Fixed user links have a username and password associated with the connect string. The username and password are stored in unencrypted form in the data dictionary in the LINK$ table.

Caution: The fact that the username and password are stored in unencrypted form in the data dictionary creates a potential security weakness of fixed user database links.

If the O7_DICTIONARY_ACCESSIBILITY initialization parameter is set to TRUE, a user with the SELECT ANY TABLE system privilege has access to the data dictionary, and thus the authentication associated with a fixed user is compromised.

The default for the O7_DICTIONARY_ACCESSIBILITY initialization parameter is FALSE.

For an example of this security problem, assume that jane does not have privileges to use a private link that connects to the hq database as scott/tiger, but has SELECT ANY TABLE privilege on a database in which the O7_DICTIONARY_ACCESSIBILITY initialization parameter is set to TRUE. She can select from LINK$ and read that the connect string to hq is scott/tiger. If jane has an account on the host on which hq resides, then she can connect to the host and then connect to hq as scott using the password tiger. She will have all scott's privileges if she connects locally and any audit records will be recorded as if she were scott.

See Also: "System Privileges" on page 25-2 for more information about system privileges and the O7_DICTIONARY_ACCESSIBILITY initialization parameter

Current User Database Links

Current user database links make use of a global user. A global user must be authenticated by an X.509 certificate or a password, and be a user on both databases involved in the link.

The user invoking the CURRENT_USER link does not have to be a global user. For example, if jane is authenticated (not as a global user) by password to the Accounts Payable database, she can access a stored procedure to retrieve data from the hq database. The procedure uses a current user database link, which connects her to hq as global user scott. User scott is a global user and authenticated through a certificate over SSL, but jane is not.

Note that current user database links have these consequences:

- If the current user database link is *not* accessed from within a stored object, then the current user is the same as the connected user accessing the link. For

example, if scott issues a SELECT statement through a current user link, then the current user is scott.

- When executing a stored object such as a procedure, view, or trigger that accesses a database link, the current user is the user that *owns* the stored object, and not the user that *calls* the object. For example, if jane calls procedure scott.p (created by scott), and a current user link appears *within* the called procedure, then scott is the current user of the link.
- If the stored object is an invoker-rights function, procedure, or package, then the invoker's authorization ID is used to connect as a remote user. For example, if user jane calls procedure scott.p (an invoker-rights procedure created by scott), and the link appears inside procedure scott.p, then jane is the current user.
- You cannot connect to a database as an enterprise user and then use a current user link in a stored procedure that exists in a shared, global schema. For example, if user jane accesses a stored procedure in the shared schema guest on database hq, she cannot use a current user link in this schema to log on to a remote database.

See Also:

- "Distributed Database Security" on page 28-24 for more information about security issues relating to database links
- *Oracle Advanced Security Administrator's Guide*

Creation of Database Links: Examples

Create database links using the CREATE DATABASE LINK statement. The table gives examples of SQL statements that create database links in a local database to the remote sales.us.americas.acme_auto.com database:

SQL Statement	Connects To Database	Connects As	Link Type
CREATE DATABASE LINK sales.us.americas.acme_ auto.com USING 'sales_us';	sales using net service name sales_us	Connected user	Private connected user
CREATE DATABASE LINK foo CONNECT TO CURRENT_USER USING 'am_sls';	sales using service name am_sls	Current global user	Private current user

SQL Statement	Connects To Database	Connects As	Link Type
`CREATE DATABASE LINK sales.us.americas.acme_auto.com CONNECT TO scott IDENTIFIED BY tiger USING 'sales_us';`	`sales` using net service name `sales_us`	`scott` using password `tiger`	Private fixed user
`CREATE PUBLIC DATABASE LINK sales CONNECT TO scott IDENTIFIED BY tiger USING 'rev';`	`sales` using net service name `rev`	`scott` using password `tiger`	Public fixed user
`CREATE SHARED PUBLIC DATABASE LINK sales.us.americas.acme_auto.com CONNECT TO scott IDENTIFIED BY tiger AUTHENTICATED BY anupam IDENTIFIED BY bhide USING 'sales';`	`sales` using net service name `sales`	`scott` using password `tiger`, authenticated as `anupam` using password `bhide`	Shared public fixed user

See Also:

- "Creating Database Links" on page 29-8 to learn how to create link
- *Oracle9i SQL Reference* for information about the `CREATE DATABASE LINK` statement syntax

Schema Objects and Database Links

After you have created a database link, you can execute SQL statements that access objects on the remote database. For example, to access remote object `emp` using database link `foo`, you can issue:

```
SELECT * FROM emp@foo;
```

Constructing properly formed object names using database links is an essential aspect of data manipulation in distributed systems.

Naming of Schema Objects Using Database Links

Oracle uses the global database name to name the schema objects globally using the following scheme:

schema.schema_object@global_database_name

where:

schema	is a collection of logical structures of data, or schema objects. A schema is owned by a database user and has the same name as that user. Each user owns a single schema.
schema_object	is a logical data structure like a table, index, view, synonym, procedure, package, or a database link.
global_database_name	is the name that uniquely identifies a remote database. This name must be the same as the concatenation of the remote database's initialization parameters DB_NAME and DB_DOMAIN, unless the parameter GLOBAL_NAMES is set to FALSE, in which case any name is acceptable.

For example, using a database link to database `sales.division3.acme.com`, a user or application can reference remote data as follows:

```
SELECT * FROM scott.emp@sales.division3.acme.com;  # emp table in scott's schema
SELECT loc FROM scott.dept@sales.division3.acme.com;
```

If GLOBAL_NAMES is set to FALSE, then you can use any name for the link to `sales.division3.acme.com`. For example, you can call the link `foo`. Then, you can access the remote database as follows:

```
SELECT name FROM scott.emp@foo;  # link name different from global name
```

Synonyms for Schema Objects

Oracle lets you create synonyms so that you can hide the database link name from the user. A synonym allows access to a table on a remote database using the same syntax that you would use to access a table on a local database. For example, assume you issue the following query against a table in a remote database:

```
SELECT * FROM emp@hq.acme.com;
```

You can create the synonym `emp` for `emp@hq.acme.com` so that you can issue the following query instead to access the same data:

```
SELECT * FROM emp;
```

> **See Also:** "Using Synonyms to Create Location Transparency" on page 29-28 to learn how to create synonyms for objects specified using database links

Schema Object Name Resolution

To resolve application references to schema objects (a process called **name resolution**), Oracle forms object names hierarchically. For example, Oracle guarantees that each schema within a database has a unique name, and that within a schema each object has a unique name. As a result, a schema object's name is always unique within the database. Furthermore, Oracle resolves application references to an object's local name.

In a distributed database, a schema object such as a table is accessible to all applications in the system. Oracle extends the hierarchical naming model with global database names to effectively create **global object names** and resolve references to the schema objects in a distributed database system. For example, a query can reference a remote table by specifying its fully qualified name, including the database in which it resides.

For example, assume that you connect to the local database as user SYSTEM:

```
CONNECT SYSTEM/password@sales1
```

You then issue the following statements using database link hq.acme.com to access objects in the scott and jane schemas on remote database hq:

```
SELECT * FROM scott.emp@hq.acme.com;
INSERT INTO jane.accounts@hq.acme.com (acc_no, acc_name, balance)
  VALUES (5001, 'BOWER', 2000);
UPDATE jane.accounts@hq.acme.com
  SET balance = balance + 500;
DELETE FROM jane.accounts@hq.acme.com
  WHERE acc_name = 'BOWER';
```

Database Link Restrictions

You *cannot* perform the following operations using database links:

- Grant privileges on remote objects
- Execute DESCRIBE operations on some remote objects. The following remote objects, however, do support DESCRIBE operations:
  - Tables
  - Views
  - Procedures
  - Functions

- ANALYZE remote objects
- Define or enforce referential integrity
- Grant roles to users in a remote database
- Obtain nondefault roles on a remote database. For example, if `jane` connects to the local database and executes a stored procedure that uses a fixed user link connecting as `scott`, `jane` receives `scott`'s default roles on the remote database. Jane cannot issue `SET ROLE` to obtain a non-default role.
- Execute hash query joins that use shared server connections
- Use a current user link without authentication through SSL, password, or NT native authentication

Distributed Database Administration

The following sections explain some of the topics relating to database management in an Oracle distributed database system:

- Site Autonomy
- Distributed Database Security
- Auditing Database Links
- Administration Tools

See Also:

- Chapter 29, "Managing a Distributed Database" to learn how to administer homogenous systems
- *Oracle9i Heterogeneous Connectivity Administrator's Guide* to learn about heterogeneous services concepts

Site Autonomy

Site autonomy means that each server participating in a distributed database is administered independently from all other databases. Although several databases can work together, each database is a separate repository of data that is managed individually. Some of the benefits of site autonomy in an Oracle distributed database include:

- Nodes of the system can mirror the logical organization of companies or groups that need to maintain independence.

- Local administrators control corresponding local data. Therefore, each database administrator's domain of responsibility is smaller and more manageable.
- Independent failures are less likely to disrupt other nodes of the distributed database. No single database failure need halt all distributed operations or be a performance bottleneck.
- Administrators can recover from isolated system failures independently from other nodes in the system.
- A data dictionary exists for each local database—a global catalog is not necessary to access local data.
- Nodes can upgrade software independently.

Although Oracle permits you to manage each database in a distributed database system independently, you should not ignore the global requirements of the system. For example, you may need to:

- Create additional user accounts in each database to support the links that you create to facilitate server-to-server connections.
- Set additional initialization parameters such as `DISTRIBUTED_TRANSACTIONS` and `COMMIT_POINT_STRENGTH`.

Distributed Database Security

Oracle supports all of the security features that are available with a nondistributed database environment for distributed database systems, including:

- Password authentication for users and roles
- Some types of external authentication for users and roles including:
  - Kerberos version 5 for connected user links
  - DCE for connected user links
- Login packet encryption for client-to-server and server-to-server connections

The following sections explain some additional topics to consider when configuring an Oracle distributed database system:

- Authentication Through Database Links
- Authentication Without Passwords
- Supporting User Accounts and Roles
- Centralized User and Privilege Management

- Data Encryption

See Also: *Oracle Advanced Security Administrator's Guide* for more information about external authentication

Authentication Through Database Links

Database links are either private or public, **authenticated** or **non-authenticated**. You create public links by specifying the `PUBLIC` keyword in the link creation statement. For example, you can issue:

```
CREATE PUBLIC DATABASE LINK foo USING 'sales';
```

You create authenticated links by specifying the `CONNECT TO` clause, `AUTHENTICATED BY` clause, or both clauses together in the database link creation statement. For example, you can issue:

```
CREATE DATABASE LINK sales CONNECT TO scott IDENTIFIED BY tiger USING 'sales';
CREATE SHARED PUBLIC DATABASE LINK sales CONNECT TO mick IDENTIFIED BY jagger
     AUTHENTICATED BY david IDENTIFIED BY bowie USING 'sales';
```

This table describes how users access the remote database through the link:

Link Type	Authenticated?	Security Access
Private	No	When connecting to the remote database, Oracle uses security information (userid / password) taken from the local session. Hence, the link is a connected user database link. Passwords must be synchronized between the two databases.
Private	Yes	The userid / password is taken from the link definition rather than from the local session context. Hence, the link is a fixed user database link. This configuration allows passwords to be different on the two databases, but the local database link password must match the remote database password. The password is stored in clear text on the local system catalog, adding a security risk.
Public	No	Works the same as a private non-authenticated link, except that all users can reference this pointer to the remote database.

Link Type	Authenticated?	Security Access
Public	Yes	All users on the local database can access the remote database and all use the same userid / password to make the connection. Also, the password is stored in clear text in the local catalog, so you can see the password if you have sufficient privileges in the local database.

Authentication Without Passwords

When using a connected user or current user database link, you can use an external authentication source such as Kerberos to obtain **end-to-end security**. In end-to-end authentication, credentials are passed from server to server and can be authenticated by a database server belonging to the same domain. For example, if `jane` is authenticated externally on a local database, and wants to use a connected user link to connect as herself to a remote database, the local server passes the security ticket to the remote database.

Supporting User Accounts and Roles

In a distributed database system, you must carefully plan the user accounts and roles that are necessary to support applications using the system. Note that:

- The user accounts necessary to establish server-to-server connections must be available in all databases of the distributed database system.
- The roles necessary to make available application privileges to distributed database application users must be present in all databases of the distributed database system.

As you create the database links for the nodes in a distributed database system, determine which user accounts and roles each site needs to support server-to-server connections that use the links.

In a distributed environment, users typically require access to many network services. When you must configure separate authentications for each user to access each network service, security administration can become unwieldy, especially for large systems.

> **See Also:** "Creating Database Links" on page 29-8 for more information about the user accounts that must be available to support different types of database links in the system

Centralized User and Privilege Management

Oracle provides different ways for you to manage the users and privileges involved in a distributed system. For example, you have these options:

- Enterprise user management. You can create global users who are authenticated through SSL or by using passwords, then manage these users and their privileges in a directory through an independent enterprise directory service.
- Network authentication service. This common technique simplifies security management for distributed environments. You can use the Oracle Advanced Security option to enhance Oracle Net and the security of an Oracle distributed database system. Windows NT native authentication is an example of a non-Oracle authentication solution.

  See Also: For more information about global user security:

  - *Oracle Net Services Administrator's Guide*
  - *Oracle Advanced Security Administrator's Guide*

Schema-Dependent Global Users One option for centralizing user and privilege management is to create the following:

- A global user in a centralized directory
- A user in every database that the global user must connect to

For example, you can create a global user called `fred` with the following SQL statement:

```
CREATE USER fred IDENTIFIED GLOBALLY AS 'CN=fred adams,O=Oracle,C=England';
```

This solution allows a single global user to be authenticated by a centralized directory.

The schema-dependent global user solution has the consequence that you must create a user called `fred` on every database that this user must access. Because most users need permission to access an application schema but do not need their own schemas, the creation of a separate account in each database for every global user creates significant overhead. Because of this problem, Oracle also supports schema-independent users, which are global users that an access a single, generic schema in every database.

Schema-Independent Global Users Oracle supports functionality that allows a global user to be centrally managed by an enterprise directory service. Users who are

managed in the directory are called **enterprise users**. This directory contains information about:

- Which databases in a distributed system an enterprise user can access
- Which role on each database an enterprise user can use
- Which schema on each database an enterprise user can connect to

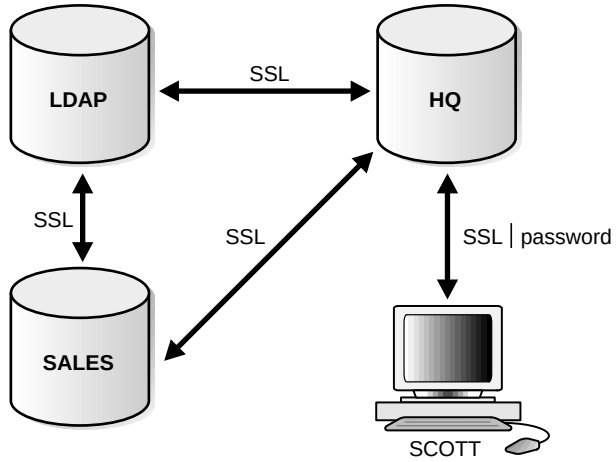
The administrator of each database is not required to create a global user account for each enterprise user on each database to which the enterprise user needs to connect. Instead, multiple enterprise users can connect to the same database schema, called a **shared schema**.

Note: You cannot access a current user database link in a shared schema.

For example, suppose `jane`, `bill`, and `scott` all use a human resources application. The `hq` application objects are all contained in the `guest` schema on the `hq` database. In this case, you can create a local global user account to be used as a shared schema. This global username, that is, shared schema name, is `guest`. `jane`, `bill`, and `scott` are all created as enterprise users in the directory service. They are also mapped to the `guest` schema in the directory, and can be assigned different authorizations in the `hq` application.

Figure 28–5 illustrates an example of global user security using the enterprise directory service:

Figure 28–5 Global User Security



Assume that the enterprise directory service contains the following information on enterprise users for `hq` and `sales`:

Database	Role	Schema	Enterprise Users
`hq`	`clerk1`	`guest`	`bill` `scott`
`sales`	`clerk2`	`guest`	`jane` `scott`

Also, assume that the local administrators for `hq` and `sales` have issued statements as follows:

Database	CREATE Statements

`hq`	`CREATE USER guest IDENTIFIED GLOBALLY AS '';`
	`CREATE ROLE clerk1 GRANT select ON emp;`
	`CREATE PUBLIC DATABASE LINK sales_link CONNECT AS CURRENT_USER USING 'sales';`

`sales`	`CREATE USER guest IDENTIFIED GLOBALLY AS '';` `CREATE ROLE clerk2 GRANT select ON dept;`

Assume that enterprise user scott requests a connection to local database hq in order to execute a distributed transaction involving sales. The following steps occur (not necessarily in this exact order):

1. Enterprise user scott is authenticated using SSL or a password.
2. User scott issues the following statement:

```
SELECT e.ename, d.loc
FROM emp e, dept@sales_link d
WHERE e.deptno=d.deptno
```

3. Databases hq and sales mutually authenticate one another using SSL.
4. Database hq queries the enterprise directory service to determine whether enterprise user scott has access to hq, and discovers scott can access local schema guest using role clerk1.
5. Database sales queries the enterprise directory service to determine whether enterprise user scott has access to sales, and discovers scott can access local schema guest using role clerk2.
6. Enterprise user scott logs into sales to schema guest with role clerk2 and issues a SELECT to obtain the required information and transfer it to hq.
7. Database hq receives the requested data from sales and returns it to the client scott.

See Also: For more information about enterprise user security:

- *Oracle Net Services Administrator's Guide*
- *Oracle Advanced Security Administrator's Guide*

Data Encryption

The Oracle Advanced Security option also enables Oracle Net and related products to use network data encryption and checksumming so that data cannot be read or altered. It protects data from unauthorized viewing by using the RSA Data Security RC4 or the Data Encryption Standard (DES) encryption algorithm.

To ensure that data has not been modified, deleted, or replayed during transmission, the security services of the Oracle Advanced Security option can generate a cryptographically secure message digest and include it with each packet sent across the network.

See Also: For more information about these and other features of the Oracle Advanced Security option:

- *Oracle Net Services Administrator's Guide*
- *Oracle Advanced Security Administrator's Guide*

Auditing Database Links

You must always perform auditing operations locally. That is, if a user acts in a local database and accesses a remote database through a database link, the local actions are audited in the local database, and the remote actions are audited in the remote database—provided appropriate audit options are set in the respective databases.

The remote database cannot determine whether a successful connect request and subsequent SQL statements come from another server or from a locally connected client. For example, assume the following:

- Fixed user link `hq.acme.com` connects local user `jane` to the remote `hq` database as remote user `scott.`
- User `scott` is audited on the remote database.

Actions performed during the remote database session are audited as if `scott` were connected locally to `hq` and performing the same actions there. You must set audit options in the remote database to capture the actions of the username—in this case, `scott` on the `hq` database—embedded in the link if the desired effect is to audit what `jane` is doing in the remote database.

Note: You can audit the global username for global users.

You cannot set local auditing options on remote objects. Therefore, you cannot audit use of a database link, although access to remote objects can be audited on the remote database.

Administration Tools

The database administrator has several choices for tools to use when managing an Oracle distributed database system:

- Enterprise Manager
- Third-Party Administration Tools

- SNMP Support

Enterprise Manager

Enterprise Manager is Oracle's database administration tool that provides a graphical user interface (GUI). Enterprise Manager provides administrative functionality for distributed databases through an easy-to-use interface. You can use Enterprise Manager to:

- Administer multiple databases. You can use Enterprise Manager to administer a single database or to simultaneously administer multiple databases.
- Centralize database administration tasks. You can administer both local and remote databases running on any Oracle platform in any location worldwide. In addition, these Oracle platforms can be connected by any network protocols supported by Oracle Net.
- Dynamically execute SQL, PL/SQL, and Enterprise Manager commands. You can use Enterprise Manager to enter, edit, and execute statements. Enterprise Manager also maintains a history of statements executed.

  Thus, you can reexecute statements without retyping them, a particularly useful feature if you need to execute lengthy statements repeatedly in a distributed database system.
- Manage security features such as global users, global roles, and the enterprise directory service.

Third-Party Administration Tools

Currently more than 60 companies produce more than 150 products that help manage Oracle databases and networks, providing a truly open environment.

SNMP Support

Besides its network administration capabilities, Oracle **Simple Network Management Protocol** (*SNMP*) support allows an Oracle database server to be located and queried by any SNMP-based network management system. SNMP is the accepted standard underlying many popular network management systems such as:

- HP's OpenView
- Digital's POLYCENTER Manager on NetView
- IBM's NetView/6000

- Novell's NetWare Management System
- SunSoft's SunNet Manager

> **See Also:** *Oracle SNMP Support Reference Guide* for more information about SNMP

Transaction Processing in a Distributed System

A transaction is a logical unit of work constituted by one or more SQL statements executed by a single user. A transaction begins with the user's first executable SQL statement and ends when it is committed or rolled back by that user.

A **remote transaction** contains only statements that access a single remote node. A **distributed transaction** contains statements that access more than one node.

The following sections define important concepts in transaction processing and explain how transactions access data in a distributed database:

- Remote SQL Statements
- Distributed SQL Statements
- Shared SQL for Remote and Distributed Statements
- Remote Transactions
- Distributed Transactions
- Two-Phase Commit Mechanism
- Database Link Name Resolution
- Schema Object Name Resolution

Remote SQL Statements

A **remote query** statement is a query that selects information from one or more remote tables, all of which reside at the same remote node. For example, the following query accesses data from the `dept` table in the `scott` schema of the remote `sales` database:

```
SELECT * FROM scott.dept@sales.us.americas.acme_auto.com;
```

A **remote update** statement is an update that modifies data in one or more tables, all of which are located at the same remote node. For example, the following query updates the `dept` table in the `scott` schema of the remote `sales` database:

```
UPDATE scott.dept@mktng.us.americas.acme_auto.com
  SET loc = 'NEW YORK'
  WHERE deptno = 10;
```

> **Note:** A remote update can include a subquery that retrieves data from one or more remote nodes, but because the update happens at only a single remote node, the statement is classified as a remote update.

Distributed SQL Statements

A **distributed query** statement retrieves information from two or more nodes. For example, the following query accesses data from the local database as well as the remote `sales` database:

```
SELECT ename, dname
  FROM scott.emp e, scott.dept@sales.us.americas.acme_auto.com d
  WHERE e.deptno = d.deptno;
```

A **distributed update** statement modifies data on two or more nodes. A distributed update is possible using a PL/SQL subprogram unit such as a procedure or trigger that includes two or more remote updates that access data on different nodes. For example, the following PL/SQL program unit updates tables on the local database and the remote `sales` database:

```
BEGIN
  UPDATE scott.dept@sales.us.americas.acme_auto.com
    SET loc = 'NEW YORK'
    WHERE deptno = 10;
  UPDATE scott.emp
    SET deptno = 11
    WHERE deptno = 10;
END;
COMMIT;
```

Oracle sends statements in the program to the remote nodes, and their execution succeeds or fails as a unit.

Shared SQL for Remote and Distributed Statements

The mechanics of a remote or distributed statement using shared SQL are essentially the same as those of a local statement. The SQL text must match, and the

referenced objects must match. If available, shared SQL areas can be used for the local and remote handling of any statement or decomposed query.

> **See Also:** *Oracle9i Database Concepts* for more information about shared SQL

Remote Transactions

A remote transaction contains one or more remote statements, all of which reference a single remote node. For example, the following transaction contains two statements, each of which accesses the remote `sales` database:

```
UPDATE scott.dept@sales.us.americas.acme_auto.com
  SET loc = 'NEW YORK'
  WHERE deptno = 10;
UPDATE scott.emp@sales.us.americas.acme_auto.com
  SET deptno = 11
  WHERE deptno = 10;
COMMIT;
```

Distributed Transactions

A distributed transaction is a transaction that includes one or more statements that, individually or as a group, update data on two or more distinct nodes of a distributed database. For example, this transaction updates the local database and the remote `sales` database:

```
UPDATE scott.dept@sales.us.americas.acme_auto.com
  SET loc = 'NEW YORK'
  WHERE deptno = 10;
UPDATE scott.emp
  SET deptno = 11
  WHERE deptno = 10;
COMMIT;
```

> **Note:** If all statements of a transaction reference only a single remote node, the transaction is remote, not distributed.

Two-Phase Commit Mechanism

A database must guarantee that all statements in a transaction, distributed or nondistributed, either commit or roll back as a unit. The effects of an ongoing transaction should be invisible to all other transactions at all nodes; this

transparency should be true for transactions that include any type of operation, including queries, updates, or remote procedure calls.

The general mechanisms of transaction control in a nondistributed database are discussed in the *Oracle9i Database Concepts*. In a distributed database, Oracle must coordinate transaction control with the same characteristics over a network and maintain data consistency, even if a network or system failure occurs.

Oracle's **two-phase commit** mechanism guarantees that *all* database servers participating in a distributed transaction either all commit or all roll back the statements in the transaction. A two-phase commit mechanism also protects implicit DML operations performed by integrity constraints, remote procedure calls, and triggers.

> **See Also:** Chapter 31, "Distributed Transactions Concepts" for more information about Oracle's two-phase commit mechanism

Database Link Name Resolution

A **global object name** is an object specified using a database link. The essential components of a global object name are:

- Object name
- Database name
- Domain

The following table shows the components of an explicitly specified global database object name:

Statement	Object	Database	Domain
`SELECT * FROM joan.dept@sales.acme.com`	`dept`	`sales`	`acme.com`
`SELECT * FROM emp@mktg.us.acme.com`	`emp`	`mktg`	`us.acme.com`

Whenever a SQL statement includes a reference to a global object name, Oracle searches for a database link with a name that matches the database name specified in the global object name. For example, if you issue the following statement:

```
SELECT * FROM scott.emp@orders.us.acme.com;
```

Oracle searches for a database link called `orders.us.acme.com`. Oracle performs this operation to determine the path to the specified remote database.

Oracle always searches for matching database links in the following order:

1. Private database links in the schema of the user who issued the SQL statement.
2. Public database links in the local database.
3. Global database links (only if an Oracle Names Server is available).

Name Resolution When the Global Database Name Is Complete

Assume that you issue the following SQL statement, which specifies a complete global database name:

```
SELECT * FROM emp@prod1.us.oracle.com
```

In this case, both the database name (`prod1`) and domain components (`us.oracle.com`) are specified, so Oracle searches for private, public, and global database links. Oracle searches only for links that match the specified global database name.

Name Resolution When the Global Database Name Is Partial

If any part of the domain is specified, Oracle assumes that a complete global database name is specified. If a SQL statement specifies a partial global database name (that is, only the database component is specified), Oracle appends the value in the `DB_DOMAIN` initialization parameter to the value in the `DB_NAME` initialization parameter to construct a complete name. For example, assume you issue the following statements:

```
CONNECT scott/tiger@locdb
SELECT * FROM scott.emp@orders;
```

If the network domain for `locdb` is `us.acme.com`, then Oracle appends this domain to `orders` to construct the complete global database name of `orders.us.acme.com`. Oracle searches for database links that match only the constructed global name. If a matching link is not found, Oracle returns an error and the SQL statement cannot execute.

Name Resolution When No Global Database Name Is Specified

If a global object name references an object in the local database and a database link name is *not* specified using the @ symbol, then Oracle automatically detects that the

object is local and does not search for or use database links to resolve the object reference. For example, assume that you issue the following statements:

```
CONNECT scott/tiger@locdb
SELECT * from scott.emp;
```

Because the second statement does not specify a global database name using a database link connect string, Oracle does not search for database links.

Terminating the Search for Name Resolution

Oracle does not necessarily stop searching for matching database links when it finds the first match. Oracle must search for matching private, public, and network database links until it determines a complete path to the remote database (both a remote account and service name).

The first match determines the remote schema as illustrated in the following table:

If you...	Then Oracle...	As in the example...
Do *not* specify the `CONNECT` clause	Uses a connected user database link	`CREATE DATABASE LINK k1 USING 'prod'`
Do specify the `CONNECT TO ... IDENTIFIED BY` clause	Uses a fixed user database link	`CREATE DATABASE LINK k2 CONNECT TO scott IDENTIFIED BY tiger USING 'prod'`
Specify the `CONNECT TO CURRENT_USER` clause	Uses a current user database link	`CREATE DATABASE LINK k3 CONNECT TO CURRENT_USER USING 'prod'`
Do *not* specify the `USING` clause	Searches until it finds a link specifying a database string. If matching database links are found and a string is never identified, Oracle returns an error.	`CREATE DATABASE LINK k4 CONNECT TO CURRENT_USER`

After Oracle determines a complete path, it creates a remote session—assuming that an identical connection is not already open on behalf of the same local session. If a session already exists, Oracle reuses it.

Schema Object Name Resolution

After the local Oracle database connects to the specified remote database on behalf of the local user that issued the SQL statement, object resolution continues as if the remote user had issued the associated SQL statement. The first match determines the remote schema according to the following rules:

If you use...	Then object resolution proceeds in the...
A fixed user database link	Schema specified in the link creation statement
A connected user database link	Connected user's remote schema
A current user database link	Current user's schema

If Oracle cannot find the object, then it checks public objects of the remote database. If it cannot resolve the object, then the established remote session remains but the SQL statement cannot execute and returns an error.

The following are examples of global object name resolution in a distributed database system. For all the following examples, assume that:

Example of Global Object Name Resolution: Complete Object Name

This example illustrates how Oracle resolves a complete global object name and determines the appropriate path to the remote database using both a private and public database link. For this example, assume the following:

- The remote database is named `sales.division3.acme.com`.
- The local database is named `hq.division3.acme.com`.
- An Oracle Names Server (and therefore, global database links) is not available.
- A remote table `emp` is contained in the schema `tsmith`.

Consider the following statements issued by `scott` at the local database:

```
CONNECT scott/tiger@hq

CREATE PUBLIC DATABASE LINK sales.division3.acme.com
CONNECT TO guest IDENTIFIED BY network
  USING 'dbstring';
```

Later, JWARD connects and issues the following statements:

```
CONNECT jward/bronco@hq
```

```
CREATE DATABASE LINK sales.division3.acme.com
  CONNECT TO tsmith IDENTIFIED BY radio;

UPDATE tsmith.emp@sales.division3.acme.com
  SET deptno = 40
  WHERE deptno = 10;
```

Oracle processes the final statement as follows:

1. Oracle determines that a complete global object name is referenced in `jward`'s update statement. Therefore, the system begins searching in the local database for a database link with a matching name.
2. Oracle finds a matching private database link in the schema `jward`. Nevertheless, the private database link `jward.sales.division3.acme.com` does not indicate a complete path to the remote `sales` database, only a remote account. Therefore, Oracle now searches for a matching public database link.
3. Oracle finds the public database link in `scott`'s schema. From this public database link, Oracle takes the service name `dbstring`.
4. Combined with the remote account taken from the matching private fixed user database link, Oracle determines a complete path and proceeds to establish a connection to the remote `sales` database as user `tsmith/radio`.
5. The remote database can now resolve the object reference to the `emp` table. Oracle searches in the `tsmith` schema and finds the referenced `emp` table.
6. The remote database completes the execution of the statement and returns the results to the local database.

Example of Global Object Name Resolution: Partial Object Name

This example illustrates how Oracle resolves a partial global object name and determines the appropriate path to the remote database using both a private and public database link.

For this example, assume that:

- The remote database is named `sales.division3.acme.com`.
- The local database is named `hq.division3.acme.com`.
- An Oracle Names Server (and therefore, global database links) is not available.
- A table `emp` on the remote database `sales` is contained in the schema `tsmith`, but not in schema `scott`.

- A public synonym named emp resides at remote database sales and points to tsmith.emp in the remote database sales.
- The public database link in "Example of Global Object Name Resolution: Complete Object Name" on page 28-39 is already created on local database hq:

```
CREATE PUBLIC DATABASE LINK sales.division3.acme.com
  CONNECT TO guest IDENTIFIED BY network
  USING 'dbstring';
```

Consider the following statements issued at local database hq:

```
CONNECT scott/tiger@hq

CREATE DATABASE LINK sales.division3.acme.com;

DELETE FROM emp@sales
  WHERE empno = 4299;
```

Oracle processes the final DELETE statement as follows:

1. Oracle notices that a partial global object name is referenced in scott's DELETE statement. It expands it to a complete global object name using the domain of the local database as follows:

   ```
   DELETE FROM emp@sales.division3.acme.com
     WHERE empno = 4299;
   ```

2. Oracle searches the local database for a database link with a matching name.
3. Oracle finds a matching *private* connected user link in the schema scott, but the private database link indicates no path at all. Oracle uses the connected username/password as the remote account portion of the path and then searches for and finds a matching *public* database link:

   ```
   CREATE PUBLIC DATABASE LINK sales.division3.acme.com
     CONNECT TO guest IDENTIFIED BY network
     USING 'dbstring';
   ```

4. Oracle takes the database net service name dbstring from the public database link. At this point, Oracle has determined a complete path.
5. Oracle connects to the remote database as scott/tiger and searches for and does not find an object named emp in the schema scott.
6. The remote database searches for a public synonym named emp and finds it.

7. The remote database executes the statement and returns the results to the local database.

Global Name Resolution in Views, Synonyms, and Procedures

A view, synonym, or PL/SQL program unit (for example, a procedure, function, or trigger) can reference a remote schema object by its global object name. If the global object name is complete, then Oracle stores the definition of the object without expanding the global object name. If the name is partial, however, Oracle expands the name using the domain of the local database name.

The following table explains when Oracle completes the expansion of a partial global object name for views, synonyms, and program units:

If you...	Then Oracle...
Create a view	Does *not* expand partial global names—the data dictionary stores the exact text of the defining query. Instead, Oracle expands a partial global object name each time a statement that uses the view is parsed.
Create a synonym	Expands partial global names. The definition of the synonym stored in the data dictionary includes the expanded global object name.
Compile a program unit	Expands partial global names.

What Happens When Global Names Change

Global name changes can affect views, synonyms, and procedures that reference remote data using partial global object names. If the global name of the referenced database changes, views and procedures may try to reference a nonexistent or incorrect database. On the other hand, synonyms do not expand database link names at runtime, so they do not change.

Scenarios for Global Name Changes

For example, consider two databases named `sales.uk.acme.com` and `hq.uk.acme.com`. Also, assume that the `sales` database contains the following view and synonym:

```
CREATE VIEW employee_names AS
        SELECT ename FROM scott.emp@hr;

CREATE SYNONYM employee FOR scott.emp@hr;
```

Oracle expands the `employee` synonym definition and stores it as:

`scott.emp@hr.uk.acme.com`

Scenario 1: Both Databases Change Names First, consider the situation where both the Sales and Human Resources departments are relocated to the United States. Consequently, the corresponding global database names are both changed as follows:

Old Global Name	New Global Name
`sales.uk.acme.com`	`sales.us.oracle.com`
`hq.uk.acme.com`	`hq.us.acme.com`

The following table describes query expansion before and after the change in global names:

Query on `sales`	Expansion Before Change	Expansion After Change
`SELECT * FROM employee_names`	`SELECT * FROM scott.emp@hr.uk.acme.com`	`SELECT * FROM scott.emp@hr.us.acme.com`
`SELECT * FROM employee`	`SELECT * FROM scott.emp@hr.uk.acme.com`	`SELECT * FROM scott.emp@hr.uk.acme.com`

Scenario 2: One Database Changes Names Now consider that only the Sales department is moved to the United States; Human Resources remains in the UK. Consequently, the corresponding global database names are both changed as follows:

Old Global Name	New Global Name
`sales.uk.acme.com`	`sales.us.oracle.com`
`hq.uk.acme.com`	no change

The following table describes query expansion before and after the change in global names:

Query on `sales`	Expansion Before Change	Expansion After Change
`SELECT * FROM employee_names`	`SELECT * FROM scott.emp@hr.uk.acme.com`	`SELECT * FROM scott.emp@hr.us.acme.com`

Query on sales	Expansion Before Change	Expansion After Change
SELECT * FROM employee	SELECT * FROM scott.emp@hr.uk.acme.com	SELECT * FROM scott.emp@hr.uk.acme.com

In this case, the defining query of the `employee_names` view expands to a non-existent global database name. On the other hand, the `employee` synonym continues to reference the correct database, `hq.uk.acme.com`.

Distributed Database Application Development

Application development in a distributed system raises issues that are not applicable in a nondistributed system. This section contains the following topics relevant for distributed application development:

- Transparency in a Distributed Database System
- Remote Procedure Calls (RPCs)
- Distributed Query Optimization

> **See Also:** Chapter 30, "Developing Applications for a Distributed Database System" to learn how to develop applications for distributed systems

Transparency in a Distributed Database System

With minimal effort, you can develop applications that make an Oracle distributed database system transparent to users that work with the system. The goal of transparency is to make a distributed database system appear as though it is a single Oracle database. Consequently, the system does not burden developers and users of the system with complexities that would otherwise make distributed database application development challenging and detract from user productivity.

The following sections explain more about transparency in a distributed database system.

Location Transparency

An Oracle distributed database system has features that allow application developers and administrators to hide the physical location of database objects from applications and users. **Location transparency** exists when a user can universally refer to a database object such as a table, regardless of the node to which an application connects. Location transparency has several benefits, including:

- Access to remote data is simple, because database users do not need to know the physical location of database objects.
- Administrators can move database objects with no impact on end-users or existing database applications.

Typically, administrators and developers use synonyms to establish location transparency for the tables and supporting objects in an application schema. For example, the following statements create synonyms in a database for tables in another, remote database.

```
CREATE PUBLIC SYNONYM emp
  FOR scott.emp@sales.us.americas.acme_auto.com
CREATE PUBLIC SYNONYM dept
  FOR scott.dept@sales.us.americas.acme_auto.com
```

Now, rather than access the remote tables with a query such as:

```
SELECT ename, dname
  FROM scott.emp@sales.us.americas.acme_auto.com e,
       scott.dept@sales.us.americas.acme_auto.com d
  WHERE e.deptno = d.deptno;
```

An application can issue a much simpler query that does not have to account for the location of the remote tables.

```
SELECT ename, dname
  FROM emp e, dept d
  WHERE e.deptno = d.deptno;
```

In addition to synonyms, developers can also use views and stored procedures to establish location transparency for applications that work in a distributed database system.

SQL and COMMIT Transparency

Oracle's distributed database architecture also provides query, update, and transaction transparency. For example, standard SQL statements such as `SELECT`, `INSERT`, `UPDATE`, and `DELETE` work just as they do in a nondistributed database environment. Additionally, applications control transactions using the standard SQL statements `COMMIT`, `SAVEPOINT`, and `ROLLBACK`—there is no requirement for complex programming or other special operations to provide distributed transaction control.

- The statements in a single transaction can reference any number of local or remote tables.

- Oracle guarantees that all nodes involved in a distributed transaction take the same action: they either all commit or all roll back the transaction.
- If a network or system failure occurs during the commit of a distributed transaction, the transaction is automatically and transparently resolved globally. Specifically, when the network or system is restored, the nodes either all commit or all roll back the transaction.

Internal to Oracle, each committed transaction has an associated **system change number** (**SCN**) to uniquely identify the changes made by the statements within that transaction. In a distributed database, the SCNs of communicating nodes are coordinated when:

- A connection is established using the path described by one or more database links.
- A distributed SQL statement is executed.
- A distributed transaction is committed.

Among other benefits, the coordination of SCNs among the nodes of a distributed database system allows global distributed read-consistency at both the statement and transaction level. If necessary, global distributed time-based recovery can also be completed.

Replication Transparency

Oracle also provide many features to transparently replicate data among the nodes of the system. For more information about Oracle's replication features, see *Oracle9i Replication*.

Remote Procedure Calls (RPCs)

Developers can code PL/SQL packages and procedures to support applications that work with a distributed database. Applications can make local procedure calls to perform work at the local database and **remote procedure calls** (**RPCs**) to perform work at a remote database.

When a program calls a remote procedure, the local server passes all procedure parameters to the remote server in the call. For example, the following PL/SQL program unit calls the packaged procedure `del_emp` located at the remote `sales` database and passes it the parameter 1257:

```
BEGIN
 emp_mgmt.del_emp@sales.us.americas.acme_auto.com(1257);
END;
```

In order for the RPC to succeed, the called procedure must exist at the remote site, and the user being connected to must have the proper privileges to execute the procedure.

When developing packages and procedures for distributed database systems, developers must code with an understanding of what program units should do at remote locations, and how to return the results to a calling application.

Distributed Query Optimization

Distributed query optimization is an Oracle feature that reduces the amount of data transfer required between sites when a transaction retrieves data from remote tables referenced in a distributed SQL statement.

Distributed query optimization uses Oracle's cost-based optimization to find or generate SQL expressions that extract only the necessary data from remote tables, process that data at a remote site or sometimes at the local site, and send the results to the local site for final processing. This operation reduces the amount of required data transfer when compared to the time it takes to transfer all the table data to the local site for processing.

Using various cost-based optimizer hints such as `DRIVING_SITE`, `NO_MERGE`, and `INDEX`, you can control where Oracle processes the data and how it accesses the data.

> **See Also:** "Using Cost-Based Optimization" on page 30-5 for more information about cost-based optimization

Character Set Support

Oracle supports environments in which clients, Oracle database servers, and non-Oracle servers use different character sets. In Oracle, `NCHAR` support is provided for heterogeneous environments. You can set a variety of National Language Support (NLS) and Heterogeneous Services (HS) environment variables and initialization parameters to control data conversion between different character sets.

Character settings are defined by the following NLS and HS parameters:

Parameters	Environment	Defined For

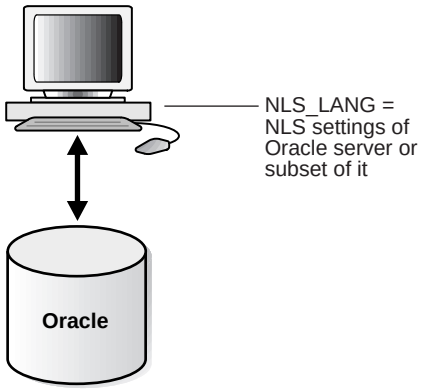
NLS_LANG (environment variable)	Client-Server	Client
NLS_LANGUAGE NLS_CHARACTERSET NLS_TERRITORY	Client-Server Non-Heterogeneous Distributed Heterogeneous Distributed	Oracle database server
HS_LANGUAGE	Heterogeneous Distributed	Non-Oracle server Transparent gateway
NLS_NCHAR (environment variable) HS_NLS_NCHAR	Heterogeneous Distributed	Oracle database server Transparent gateway

See Also: *Oracle9i Database Reference* for more information about these NLS and HS parameters

Client/Server Environment

In a client / server environment, set the client character set to be the same as or a subset of the Oracle database server character set, as illustrated in Figure 28–6:

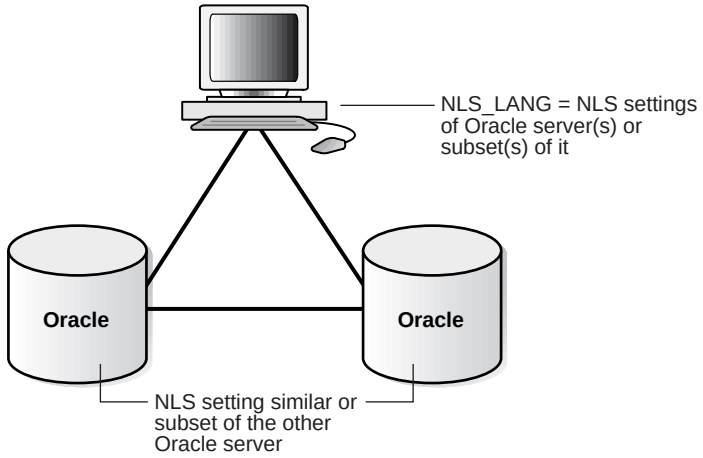
Figure 28–6 NLS Parameter Settings in a Client-Server Environment



Homogeneous Distributed Environment

In a non-heterogeneous environment, the client and server character sets should be either the same as or subsets of the main server character set, as illustrated in Figure 28–7:

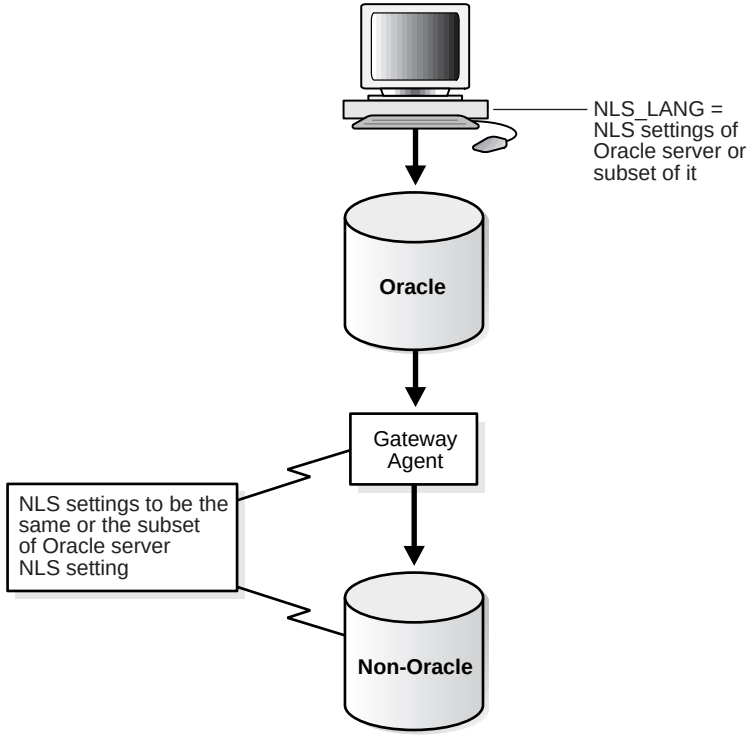
Figure 28–7 NLS Parameter Settings in a Homogeneous Environment



Heterogeneous Distributed Environment

In a heterogeneous environment, the NLS settings of the client, the transparent gateway, and the non-Oracle data source should be either the same or a subset of the Oracle database server character set as illustrated in Figure 28–8. Transparent gateways have full NLS support.

Figure 28–8 NLS Parameter Settings in a Heterogeneous Environment



In a heterogeneous environment, only transparent gateways built with HS technology support complete NCHAR capabilities. Whether a specific transparent gateway supports NCHAR depends on the non-Oracle data source it is targeting. For information on how a particular transparent gateway handles NCHAR support, consult the system-specific transparent gateway documentation.

> **See Also:** *Oracle9i Heterogeneous Connectivity Administrator's Guide* for more detailed information about Heterogeneous Services

29

Managing a Distributed Database

This chapter describes how to manage and maintain a distributed database system and contains the following topics:

- Managing Global Names in a Distributed System
- Creating Database Links
- Creating Shared Database Links
- Managing Database Links
- Viewing Information About Database Links
- Creating Location Transparency
- Managing Statement Transparency
- Managing a Distributed Database: Scenarios

Managing Global Names in a Distributed System

In a distributed database system, each database should have a unique **global database name**. Global database names uniquely identify a database in the system. A primary administration task in a distributed system is managing the creation and alteration of global database names.

This section contains the following topics:

Understanding How Global Database Names Are Formed

A global database name is formed from two components: a database name and a domain. The database name and the domain name are determined by the following initialization parameters at database creation:

Component	Parameter	Requirements	Example
Database name	DB_NAME	Must be eight characters or less.	sales
Domain containing the database	DB_DOMAIN	Must follow standard Internet conventions. Levels in domain names must be separated by dots and the order of domain names is from leaf to root, left to right.	us.acme.com

These are examples of valid global database names:

DB_NAME	DB_DOMAIN	Global Database Name
sales	au.oracle.com	sales.au.oracle.com
sales	us.oracle.com	sales.us.oracle.com
mktg	us.oracle.com	mktg.us.oracle.com
payroll	nonprofit.org	payroll.nonprofit.org

The DB_DOMAIN initialization parameter is only important at database creation time when it is used, together with the DB_NAME parameter, to form the database's global name. At this point, the database's global name is stored in the data dictionary. You must change the global name using an ALTER DATABASE statement, *not* by altering the DB_DOMAIN parameter in the initialization parameter file. It is good practice, however, to change the DB_DOMAIN parameter to reflect the change in the domain name before the next database startup.

Determining Whether Global Naming Is Enforced

The name that you give to a link on the local database depends on whether the remote database that you want to access enforces global naming. If the remote database enforces global naming, then you must use the remote database's global database name as the name of the link. For example, if you are connected to the local hq server and want to create a link to the remote mfg database, and mfg enforces global naming, then you must use mfg's global database name as the link name.

You can also use service names as part of the database link name. For example, if you use the service names sn1 and sn2 to connect to database hq.acme.com, and hq enforces global naming, then you can create the following link names to hq:

```
HQ.ACME.COM@SN1
HQ.ACME.COM@SN2
```

> **See Also:** "Using Connection Qualifiers to Specify Service Names Within Link Names" on page 29-13 for more information about using services names in link names

To determine whether global naming on a database is enforced on a database, either examine the database's initialization parameter file or query the V$PARAMETER view. For example, to see whether global naming is enforced on mfg, you could start a session on mfg and then create and execute the following globalnames.sql script (sample output included):

```
COL NAME FORMAT A12
COL VALUE FORMAT A6
SELECT NAME, VALUE FROM V$PARAMETER
WHERE NAME = 'global_names'
/

SQL> @globalnames
```

```
NAME         VALUE
------------ ------
global_names FALSE
```

Viewing a Global Database Name

Use the data dictionary view GLOBAL_NAME to view the database's global name. For example, issue the following:

```
SELECT * FROM GLOBAL_NAME;

GLOBAL_NAME
--------------------------------------------------------------------------------
SALES.AU.ORACLE.COM
```

Changing the Domain in a Global Database Name

Use the ALTER DATABASE statement to change the domain in a database's global name. Note that after the database is created, changing the initialization parameter DB_DOMAIN has no effect on the global database name or on the resolution of database link names.

The following example shows the syntax for the renaming statement, where *database* is a database name and *domain* is the network domain:

```
ALTER DATABASE RENAME GLOBAL_NAME TO database.domain;
```

Use the following procedure to change the domain in a global database name:

1. Determine the current global database name. For example, issue:

   ```
   SELECT * FROM GLOBAL_NAME;

   GLOBAL_NAME
   --------------------------------------------------------------------------------
   SALES.AU.ORACLE.COM
   ```

2. Rename the global database name using an ALTER DATABASE statement. For example, enter:

   ```
   ALTER DATABASE RENAME GLOBAL_NAME TO sales.us.oracle.com;
   ```

3. Query the GLOBAL_NAME table to check the new name. For example, enter:

   ```
   SELECT * FROM GLOBAL_NAME;
   ```

```
GLOBAL_NAME
--------------------------------------------------------------------------------
SALES.US.ORACLE.COM
```

Changing a Global Database Name: Scenario

In this scenario, you change the domain part of the global database name of the local database. You also create database links using partially-specified global names to test how Oracle resolves the names. You discover that Oracle resolves the partial names using the domain part of the current global database name of the local database, not the value for the initialization parameter DB_DOMAIN.

1. You connect to SALES.US.ACME.COM and query the GLOBAL_NAME data dictionary view to determine the database's current global name:

```
CONNECT SYSTEM/password@sales.us.acme.com
SELECT * FROM GLOBAL_NAME;

GLOBAL_NAME
--------------------------------------------------------------------------------
SALES.US.ACME.COM
```

2. You query the V$PARAMETER view to determine the current setting for the DB_DOMAIN initialization parameter:

```
SELECT NAME, VALUE FROM V$PARAMETER WHERE NAME = 'db_domain';

NAME       VALUE
---------  -----------
db_domain  US.ACME.COM
```

3. You then create a database link to a database called hq, using only a partially-specified global name:

```
CREATE DATABASE LINK hq USING 'sales';
```

   Oracle expands the global database name for this link by appending the domain part of the global database name of the *local* database to the name of the database specified in the link.

4. You query USER_DB_LINKS to determine which domain name Oracle uses to resolve the partially specified global database name:

```
SELECT DB_LINK FROM USER_DB_LINKS;
DB_LINK
------------------
```

```
HQ.US.ACME.COM
```

This result indicates that the domain part of the global database name of the local database is `us.acme.com`. Oracle uses this domain in resolving partial database link names when the database link is created.

5. Because you have received word that the `sales` database will move to Japan, you rename the `sales` database to `sales.jp.acme.com`:

```
ALTER DATABASE RENAME GLOBAL_NAME TO sales.jp.acme.com;
SELECT * FROM GLOBAL_NAME;

GLOBAL_NAME
--------------------------------------------------------------------------------
SALES.JP.ACME.COM
```

6. You query `V$PARAMETER` again and discover that the value of `DB_DOMAIN` is *not* changed, although you renamed the domain part of the global database name:

```
SELECT NAME, VALUE FROM V$PARAMETER
  WHERE NAME = 'db_domain';

NAME       VALUE
---------  -----------
db_domain  US.ACME.COM
```

This result indicates that the value of the `DB_DOMAIN` initialization parameter is independent of the `ALTER DATABASE RENAME GLOBAL_NAME` statement. The `ALTER DATABASE` statement determines the domain of the global database name, not the `DB_DOMAIN` initialization parameter (although it is good practice to alter `DB_DOMAIN` to reflect the new domain name).

7. You create another database link to database `supply`, and then query `USER_DB_LINKS` to see how Oracle resolves the domain part of `supply`'s global database name:

```
CREATE DATABASE LINK supply USING 'supply';
SELECT DB_LINK FROM USER_DB_LINKS;

DB_LINK
------------------
HQ.US.ACME.COM
SUPPLY.JP.ACME.COM
```

This result indicates that Oracle resolves the partially specified link name by using the domain `jp.acme.com`. This domain is used when the link is created because it is the domain part of the global database name of the local database. Oracle does *not* use the `DB_DOMAIN` initialization parameter setting when resolving the partial link name.

8. You then receive word that your previous information was faulty: `sales` will be in the `ASIA.JP.ACME.COM` domain, not the `JP.ACME.COM` domain. Consequently, you rename the global database name as follows:

```
ALTER DATABASE RENAME GLOBAL_NAME TO sales.asia.jp.acme.com;
SELECT * FROM GLOBAL_NAME;

GLOBAL_NAME
--------------------------------------------------------------------------------
SALES.ASIA.JP.ACME.COM
```

9. You query `V$PARAMETER` to again check the setting for the parameter `DB_DOMAIN`:

```
SELECT NAME, VALUE FROM V$PARAMETER
  WHERE NAME = 'db_domain';

NAME        VALUE
----------  -----------
db_domain   US.ACME.COM
```

The result indicates that the domain setting in the parameter file is exactly the same as it was before you issued *either* of the `ALTER DATABASE RENAME` statements.

10. Finally, you create a link to the `warehouse` database and again query `USER_DB_LINKS` to determine how Oracle resolves the partially-specified global name:

```
CREATE DATABASE LINK warehouse USING 'warehouse';
SELECT DB_LINK FROM USER_DB_LINKS;

DB_LINK
------------------
HQ.US.ACME.COM
SUPPLY.JP.ACME.COM
WAREHOUSE.ASIA.JP.ACME.COM
```

Again, you see that Oracle uses the domain part of the global database name of the local database to expand the partial link name during link creation.

Note: In order to correct the `supply` database link, it must be dropped and recreated.

See Also: *Oracle9i Database Reference* for more information about specifying the `DB_NAME` and `DB_DOMAIN` initialization parameters

Creating Database Links

To support application access to the data and schema objects throughout a distributed database system, you must create all necessary database links. This section contains the following topics:

- Obtaining Privileges Necessary for Creating Database Links
- Specifying Link Types
- Specifying Link Users
- Using Connection Qualifiers to Specify Service Names Within Link Names

Obtaining Privileges Necessary for Creating Database Links

A database link is a pointer in the local database that allows you to access objects on a remote database. To create a private database link, you must have been granted the proper privileges. The following table illustrates which privileges are required on which database for which type of link:

Privilege	Database	Required For
`CREATE DATABASE LINK`	Local	Creation of a private database link.
`CREATE PUBLIC DATABASE LINK`	Local	Creation of a public database link.
`CREATE SESSION`	Remote	Creation of any type of database link.

To see which privileges you currently have available, query `ROLE_SYS_PRIVS`. For example, you could create and execute the following `privs.sql` script (sample output included):

```
SELECT DISTINCT PRIVILEGE AS "Database Link Privileges"
```

```
FROM ROLE_SYS_PRIVS
WHERE PRIVILEGE IN ( 'CREATE SESSION','CREATE DATABASE LINK',
                     'CREATE PUBLIC DATABASE LINK')
/

SQL> @privs

Database Link Privileges
----------------------------------------
CREATE DATABASE LINK
CREATE PUBLIC DATABASE LINK
CREATE SESSION
```

Specifying Link Types

When you create a database link, you must decide who will have access to it. The following sections describe how to create the three basic types of links:

- Creating Private Database Links
- Creating Public Database Links
- Creating Global Database Links

Creating Private Database Links

To create a private database link, specify the following (where *link_name* is the global database name or an arbitrary link name):

```
CREATE DATABASE LINK link_name ...;
```

Following are examples of private database links:

This SQL Statement...	Creates...
`CREATE DATABASE LINK supply.us.acme.com;`	A private link using the global database name to the remote `supply` database. The link uses the userid / password of the connected user. So if `scott` (identified by `tiger`) uses the link in a query, the link establishes a connection to the remote database as `scott/tiger`.
`CREATE DATABASE LINK link_2 CONNECT TO jane IDENTIFIED BY doe USING 'us_supply';`	A private fixed user link called `link_2` to the database with service name `us_supply`. The link connects to the remote database with the userid / password of `jane/doe` regardless of the connected user.

This SQL Statement...	Creates...
`CREATE DATABASE LINK link_1 CONNECT TO CURRENT_USER USING 'us_supply';`	A private link called `link_1` to the database with service name `us_supply`. The link uses the userid / password of the current user to log onto the remote database. **Note:** The current user may not be the same as the connected user, and must be a global user on both databases involved in the link (see "Users of Database Links" on page 28-16). Current user links are part of the Oracle Advanced Security option.

See Also: *Oracle9i SQL Reference* for `CREATE DATABASE LINK` syntax

Creating Public Database Links

To create a public database link, use the keyword `PUBLIC` (where *link_name* is the global database name or an arbitrary link name):

```
CREATE PUBLIC DATABASE LINK link_name ...;
```

Following are examples of public database links:

This SQL Statement...	Creates...
`CREATE PUBLIC DATABASE LINK supply.us.acme.com;`	A public link to the remote `supply` database. The link uses the userid / password of the connected user. So if `scott` (identified by `tiger`) uses the link in a query, the link establishes a connection to the remote database as `scott/tiger`.
`CREATE PUBLIC DATABASE LINK pu_link CONNECT TO CURRENT_USER USING 'supply';`	A public link called `pu_link` to the database with service name `supply`. The link uses the userid / password of the current user to log onto the remote database. **Note:** The current user may not be the same as the connected user, and must be a global user on both databases involved in the link (see "Users of Database Links" on page 28-16).
`CREATE PUBLIC DATABASE LINK sales.us.acme.com CONNECT TO jane IDENTIFIED BY doe;`	A public fixed user link to the remote `sales` database. The link connects to the remote database with the userid / password of `jane/doe`.

See Also: *Oracle9i SQL Reference* for `CREATE PUBLIC DATABASE LINK` syntax

Creating Global Database Links

You must define **global database links** in the Oracle Names Server. See the *Oracle Net Services Administrator's Guide* to learn how to create global database links.

Specifying Link Users

A database link defines a communication path from one database to another. When an application uses a database link to access a remote database, Oracle establishes a database session in the remote database on behalf of the local application request.

When you create a private or public database link, you can determine which schema on the remote database the link will establish connections to by creating fixed user, current user, and connected user database links.

Creating Fixed User Database Links

To create a **fixed user database link**, you embed the credentials (in this case, a username and password) required to access the remote database in the definition of the link:

```
CREATE DATABASE LINK ... CONNECT TO username IDENTIFIED BY password ...;
```

Following are examples of fixed user database links:

This SQL Statement...	Creates...
`CREATE PUBLIC DATABASE LINK supply.us.acme.com CONNECT TO scott AS tiger;`	A public link using the global database name to the remote `supply` database. The link connects to the remote database with the userid / password `scott/tiger`.
`CREATE DATABASE LINK foo CONNECT TO jane IDENTIFIED BY doe USING 'finance';`	A private fixed user link called `foo` to the database with service name `finance`. The link connects to the remote database with the userid / password `jane/doe`.

When an application uses a fixed user database link, the local server always establishes a connection to a fixed remote schema in the remote database. The local server also sends the fixed user's credentials across the network when an application uses the link to access the remote database.

Creating Connected User and Current User Database Links

Connected user and current user database links do not include credentials in the definition of the link. The credentials used to connect to the remote database can change depending on the user that references the database link and the operation performed by the application.

> **Note:** For many distributed applications, you do not want a user to have privileges in a remote database. One simple way to achieve this result is to create a procedure that contains a fixed user or current user database link within it. In this way, the user accessing the procedure temporarily assumes someone else's privileges.

For an extended conceptual discussion of the distinction between connected users and current users, see "Users of Database Links" on page 28-16.

Creating a Connected User Database Link To create a connected user database link, omit the `CONNECT TO` clause. The following syntax creates a connected user database link, where *dblink* is the name of the link and *net_service_name* is an optional connect string:

```
CREATE [SHARED] [PUBLIC] DATABASE LINK dblink ... [USING 'net_service_name'];
```

For example, to create a connected user database link, use the following syntax:

```
CREATE DATABASE LINK sales.division3.acme.com USING 'sales';
```

Creating a Current User Database Link To create a current user database link, use the `CONNECT TO CURRENT_USER` clause in the link creation statement. Current user links are only available through the Oracle Advanced Security option.

The following syntax creates a current user database link, where *dblink* is the name of the link and *net_service_name* is an optional connect string:

```
CREATE [SHARED] [PUBLIC] DATABASE LINK dblink CONNECT TO CURRENT_USER
[USING 'net_service_name'];
```

For example, to create a connected user database link to the `sales` database, you might use the following syntax:

```
CREATE DATABASE LINK sales CONNECT TO CURRENT_USER USING 'sales';
```

> **Note:** To use a current user database link, the current user must be a global user on both databases involved in the link.

See Also: *Oracle9i SQL Reference* for more syntax information about creating database links

Using Connection Qualifiers to Specify Service Names Within Link Names

In some situations, you may want to have several database links of the same type (for example, public) that point to the same remote database, yet establish connections to the remote database using different communication pathways. Some cases in which this strategy is useful are:

- A remote database is part of an Oracle Real Application Clusters configuration, so you define several public database links at your local node so that connections can be established to specific instances of the remote database.
- Some clients connect to the Oracle server using TCP/IP while others use DECNET.

To facilitate such functionality, Oracle allows you to create a database link with an optional service name in the database link name. When creating a database link, a service name is specified as the trailing portion of the database link name, separated by an @ sign, as in `@sales`. This string is called a **connection qualifier**.

For example, assume that remote database `hq.acme.com` is managed in a Oracle Real Application Clusters environment. The `hq` database has two instances named `hq_1` and `hq_2`. The local database can contain the following public database links to define pathways to the remote instances of the `hq` database:

```
CREATE PUBLIC DATABASE LINK hq.acme.com@hq_1
  USING 'string_to_hq_1';
CREATE PUBLIC DATABASE LINK hq.acme.com@hq_2
  USING 'string_to_hq_2';
CREATE PUBLIC DATABASE LINK hq.acme.com
  USING 'string_to_hq';
```

Notice in the first two examples that a service name is simply a part of the database link name. The text of the service name does not necessarily indicate how a connection is to be established; this information is specified in the service name of the `USING` clause. Also notice that in the third example, a service name is not specified as part of the link name. In this case, just as when a service name is specified as part of the link name, the instance is determined by the `USING` string.

To use a service name to specify a particular instance, include the service name at the end of the global object name:

```
SELECT * FROM scott.emp@hq.acme.com@hq_1
```

Note that in this example, there are two @ symbols.

Creating Shared Database Links

Every application that references a remote server using a standard database link establishes a connection between the local database and the remote database. Many users running applications simultaneously can cause a high number of connections between the local and remote databases.

Shared database links enable you to limit the number of network connections required between the local server and the remote server.

This section contains the following topics:

- Determining Whether to Use Shared Database Links
- Creating Shared Database Links
- Configuring Shared Database Links

See Also: "What Are Shared Database Links?" on page 28-10 for a conceptual overview of shared database links

Determining Whether to Use Shared Database Links

Look carefully at your application and shared server configuration to determine whether to use shared links. A simple guideline is to use shared database links when the number of users accessing a database link is expected to be much larger than the number of server processes in the local database.

The following table illustrates three possible configurations involving database links:

Link Type	Server Mode	Consequences
Non-Shared	Dedicated / shared server	If your application uses a standard public database link, and 100 users simultaneously require a connection, then 100 direct network connections to the remote database are required.
Shared	shared server	If 10 shared server processes exist in the local shared server mode database, then 100 users that use the same database link require 10 or fewer network connections to the remote server. Each local shared server process may only need one connection to the remote server.

Link Type	Server Mode	Consequences
Shared	Dedicated	If 10 clients connect to a local dedicated server, and each client has 10 sessions on the same connection (thus establishing 100 sessions overall), and each session references the same remote database, then only 10 connections are needed. With a non-shared database link, 100 connections are needed.

Shared database links are not useful in all situations. Assume that only one user accesses the remote server. If this user defines a shared database link and 10 shared server processes exist in the local database, then this user can require up to 10 network connections to the remote server. Because the user can use each shared server process, each process can establish a connection to the remote server.

Clearly, a non-shared database link is preferable in this situation because it requires only one network connection. Shared database links lead to more network connections in single-user scenarios, so use shared links only when many users need to use the same link. Typically, shared links are used for public database links, but can also be used for private database links when many clients access the same local schema (and therefore the same private database link).

Creating Shared Database Links

To create a shared database link, use the keyword SHARED in the CREATE DATABASE LINK statement:

```
CREATE SHARED DATABASE LINK dblink_name
[CONNECT TO username IDENTIFIED BY password]|[CONNECT TO CURRENT_USER]
AUTHENTICATED BY schema_name IDENTIFIED BY password
[USING 'service_name'];
```

The following example creates a fixed user, shared link to database sales, connecting as scott and authenticated as keith:

```
CREATE SHARED DATABASE LINK link2sales
CONNECT TO scott IDENTIFIED BY tiger
AUTHENTICATED BY keith IDENTIFIED BY richards
USING 'sales';
```

Whenever you use the keyword SHARED, the clause AUTHENTICATED BY is required. The schema specified in the AUTHENTICATED BY clause is only used for security reasons and can be considered a dummy schema. It is not affected when using shared database links, nor does it affect the users of the shared database link.

The AUTHENTICATED BY clause is required to prevent unauthorized clients from masquerading as a database link user and gaining access to privileged information.

> **See Also:** *Oracle9i SQL Reference* for information about the CREATE DATABASE LINK statement

Configuring Shared Database Links

You can configure shared database links in the following ways:

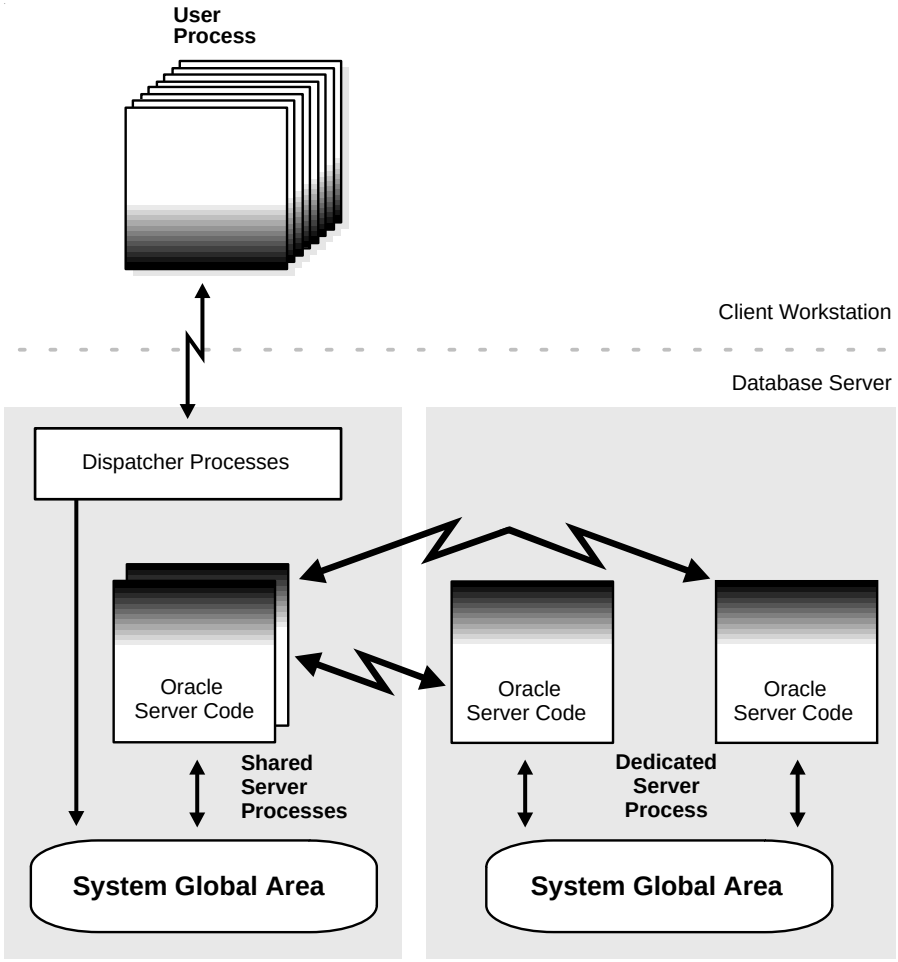
- Creating Shared Links to Dedicated Servers
- Creating Shared Links to Shared Servers

Creating Shared Links to Dedicated Servers

In the configuration illustrated in Figure 29–1, a shared server process in the local server owns a dedicated remote server process. The advantage is that a direct network transport exists between the local shared server and the remote dedicated server. A disadvantage is that extra back-end server processes are needed.

Note: The remote server can either be a shared server or dedicated server. There is a dedicated connection between the local and remote servers. When the remote server is a shared server, you can force a dedicated server connection by using the (SERVER=DEDICATED) clause in the definition of the service name.

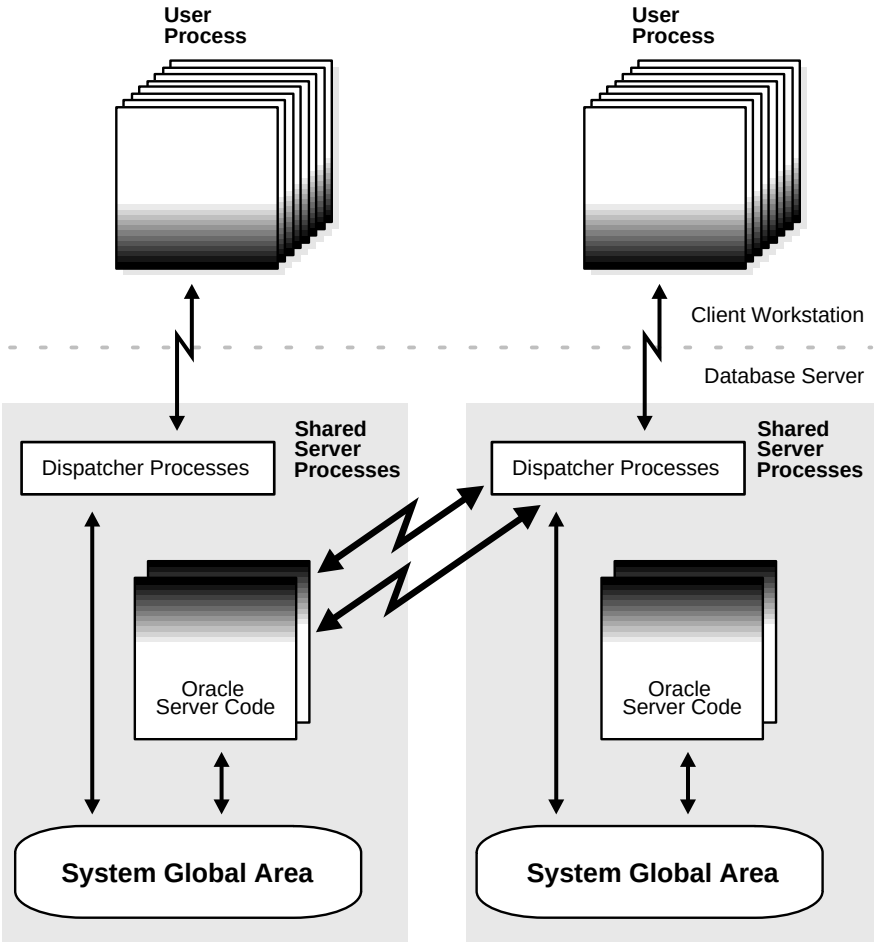
Figure 29–1 A Shared Database Link to Dedicated Server Processes



Creating Shared Links to Shared Servers

The configuration illustrated in Figure 29–2 uses shared server processes on the remote server. This configuration eliminates the need for more dedicated servers, but requires the connection to go through the dispatcher on the remote server. Note that both the local and the remote server must be configured as shared servers.

Figure 29–2 Shared Database Link to Shared Server



See Also: *Oracle Net Services Administrator's Guide* for information about the shared server option

Managing Database Links

This section contains the following topics:

- Closing Database Links
- Dropping Database Links

- Limiting the Number of Active Database Link Connections

Closing Database Links

If you access a database link in a session, then the link remains open until you close the session. A link is open in the sense that a process is active on each of the remote databases accessed through the link. This situation has the following consequences:

- If 20 users open sessions and access the same public link in a local database, then 20 database link connections are open.
- If 20 users open sessions and each user accesses a private link, then 20 database link connections are open.
- If one user starts a session and accesses 20 different links, then 20 database link connections are open.

After you close a session, the links that were active in the session are automatically closed. You may have occasion to close the link manually. For example, close links when:

- The network connection established by a link is used infrequently in an application.
- The user session must be terminated.

If you want to close a link, issue the following statement, where *linkname* refers to the name of the link:

```
ALTER SESSION CLOSE DATABASE LINK linkname;
```

Note that this statement only closes the links that are active in your current session.

Dropping Database Links

You can drop a database link just as you can drop a table or view. If the link is private, then it must be in your schema. If the link is public, then you must have the `DROP PUBLIC DATABASE LINK` system privilege.

The statement syntax is as follows, where *dblink* is the name of the link:

```
DROP [PUBLIC] DATABASE LINK dblink;
```

Procedure for Dropping a Private Database Link

1. Connect to the local database using SQL*Plus. For example, enter:

```
CONNECT scott/tiger@local_db
```

2. Query USER_DB_LINKS to view the links that you own. For example, enter:

```
SELECT DB_LINK FROM USER_DB_LINKS;

DB_LINK
----------------------------------
SALES.US.ORACLE.COM
MKTG.US.ORACLE.COM
2 rows selected.
```

3. Drop the desired link using the DROP DATABASE LINK statement. For example, enter:

```
DROP DATABASE LINK sales.us.oracle.com;
```

Procedure for Dropping a Public Database Link

1. Connect to the local database as a user with the DROP PUBLIC DATABASE LINK privilege. For example, enter:

```
CONNECT SYSTEM/password@local_db AS SYSDBA
```

2. Query DBA_DB_LINKS to view the public links. For example, enter:

```
SELECT DB_LINK FROM USER_DB_LINKS
  WHERE OWNER = 'PUBLIC';

DB_LINK
----------------------------------
DBL1.US.ORACLE.COM
SALES.US.ORACLE.COM
INST2.US.ORACLE.COM
RMAN2.US.ORACLE.COM
4 rows selected.
```

3. Drop the desired link using the DROP PUBLIC DATABASE LINK statement. For example, enter:

```
DROP PUBLIC DATABASE LINK sales.us.oracle.com;
```

Limiting the Number of Active Database Link Connections

You can limit the number of connections from a user process to remote databases using the static initialization parameter OPEN_LINKS. This parameter controls the

number of remote connections that a single user session can use concurrently in distributed transactions.

Note the following considerations for setting this parameter:

- The value should be greater than or equal to the number of databases referred to in a single SQL statement that references multiple databases.
- Increase the value if several distributed databases are accessed over time. Thus, if you regularly access three database, set OPEN_LINKS to 3 or greater.
- The default value for OPEN_LINKS is 4. If OPEN_LINKS is set to 0, then no distributed transactions are allowed.

> **See Also:** *Oracle9i Database Reference* for more information about OPEN_LINKS

Viewing Information About Database Links

The data dictionary of each database stores the definitions of all the database links in the database. You can use data dictionary tables and views to gain information about the links. This section contains the following topics:

- Determining Which Links Are in the Database
- Determining Which Link Connections Are Open

Determining Which Links Are in the Database

The following views show the database links that have been defined at the local database and stored in the data dictionary:

View	Purpose
DBA_DB_LINKS	Lists all database links in the database.
ALL_DB_LINKS	Lists all database links accessible to the connected user.
USER_DB_LINKS	Lists all database links owned by the connected user.

These data dictionary views contain the same basic information about database links, with some exceptions:

Column	Which Views?	Description
OWNER	All except USER_*	The user who created the database link. If the link is public, then the user is listed as PUBLIC.

Column	Which Views?	Description
DB_LINK	All	The name of the database link.
USERNAME	All	If the link definition includes a fixed user, then this column displays the username of the fixed user. If there is no fixed user, the column is NULL.
PASSWORD	Only USER_*	The password for logging into the remote database.
HOST	All	The net service name used to connect to the remote database.
CREATED	All	Creation time of the database link.

Any user can query USER_DB_LINKS to determine which database links are available to that user. Only those with additional privileges can use the ALL_DB_LINKS or DBA_DB_LINKS view.

The following script queries the DBA_DB_LINKS view to access link information:

```
COL OWNER FORMAT a10
COL USERNAME FORMAT A8 HEADING "USER"
COL DB_LINK FORMAT A30
COL HOST FORMAT A7 HEADING "SERVICE"
SELECT * FROM DBA_DB_LINKS
/
```

Here, the script is invoked and the resulting output is shown:

```
SQL>@link_script

OWNER      DB_LINK                        USER     SERVICE CREATED
---------- ------------------------------ -------- ------- ----------
SYS        TARGET.US.ACME.COM             SYS      inst1   23-JUN-99
PUBLIC     DBL1.UK.ACME.COM               BLAKE    ora51   23-JUN-99
PUBLIC     RMAN2.US.ACME.COM                       inst2   23-JUN-99
PUBLIC     DEPT.US.ACME.COM                        inst2   23-JUN-99
JANE       DBL.UK.ACME.COM                BLAKE    ora51   23-JUN-99
SCOTT      EMP.US.ACME.COM                SCOTT    inst2   23-JUN-99
6 rows selected.
```

Authorization for Viewing Password Information

Only USER_DB_LINKS contains a column for password information. However, if you are an administrative user (SYS or users who connect AS SYSDBA), then you can view passwords for all links in the database by querying the LINK$ table. If you

are not an administrative user, you can be authorized to query the LINK$ table by one of the following methods:

- Being granted specific object privilege for the LINK$ table
- Being granted the SELECT ANY DICTIONARY system privilege

> **See Also:** "Identifying User Privileges" on page 25-2 for more information about privileges necessary to view objects in the SYS schema

Viewing Password Information

You can create and run the following script in SQL*Plus to obtain password information (sample output included):

```
COL USERID FORMAT A10
COL PASSWORD FORMAT A10
SELECT USERID,PASSWORD
  FROM SYS.LINK$
  WHERE PASSWORD IS NOT NULL
/

SQL>@linkpwd

USERID     PASSWORD
---------- ----------
SYS        ORACLE
BLAKE      TYGER
SCOTT      TIGER
3 rows selected.
```

Viewing Authentication Passwords

It is possible to view AUTHENTICATED BY ... IDENTIFIED BY ... usernames and passwords for all links in the database by querying the LINK$ table. You can create and run the following script in SQL*Plus to obtain password information (sample output included):

```
COL AUTHUSR FORMAT A10
COL AUTHPWD FORMAT A10
SELECT AUTHUSR AS userid, AUTHPWD AS password
  FROM SYS.LINK$
  WHERE PASSWORD IS NOT NULL
/
```

```
SQL> @authpwd

USERID     PASSWORD
---------- ----------
ELLIE      MAY
1 row selected.
```

You can also view the link and password information together in a join by creating and executing the following script (sample output included):

```
COL OWNER FORMAT A8
COL DB_LINK FORMAT A15
COL USERNAME FORMAT A8 HEADING "CON_USER"
COL PASSWORD FORMAT A8 HEADING "CON_PWD"
COL AUTHUSR FORMAT A8 HEADING "AUTH_USER"
COL AUTHPWD FORMAT A8 HEADING "AUTH_PWD"
COL HOST FORMAT A7 HEADING "SERVICE"
COL CREATED FORMAT A10

SELECT DISTINCT d.OWNER,d.DB_LINK,d.USERNAME,l.PASSWORD,
               l.AUTHUSR,l.AUTHPWD,d.HOST,d.CREATED
FROM DBA_DB_LINKS d, SYS.LINK$ l
WHERE PASSWORD IS NOT NULL
AND d.USERNAME = l.USERID
/

SQL> @user_and_pwd

OWNER    DB_LINK         CON_USER CON_PWD  AUTH_USE AUTH_PWD SERVICE CREATED
-------- --------------- -------- -------- -------- -------- ------- ----------
JANE     DBL.ACME.COM    BLAKE    TYGER    ELLIE    MAY      ora51   23-JUN-99
PUBLIC   DBL1.ACME.COM   SCOTT    TIGER                      ora51   23-JUN-99
SYS      TARGET.ACME.COM SYS      ORACLE                     inst1   23-JUN-99
```

Determining Which Link Connections Are Open

You may find it useful to determine which database link connections are currently open in your session. Note that if you connect as SYSDBA, you cannot query a view to determine all the links open for all sessions; you can only access the link information in the session within which you are working.

The following views show the database link connections that are currently open in your current session:

View	Purpose
V$DBLINK	Lists all open database links in your session, that is, all database links with the IN_TRANSACTION column set to YES.
GV$DBLINK	Lists all open database links in your session along with their corresponding instances. This view is useful in an Oracle Real Application Clusters configuration.

These data dictionary views contain the same basic information about database links, with one exception:

Column	Which Views?	Description
DB_LINK	All	The name of the database link.
OWNER_ID	All	The owner of the database link.
LOGGED_ON	All	Whether the database link is currently logged on.
HETEROGENEOUS	All	Whether the database link is homogeneous (NO) or heterogeneous (YES).
PROTOCOL	All	The communication protocol for the database link.
OPEN_CURSORS	All	Whether cursors are open for the database link.
IN_TRANSACTION	All	Whether the database link is accessed in a transaction that has not yet been committed or rolled back.
UPDATE_SENT	All	Whether there was an update on the database link.
COMMIT_POINT_ STRENGTH	All	The commit point strength of the transactions using the database link.
INST_ID	GV$DBLINK only	The instance from which the view information was obtained.

For example, you can create and execute the script below to determine which links are open (sample output included):

```
COL DB_LINK FORMAT A25
COL OWNER_ID FORMAT 99999 HEADING "OWNID"
COL LOGGED_ON FORMAT A5 HEADING "LOGON"
COL HETEROGENEOUS FORMAT A5 HEADING "HETER"
COL PROTOCOL FORMAT A8
COL OPEN_CURSORS FORMAT 999 HEADING "OPN_CUR"
```

```
COL IN_TRANSACTION FORMAT A3 HEADING "TXN"
COL UPDATE_SENT FORMAT A6 HEADING "UPDATE"
COL COMMIT_POINT_STRENGTH FORMAT 99999 HEADING "C_P_S"

SELECT * FROM V$DBLINK
/

SQL> @dblink

DB_LINK                   OWNID LOGON HETER PROTOCOL OPN_CUR TXN UPDATE  C_P_S
------------------------- ------ ----- ----- -------- ------- --- ------ ------
INST2.ACME.COM                 0 YES   YES    UNKN           0 YES YES       255
```

Creating Location Transparency

After you have configured the necessary database links, you can use various tools to hide the distributed nature of the database system from users. In other words, users can access remote objects as if they were local objects. The following sections explain how to hide distributed functionality from users:

- Using Views to Create Location Transparency
- Using Synonyms to Create Location Transparency
- Using Procedures to Create Location Transparency

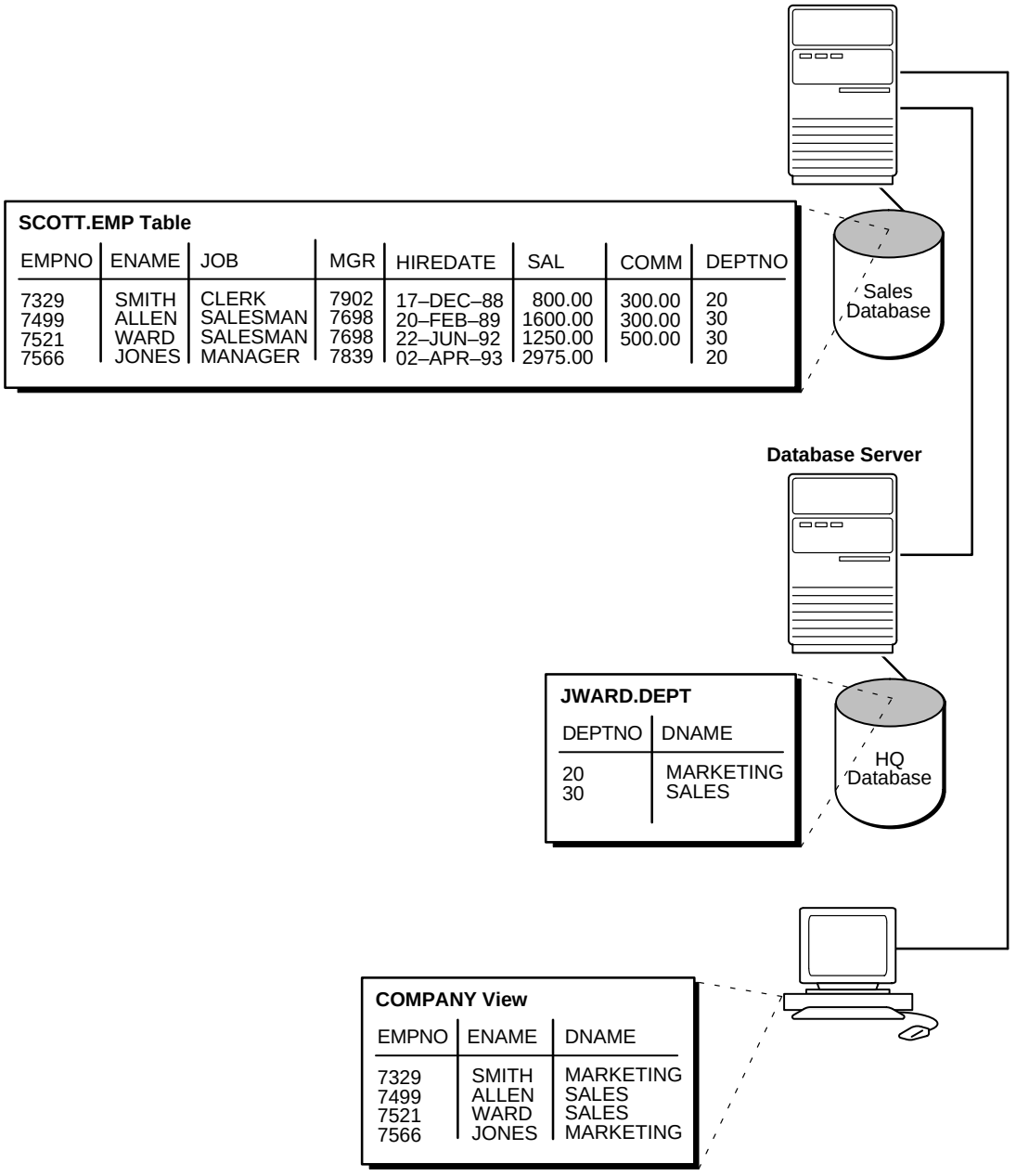
Using Views to Create Location Transparency

Local views can provide location transparency for local and remote tables in a distributed database system.

For example, assume that table `emp` is stored in a local database and table `dept` is stored in a remote database. To make these tables transparent to users of the system, you can create a view in the local database that joins local and remote data:

```
CREATE VIEW company
AS
SELECT a.empno, a.ename, b.dname
FROM scott.emp a, jward.dept@hq.acme.com b
WHERE a.deptno = b.deptno;
```

Figure 29–3 Views and Location Transparency



When users access this view, they do not need to know where the data is physically stored, or if data from more than one table is being accessed. Thus, it is easier for them to get required information. For example, the following query provides data from both the local and remote database table:

```
SELECT * FROM company;
```

The owner of the local view can grant only those object privileges on the local view that have been granted by the remote user. (The remote user is implied by the type of database link). This is similar to privilege management for views that reference local data.

Using Synonyms to Create Location Transparency

Synonyms are useful in both distributed and nondistributed environments because they hide the identity of the underlying object, including its location in a distributed database system. If you must rename or move the underlying object, you only need to redefine the synonym; applications based on the synonym continue to function normally. Synonyms also simplify SQL statements for users in a distributed database system.

Creating Synonyms

You can create synonyms for the following:

- Tables
- Types
- Views
- Materialized views
- Sequences
- Procedures
- Functions
- Packages

All synonyms are schema objects that are stored in the data dictionary of the database in which they are created. To simplify remote table access through database links, a synonym can allow single-word access to remote data, hiding the specific object name and the location from users of the synonym.

The syntax to create a synonym is:

```
CREATE [PUBLIC] synonym_name
FOR [schema.]object_name[@database_link_name]
```

where:

PUBLIC	is a keyword specifying that this synonym is available to all users. Omitting this parameter makes a synonym private, and usable only by the creator. Public synonyms can be created only by a user with CREATE PUBLIC SYNONYM system privilege.
synonym_name	specifies the alternate object name to be referenced by users and applications.
schema	specifies the schema of the object specified in *object_name*. Omitting this parameter uses the creator's schema as the schema of the object.
object_name	specifies either a table, view, sequence, materialized view, type, procedure, function or package as appropriate.
database_link_name	specifies the database link identifying the remote database and schema in which the object specified in *object_name* is located.

A synonym must be a uniquely named object for its schema. If a schema contains a schema object and a public synonym exists with the same name, then Oracle always finds the schema object when the user that owns the schema references that name.

Example: Creating a Public Synonym

Assume that in every database in a distributed database system, a public synonym is defined for the scott.emp table stored in the hq database:

```
CREATE PUBLIC SYNONYM emp FOR scott.emp@hq.acme.com;
```

You can design an employee management application without regard to where the application is used because the location of the table scott.emp@hq.acme.com is hidden by the public synonyms. SQL statements in the application access the table by referencing the public synonym emp.

Furthermore, if you move the emp table from the hq database to the hr database, then you only need to change the public synonyms on the nodes of the system. The employee management application continues to function properly on all nodes.

Managing Privileges and Synonyms

A synonym is a reference to an actual object. A user who has access to a synonym for a particular schema object must also have privileges on the underlying schema object itself. For example, if the user attempts to access a synonym but does not have privileges on the table it identifies, an error occurs indicating that the table or view does not exist.

Assume `scott` creates local synonym `emp` as an alias for remote object `scott.emp@sales.acme.com`. `scott` *cannot* grant object privileges on the synonym to another local user. `scott` cannot grant local privileges for the synonym because this operation amounts to granting privileges for the remote `emp` table on the `sales` database, which is not allowed. This behavior is different from privilege management for synonyms that are aliases for local tables or views.

Therefore, you cannot manage local privileges when synonyms are used for location transparency. Security for the base object is controlled entirely at the remote node. For example, user `admin` cannot grant object privileges for the `EMP_SYN` synonym.

Unlike a database link referenced in a view or procedure definition, a database link referenced in a synonym is resolved by first looking for a private link owned by the schema in effect at the time the reference to the synonym is parsed. Therefore, to ensure the desired object resolution, it is especially important to specify the underlying object's schema in the definition of a synonym.

Using Procedures to Create Location Transparency

PL/SQL program units called **procedures** can provide location transparency. You have these options:

- Using Local Procedures to Reference Remote Data
- Using Local Procedures to Call Remote Procedures
- Using Local Synonyms to Reference Remote Procedures

Using Local Procedures to Reference Remote Data

Procedures or functions (either standalone or in packages) can contain SQL statements that reference remote data. For example, consider the procedure created by the following statement:

```
CREATE PROCEDURE fire_emp (enum NUMBER) AS
BEGIN
  DELETE FROM emp@hq.acme.com
```

```
  WHERE empno = enum;
END;
```

When a user or application calls the `fire_emp` procedure, it is not apparent that a remote table is being modified.

A second layer of location transparency is possible when the statements in a procedure indirectly reference remote data using local procedures, views, or synonyms. For example, the following statement defines a local synonym:

```
CREATE SYNONYM emp FOR emp@hq.acme.com;
```

Given this synonym, you can create the `fire_emp` procedure using the following statement:

```
CREATE PROCEDURE fire_emp (enum NUMBER) AS
BEGIN
  DELETE FROM emp WHERE empno = enum;
END;
```

If you rename or move the table `emp@hq`, then you only need to modify the local synonym that references the table. None of the procedures and applications that call the procedure require modification.

Using Local Procedures to Call Remote Procedures

You can use a local procedure to call a remote procedure. The remote procedure can then execute the required DML. For example, assume that `scott` connects to `local_db` and creates the following procedure:

```
CONNECT scott/tiger@local_db

CREATE PROCEDURE fire_emp (enum NUMBER)
AS
BEGIN
  EXECUTE term_emp@hq.acme.com;
END;
```

Now, assume that `scott` connects to the remote database and creates the remote procedure:

```
CONNECT scott/tiger@hq.acme.com

CREATE PROCEDURE term_emp (enum NUMBER)
AS
BEGIN
```

```
  DELETE FROM emp WHERE empno = enum;
END;
```

When a user or application connected to `local_db` calls the `fire_emp` procedure, this procedure in turn calls the remote `term_emp` procedure on `hq.acme.com`.

Using Local Synonyms to Reference Remote Procedures

For example, `scott` connects to the local `sales.acme.com` database and creates the following procedure:

```
CREATE PROCEDURE fire_emp (enum NUMBER) AS
BEGIN
DELETE FROM emp@hq.acme.com
WHERE empno = enum;
END;
```

User `peggy` then connects to the `supply.acme.com` database and creates the following synonym for the procedure that `scott` created on the remote `sales` database:

```
SQL> CONNECT peggy/hill@supply
SQL> CREATE PUBLIC SYNONYM emp FOR scott.fire_emp@sales.acme.com;
```

A local user on `supply` can use this synonym to execute the procedure on `sales`.

Managing Procedures and Privileges

Assume a local procedure includes a statement that references a remote table or view. The owner of the local procedure can grant the `execute` privilege to any user, thereby giving that user the ability to execute the procedure and, indirectly, access remote data.

In general, procedures aid in security. Privileges for objects referenced within a procedure do not need to be explicitly granted to the calling users.

Managing Statement Transparency

Oracle allows the following standard DML statements to reference remote tables:

- `SELECT` (queries)
- `INSERT`
- `UPDATE`

- DELETE
- SELECT ... FOR UPDATE (not always supported in Heterogeneous Systems)
- LOCK TABLE

Queries including joins, aggregates, subqueries, and SELECT ... FOR UPDATE can reference any number of local and remote tables and views. For example, the following query joins information from two remote tables:

```
SELECT e.empno, e.ename, d.dname
  FROM scott.emp@sales.division3.acme.com e, jward.dept@hq.acme.com d
  WHERE e.deptno = d.deptno;
```

UPDATE, INSERT, DELETE, and LOCK TABLE statements can reference both local and remote tables. No programming is necessary to update remote data. For example, the following statement inserts new rows into the remote table emp in the scott.sales schema by selecting rows from the emp table in the jward schema in the local database:

```
INSERT INTO scott.emp@sales.division3.acme.com
  SELECT * FROM jward.emp;
```

Restrictions:

Several restrictions apply to statement transparency.

- Within a single SQL statement, all referenced LONG and LONG RAW columns, sequences, updated tables, and locked tables must be located at the same node.
- Oracle does not allow remote DDL statements (for example, CREATE, ALTER, and DROP) in homogeneous systems except through remote execution of procedures of the DBMS_SQL package, as in this example:

  ```
  DBMS_SQL.PARSE@link_name(crs, 'drop table emp', v7);
  ```

  Note that in Heterogeneous Systems, a pass-through facility allows you to execute DDL.
- The LIST CHAINED ROWS clause of an ANALYZE statement cannot reference remote tables.
- In a distributed database system, Oracle always evaluates environmentally-dependent SQL functions such as SYSDATE, USER, UID, and USERENV with respect to the local server, no matter where the statement (or portion of a statement) executes.

Note: Oracle supports the USERENV function for queries only.

- A number of performance restrictions relate to access of remote objects:
  - Remote views do not have statistical data.
  - Queries on partitioned tables may not be optimized.
  - No more than 20 indexes are considered for a remote table.
  - No more than 20 columns are used for a composite index.

  See Also: *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the DBMS_SQL package

- There is a restriction in Oracle's implementation of distributed read consistency that can cause one node to be in the past with respect to another node. In accordance with read consistency, a query may end up retrieving consistent, but out-of-date data. See "Managing Read Consistency" on page 32-27 to learn how to manage this problem.

Managing a Distributed Database: Scenarios

This section gives examples of various types of statements involving management of database links:

- Creating a Public Fixed User Database Link
- Creating a Public Fixed User Shared Database Link
- Creating a Public Connected User Database Link
- Creating a Public Connected User Shared Database Link
- Creating a Public Current User Database Link

Creating a Public Fixed User Database Link

The following example connects to the local database as jane and creates a public fixed user database link to database sales for scott. The database is accessed through its net service name sldb:

```
CONNECT jane/doe@local

CREATE PUBLIC DATABASE LINK sales.division3.acme.com
```

```
CONNECT TO scott IDENTIFIED BY tiger
USING 'sldb';
```

Consequences:

Any user connected to the local database can use the `sales.division3.acme.com` database link to connect to the remote database. Each user connects to the schema `scott` in the remote database.

To access the table `emp` table in `scott`'s remote schema, a user can issue the following SQL query:

```
SELECT * FROM emp@sales.division3.acme.com;
```

Note that each application or user session creates a separate connection to the common account on the server. The connection to the remote database remains open for the duration of the application or user session.

Creating a Public Fixed User Shared Database Link

The following example connects to the local database as `dana` and creates a public link to the `sales` database (using its net service name `sldb`). The link allows a connection to the remote database as `scott` and authenticates this user as `scott`:

```
CONNECT dana/sculley@local

CREATE SHARED PUBLIC DATABASE LINK sales.division3.acme.com
  CONNECT TO scott IDENTIFIED BY tiger
  AUTHENTICATED BY scott IDENTIFIED BY tiger
  USING 'sldb';
```

Consequences:

Any user connected to the local shared server can use this database link to connect to the remote `sales` database through a shared server process. The user can then query tables in the `scott` schema.

In the above example, each local shared server can establish one connection to the remote server. Whenever a local shared server process needs to access the remote server through the `sales.division3.acme.com` database link, the local shared server process reuses established network connections.

Creating a Public Connected User Database Link

The following example connects to the local database as `larry` and creates a public link to the database with the net service name `sldb`:

```
CONNECT larry/oracle@local

CREATE PUBLIC DATABASE LINK redwood
  USING 'sldb';
```

Consequences:

Any user connected to the local database can use the `redwood` database link. The connected user in the local database who uses the database link determines the remote schema.

If `scott` is the connected user and uses the database link, then the database link connects to the remote schema `scott`. If `fox` is the connected user and uses the database link, then the database link connects to remote schema `fox`.

The following statement fails for local user `fox` in the local database when the remote schema `fox` cannot resolve the `emp` schema object. That is, if the `fox` schema in the `sales.division3.acme.com` does not have `emp` as a table, view, or (public) synonym, an error will be returned.

```
CONNECT fox/mulder@local

SELECT * FROM emp@redwood;
```

Creating a Public Connected User Shared Database Link

The following example connects to the local database as `neil` and creates a shared, public link to the `sales` database (using its net service name `sldb`). The user is authenticated by the userid / password of `crazy/horse`. The following statement creates a public, connected user, shared database link:

```
CONNECT neil/young@local

CREATE SHARED PUBLIC DATABASE LINK sales.division3.acme.com
  AUTHENTICATED BY crazy IDENTIFIED BY horse
  USING 'sldb';
```

Consequences:

Each user connected to the local server can use this shared database link to connect to the remote database and query the tables in the corresponding remote schema.

Each local, shared server process establishes one connection to the remote server. Whenever a local server process needs to access the remote server through the `sales.division3.acme.com` database link, the local process reuses established network connections, even if the connected user is a different user.

If this database link is used frequently, eventually every shared server in the local database will have a remote connection. At this point, no more physical connections are needed to the remote server, even if new users use this shared database link.

Creating a Public Current User Database Link

The following example connects to the local database as the connected user and creates a public link to the `sales` database (using its net service name `sldb`). The following statement creates a public current user database link:

```
CONNECT bart/simpson@local

CREATE PUBLIC DATABASE LINK sales.division3.acme.com
  CONNECT TO CURRENT_USER
  USING 'sldb';
```

Note: To use this link, the current user must be a global user.

Consequences:

Assume `scott` creates local procedure `fire_emp` that deletes a row from the remote `emp` table, and grants execute privilege on `fire_emp` to `ford`.

```
CONNECT scott/tiger@local_db

CREATE PROCEDURE fire_emp (enum NUMBER)
AS
BEGIN
   DELETE FROM emp@sales.division3.acme.com
   WHERE empno=enum;
END;

GRANT EXECUTE ON fire_emp TO ford;
```

Now, assume that `ford` connects to the local database and runs `scott`'s procedure:

```
CONNECT ford/fairlane@local_db

EXECUTE PROCEDURE scott.fire_emp (enum 10345);
```

When ford executes the procedure scott.fire_emp, the procedure runs under scott's privileges. Because a current user database link is used, the connection is established to scott's remote schema—not ford's remote schema. Note that scott must be a global user while ford does not have to be a global user.

Note: If a connected user database link were used instead, the connection would be to ford's remote schema. For more information about invoker's-rights and privileges, see the *PL/SQL User's Guide and Reference*.

You can accomplish the same result by using a fixed user database link to scott's remote schema. With fixed user database links, however, security can be compromised because scott's username and password are available in readable format in the database.

30

Developing Applications for a Distributed Database System

This chapter describes considerations important when developing an application to run in a distributed database system. It contains the following topics:

- Managing the Distribution of an Application's Data
- Controlling Connections Established by Database Links
- Maintaining Referential Integrity in a Distributed System
- Tuning Distributed Queries
- Handling Errors in Remote Procedures

> **See Also:** *Oracle9i Application Developer's Guide - Fundamentals* for more information about application development in an Oracle environment.

Managing the Distribution of an Application's Data

In a distributed database environment, coordinate with the database administrator to determine the best location for the data. Some issues to consider are:

- Number of transactions posted from each location
- Amount of data (portion of table) used by each node
- Performance characteristics and reliability of the network
- Speed of various nodes, capacities of disks
- Importance of a node or link when it is unavailable
- Need for referential integrity among tables

Controlling Connections Established by Database Links

When a global object name is referenced in a SQL statement or remote procedure call, database links establish a connection to a session in the remote database on behalf of the local user. The remote connection and session are only created if the connection has not already been established previously for the local user session.

The connections and sessions established to remote databases persist for the duration of the local user's session, unless the application or user explicitly terminates them. Note that when you issue a `SELECT` statement across a database link, a transaction lock is placed on the rollback segments. To re-release the segment, you must issue a `COMMIT` or `ROLLBACK` statement.

Terminating remote connections established using database links is useful for disconnecting high cost connections that are no longer required by the application. You can terminate a remote connection and session using the `ALTER SESSION` statement with the `CLOSE DATABASE LINK` clause. For example, assume you issue the following transactions:

```
SELECT * FROM emp@sales;
COMMIT;
```

The following statement terminates the session in the remote database pointed to by the `sales` database link:

```
ALTER SESSION CLOSE DATABASE LINK sales;
```

To close a database link connection in your user session, you must have the `ALTER SESSION` system privilege.

Note: Before closing a database link, first close all cursors that use the link and then end your current transaction if it uses the link.

See Also: *Oracle9i SQL Reference* for more information about the `ALTER SESSION` statement.

Maintaining Referential Integrity in a Distributed System

If a part of a distributed statement fails, for example, due to an integrity constraint violation, Oracle returns error number `ORA-02055`. Subsequent statements or procedure calls return error number `ORA-02067` until a rollback or rollback to savepoint is issued.

Design your application to check for any returned error messages that indicate that a portion of the distributed update has failed. If you detect a failure, you should roll back the entire transaction before allowing the application to proceed.

Oracle does not permit declarative referential integrity constraints to be defined across nodes of a distributed system. In other words, a declarative referential integrity constraint on one table cannot specify a foreign key that references a primary or unique key of a remote table. Nevertheless, you can maintain parent/child table relationships across nodes using triggers.

If you decide to define referential integrity across the nodes of a distributed database using triggers, be aware that network failures can limit the accessibility of not only the parent table, but also the child table. For example, assume that the child table is in the `sales` database and the parent table is in the `hq` database. If the network connection between the two databases fails, some DML statements against the child table (those that insert rows into the child table or update a foreign key value in the child table) cannot proceed because the referential integrity triggers must have access to the parent table in the `hq` database.

See Also: *Oracle9i Database Concepts* for more information about using triggers to enforce referential integrity.

Tuning Distributed Queries

The local Oracle database server breaks the distributed query into a corresponding number of remote queries, which it then sends to the remote nodes for execution. The remote nodes execute the queries and send the results back to the local node.

The local node then performs any necessary post-processing and returns the results to the user or application.

You have several options for designing your application to optimize query processing. This section contains the following topics:

- Using Collocated Inline Views
- Using Cost-Based Optimization
- Using Hints
- Analyzing the Execution Plan

Using Collocated Inline Views

The most effective way of optimizing distributed queries is to access the remote databases as little as possible and to retrieve only the required data.

For example, assume you reference five remote tables from two different remote databases in a distributed query and have a complex filter (for example, `WHERE r1.salary + r2.salary > 50000`). You can improve the performance of the query by rewriting the query to access the remote databases once and to apply the filter at the remote site. This rewrite causes less data to be transferred to the query execution site.

Rewriting your query to access the remote database once is achieved by using **collocated inline views**. The following terms need to be defined:

Collocated	Two or more tables located in the same database.
Inline view	A `SELECT` statement that is substituted for a table in a parent `SELECT` statement. The embedded `SELECT` statement, shown within the parentheses is an example of an inline view: `SELECT e.empno, e.ename, d.deptno, d.dname FROM (SELECT empno, ename from emp@orc1.world) e, dept d;`
Collocated inline view	An inline view that selects data from multiple tables from a single database only. It reduces the amount of times that the remote database is accessed, improving the performance of a distributed query.

Oracle Corporation recommends that you form your distributed query using collocated inline views to increase the performance of your distributed query. Oracle's cost-based optimization can transparently rewrite many of your

distributed queries to take advantage of the performance gains offered by collocated inline views.

Using Cost-Based Optimization

In addition to rewriting your queries with collocated inline views, the cost-based optimization method optimizes distributed queries according to the gathered statistics of the referenced tables and the computations performed by the optimizer.

For example, cost-based optimization analyzes the following query. The example assumes that table statistics are available. Note that it analyzes the query inside a CREATE TABLE statement:

```
CREATE TABLE AS (
                 SELECT l.a, l.b, r1.c, r1.d, r1.e, r2.b, r2.c
                 FROM local l, remote1 r1, remote2 r2
                    WHERE l.c = r.c
                    AND r1.c = r2.c
                    AND r.e > 300
                );
```

and rewrites it as:

```
CREATE TABLE AS (
                 SELECT l.a, l.b, v.c, v.d, v.e
                 FROM (
                        SELECT r1.c, r1.d, r1.e, r2.b, r2.c
                         FROM remote1 r1, remote2 r2
                          WHERE r1.c = r2.c
                          AND r1.e > 300
                      ) v, local l
                 WHERE l.c = r1.c
                );
```

The alias v is assigned to the inline view, which can then be referenced as a table in the above SELECT statement. Creating a collocated inline view reduces the amount of queries performed at a remote site, thereby reducing costly network traffic.

How Does Cost-Based Optimization Work?

The optimizer's main task is to rewrite a distributed query to use collocated inline views. This optimization is performed in three steps:

1. All mergeable views are merged.
2. Optimizer performs collocated query block test.

3. Optimizer rewrites query using collocated inline views.

After the query is rewritten, it is executed and the data set is returned to the user.

While cost-based optimization is performed transparently to the user, it is unable to improve the performance of several distributed query scenarios. Specifically, if your distributed query contains any of the following, cost-based optimization is not effective:

- Aggregates
- Subqueries
- Complex SQL

If your distributed query contains one of the above, see "Using Hints" on page 30-8 to learn how you can modify your query and use hints to improve the performance of your distributed query.

Setting Up Cost-Based Optimization

After you have set up your system to use cost-based optimization to improve the performance of distributed queries, the operation is transparent to the user. In other words, the optimization occurs automatically when the query is issued.

You need to complete the following tasks to set up your system to take advantage of Oracle's optimizer:

- Setting Up the Environment
- Analyzing Tables

Setting Up the Environment To enable cost-based optimization, set the `OPTIMIZER_MODE` initialization parameter to `CHOOSE` or `COST`. You can set this parameter by:

- Modifying the `OPTIMIZER_MODE` parameter in the initialization parameter file
- Setting it at session level by issuing an `ALTER SESSION` statement

Issue one of the following statements to set the `OPTIMIZER_MODE` initialization parameter at the session level:

```
ALTER SESSION OPTIMIZER_MODE = CHOOSE;
ALTER SESSION OPTIMIZER_MODE = COST;
```

> **See Also:** *Oracle9i Database Performance Guide and Reference* manual for information on setting the OPTIMIZER_MODE initialization parameter in the parameter file and for configuring your system to use a cost-based optimization method.

Analyzing Tables In order for cost-based optimization to select the most efficient path for a distributed query, you must provide accurate statistics for the tables involved.

One way to generate statistics for a table is to execute an ANALYZE statement. Note that when you execute this statement, Oracle locks the tables being analyzed. For example, if you reference the emp and dept tables in your distributed query, execute the following to generate the necessary statistics:

```
ANALYZE TABLE emp COMPUTE STATISTICS;
ANALYZE TABLE dept COMPUTE STATISTICS;
```

The statistics are stored in the following locations:

Statistic Type	Tables
Tables	DBA/ALL/USER_TABLES
Columns	DBA/ALL/USER_TAB_COL_STATISTICS DBA/ALL/USER_TAB_COLUMNS
Histograms	DBA/ALL/USER_TAB_HISTOGRAMS DBA/ALL/USER_PART_HISTOGRAMS DBA/ALL/USER_SUBPART_HISTOGRAMS
User-defined statistics	DBA/ALL/USER_USTATS

> **Note:** You must connect locally with respect to the tables to execute the ANALYZE statement. You cannot execute the following:
>
> ```
> ANALYZE TABLE remote@remote.com COMPUTE STATISTICS;
> ```
>
> You must first connect to the remote site and then execute the above ANALYZE statement.

You can also collect statistics using the DBMS_STATS package. The following procedures enable the gathering of certain classes of optimizer statistics, with possible performance improvements over the ANALYZE statement:

- GATHER_INDEX_STATS
- GATHER_TABLE_STATS
- GATHER_SCHEMA_STATS
- GATHER_DATABASE_STATS

For example, assume that distributed transactions routinely access the `scott.dept` table. To ensure that the cost-based optimizer is still picking the best plan, execute the following:

```
BEGIN
   DBMS_STATS.GATHER_TABLE_STATS ('scott', 'dept');
END;
```

See Also:

- *Oracle9i Supplied PL/SQL Packages and Types Reference* for additional information on using the DBMS_STATS package
- *Oracle9i SQL Reference* for additional information on using the ANALYZE statement
- *Oracle9i Database Performance Guide and Reference* to learn how to generate statistics for more than one object at a time and to learn how to automate the process of keeping statistics current

Using Hints

If a statement is not sufficiently optimized, then you can use hints to extend the capability of cost-based optimization. Specifically, if you write your own query to utilize collocated inline views, instruct the cost-based optimizer not to rewrite your distributed query.

Additionally, if you have special knowledge about the database environment (such as statistics, load, network and CPU limitations, distributed queries, and so forth), you can specify a hint to guide cost-based optimization. For example, if you have written your own optimized query using collocated inline views that are based on your knowledge of the database environment, specify the NO_MERGE hint to prevent the optimizer from rewriting your query.

This technique is especially helpful if your distributed query contains an aggregate, subquery, or complex SQL. Because this type of distributed query cannot be rewritten by the optimizer, specifying NO_MERGE causes the optimizer to skip the steps described in "How Does Cost-Based Optimization Work?" on page 30-5.

The DRIVING_SITE hint allows you to define a remote site to act as the query execution site. In this way, the query executes on the remote site, which then returns the data to the local site. This hint is especially helpful when the remote site contains the majority of the data.

> **See Also:** *Oracle9i Database Performance Guide and Reference* for more information about using hints.

Using the NO_MERGE Hint

The NO_MERGE hint prevents Oracle from merging an inline view into a potentially non-collocated SQL statement (see "Using Hints" on page 30-8). This hint is embedded in the SELECT statement and can appear either at the beginning of the SELECT statement with the inline view as an argument or in the query block that defines the inline view.

```
/* with argument */

SELECT /*+NO_MERGE(v)*/ t1.x, v.avg_y
   FROM t1, (SELECT x, AVG(y) AS avg_y FROM t2 GROUP BY x) v,
   WHERE t1.x = v.x AND t1.y = 1;

/* in query block */

SELECT t1.x, v.avg_y
   FROM t1, (SELECT /*+NO_MERGE*/ x, AVG(y) AS avg_y FROM t2 GROUP BY x) v,
   WHERE t1.x = v.x AND t1.y = 1;
```

Typically, you use this hint when you have developed an optimized query based on your knowledge of your database environment.

Using the DRIVING_SITE Hint

The DRIVING_SITE hint allows you to specify the site where the query execution is performed. It is best to let cost-based optimization determine where the execution should be performed, but if you prefer to override the optimizer, you can specify the execution site manually.

Following is an example of a SELECT statement with a DRIVING_SITE hint:

```
SELECT /*+DRIVING_SITE(dept)*/ * FROM emp, dept@remote.com
   WHERE emp.deptno = dept.deptno;
```

Analyzing the Execution Plan

An important aspect to tuning distributed queries is analyzing the execution plan. The feedback that you receive from your analysis is an important element to testing and verifying your database. Verification becomes especially important when you want to compare plans. For example, comparing the execution plan for a distributed query optimized by cost-based optimization to a plan for a query manually optimized using hints, collocated inline views, and other techniques.

> **See Also:** *Oracle9i Database Performance Guide and Reference* for detailed information about execution plans, the `EXPLAIN PLAN` statement, and how to interpret the results.

Preparing the Database to Store the Plan

Before you can view the execution plan for the distributed query, prepare the database to store the execution plan. You can perform this preparation by executing a script. Execute the following script to prepare your database to store an execution plan:

```
SQL> @UTLXPLAN.SQL
```

> **Note:** The `utlxplan.sql` file can be found in the `$ORACLE_HOME/rdbms/admin` directory.

After you execute `utlxplan.sql`, a table, `PLAN_TABLE`, is created in the current schema to temporarily store the execution plan.

Generating the Execution Plan

After you have prepared the database to store the execution plan, you are ready to view the plan for a specified query. Instead of directly executing a SQL statement, append the statement to the `EXPLAIN PLAN FOR` clause. For example, you can execute the following:

```
EXPLAIN PLAN FOR
   SELECT d.dname
   FROM dept d
      WHERE d.deptno
      IN (SELECT deptno
          FROM emp@orc2.world
          GROUP BY deptno
          HAVING COUNT (deptno) >3
```

```
        )
/
```

Viewing the Execution Plan

After you have executed the above SQL statement, the execution plan is stored temporarily in the PLAN_TABLE that you created earlier. To view the results of the execution plan, execute the following script:

```
@UTLXPLS.SQL
```

> **Note:** The `utlxpls.sql` can be found in the `$ORACLE_HOME/rdbms/admin` directory.

Executing the `utlxpls.sql` script displays the execution plan for the SELECT statement that you specified. The results are formatted as follows:

```
Plan Table
--------------------------------------------------------------------------------
| Operation                 |  Name    |  Rows | Bytes|  Cost  | Pstart| Pstop |
--------------------------------------------------------------------------------
| SELECT STATEMENT          |          |       |      |        |       |       |
|  NESTED LOOPS             |          |       |      |        |       |       |
|   VIEW                    |          |       |      |        |       |       |
|    REMOTE                 |          |       |      |        |       |       |
|   TABLE ACCESS BY INDEX RO|DEPT      |       |      |        |       |       |
|    INDEX UNIQUE SCAN      |PK_DEPT   |       |      |        |       |       |
--------------------------------------------------------------------------------
```

If you are manually optimizing distributed queries by writing your own collocated inline views or using hints, it is best to generate an execution plan before and after your manual optimization. With both execution plans, you can compare the effectiveness of your manual optimization and make changes as necessary to improve the performance of the distributed query.

To view the SQL statement that will be executed at the remote site, execute the following select statement:

```
SELECT OTHER
FROM PLAN_TABLE
   WHERE operation = 'REMOTE';
```

Following is sample output:

```
SELECT DISTINCT "A1"."DEPTNO" FROM "EMP" "A1"
   GROUP BY "A1"."DEPTNO" HAVING COUNT("A1"."DEPTNO")>3
```

Note: If you are having difficulty viewing the entire contents of the OTHER column, execute the following SQL*Plus command:

```
SET LONG 9999999
```

Handling Errors in Remote Procedures

When Oracle executes a procedure locally or at a remote location, four types of exceptions can occur:

- PL/SQL user-defined exceptions, which must be declared using the keyword EXCEPTION
- PL/SQL predefined exceptions such as the NO_DATA_FOUND keyword
- SQL errors such as ORA-00900 and ORA-02015
- Application exceptions generated using the RAISE_APPLICATION_ERROR() procedure

When using local procedures, you can trap these messages by writing an exception handler such as the following:

```
BEGIN
  ...
EXCEPTION
   WHEN ZERO_DIVIDE THEN
   /* ... handle the exception */
END;
```

Notice that the WHEN clause requires an exception name. If the exception does not have a name, for example, exceptions generated with RAISE_APPLICATION_ERROR, you can assign one using PRAGMA_EXCEPTION_INIT. For example:

```
DECLARE
  null_salary EXCEPTION;
  PRAGMA EXCEPTION_INIT(null_salary, -20101);
BEGIN
  ...
  RAISE_APPLICATION_ERROR(-20101, 'salary is missing');
...
EXCEPTION
  WHEN null_salary THEN
  ...
END;
```

When calling a remote procedure, exceptions can be handled by an exception handler in the local procedure. The remote procedure must return an error number to the local, calling procedure, which then handles the exception as shown in the previous example. Note that PL/SQL user-defined exceptions always return `ORA-06510` to the local procedure.

Therefore, it is not possible to distinguish between two different user-defined exceptions based on the error number. All other remote exceptions can be handled in the same manner as local exceptions.

> **See Also:** *PL/SQL User's Guide and Reference* for more information about PL/SQL procedures

31

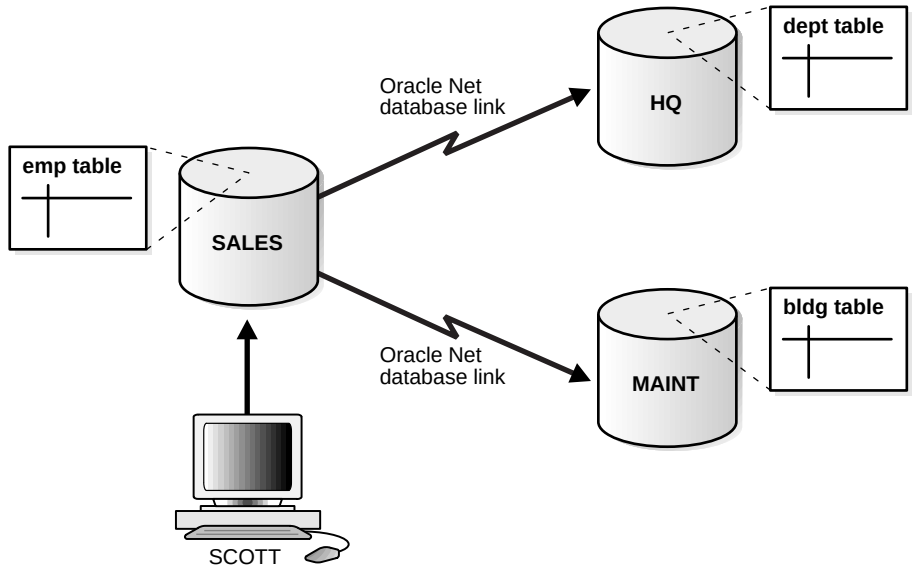
Distributed Transactions Concepts

This chapter describes what distributed transactions are and how Oracle maintains their integrity. The following topics are contained in this chapter:

What Are Distributed Transactions?

A **distributed transaction** includes one or more statements that, individually or as a group, update data on two or more distinct nodes of a distributed database. For example, assume the database configuration depicted in Figure 31–1:

Figure 31–1 Distributed System



The following distributed transaction executed by `scott` updates the local `sales` database, the remote `hq` database, and the remote `maint` database:

```
UPDATE scott.dept@hq.us.acme.com
  SET loc = 'REDWOOD SHORES'
  WHERE deptno = 10;
UPDATE scott.emp
  SET deptno = 11
  WHERE deptno = 10;
UPDATE scott.bldg@maint.us.acme.com
  SET room = 1225
  WHERE room = 1163;
COMMIT;
```

Note: If all statements of a transaction reference only a single remote node, then the transaction is remote, not distributed.

There are two types of permissible operations in distributed transactions:

- DML and DDL Transactions
- Transaction Control Statements

DML and DDL Transactions

The following list describes DML and DDL operations supported in a distributed transaction:

- `CREATE TABLE AS SELECT`
- `DELETE`
- `INSERT` (default and direct load)
- `LOCK TABLE`
- `SELECT`
- `SELECT FOR UPDATE`

You can execute DML and DDL statements in parallel, and `INSERT` direct load statements serially, but note the following restrictions:

- All remote operations must be `SELECT` statements.
- These statements must not be clauses in another distributed transaction.
- If the table referenced in the *table_expression_clause* of an `INSERT`, `UPDATE`, or `DELETE` statement is remote, then execution is serial rather than parallel.
- You cannot perform remote operations after issuing parallel DML / DDL or direct load `INSERT`.
- If the transaction begins using XA or OCI, it executes serially.
- No loopback operations can be performed on the transaction originating the parallel operation. For example, you cannot reference a remote object that is actually a synonym for a local object.
- If you perform a distributed operation other than a `SELECT` in the transaction, no DML is parallelized.

Transaction Control Statements

The following list describes supported transaction control statements:

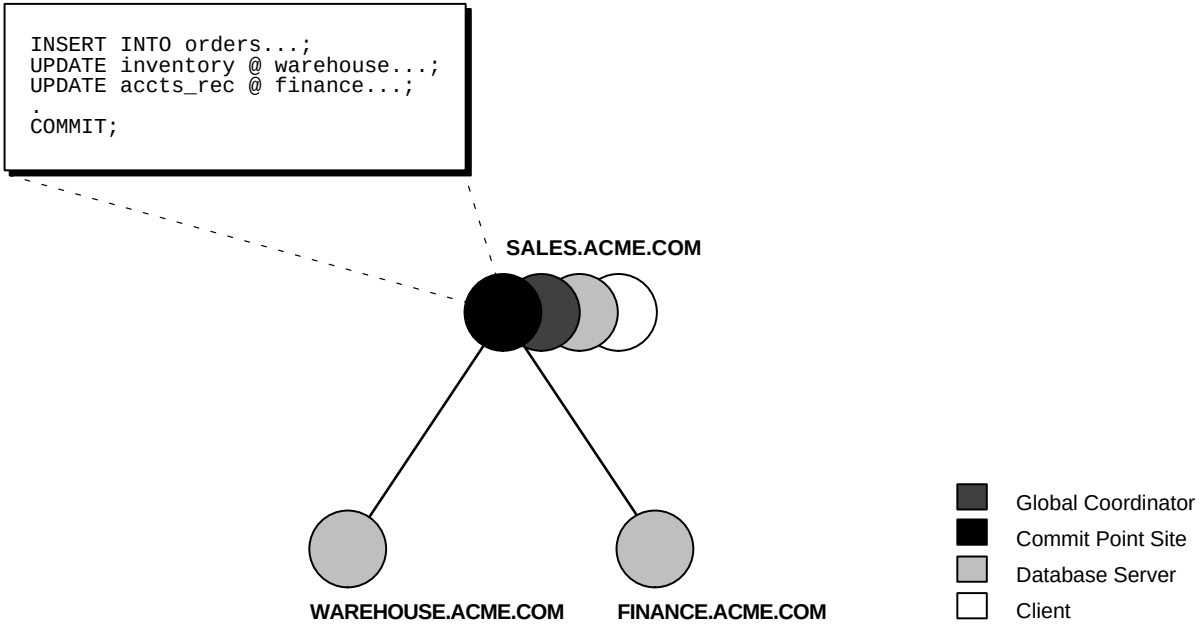
- `COMMIT`
- `ROLLBACK`
- `SAVEPOINT`

> **See Also:** *Oracle9i SQL Reference* for more information about these SQL statements

Session Trees for Distributed Transactions

As the statements in a distributed transaction are issued, Oracle defines a **session tree** of all nodes participating in the transaction. A session tree is a hierarchical model that describes the relationships among sessions and their roles. Figure 31–2 illustrates a session tree:

Figure 31–2 Example of a Session Tree



All nodes participating in the session tree of a distributed transaction assume one or more of the following roles:

Role	Description
Client	A node that references information in a database belonging to a different node.
Database server	A node that receives a request for information from another node.
Global coordinator	The node that originates the distributed transaction.
Local coordinator	A node that is forced to reference data on other nodes to complete its part of the transaction.
Commit point site	The node that commits or rolls back the transaction as instructed by the global coordinator.

The role a node plays in a distributed transaction is determined by:

- Whether the transaction is local or remote
- The **commit point strength** of the node ("Commit Point Site" on page 31-7)
- Whether all requested data is available at a node, or whether other nodes need to be referenced to complete the transaction
- Whether the node is read-only

Clients

A node acts as a client when it references information from another node's database. The referenced node is a database server. In Figure 31–2, the node `sales` is a client of the nodes that host the `warehouse` and `finance` databases.

Database Servers

A database server is a node that hosts a database from which a client requests data.

In Figure 31–2, an application at the `sales` node initiates a distributed transaction that accesses data from the `warehouse` and `finance` nodes. Therefore, `sales.acme.com` has the role of client node, and `warehouse` and `finance` are both database servers. In this example, `sales` is a database server *and* a client because the application also modifies data in the `sales` database.

Local Coordinators

A node that must reference data on other nodes to complete its part in the distributed transaction is called a local coordinator. In Figure 31–2, `sales` is a local coordinator because it coordinates the nodes it directly references: `warehouse` and `finance`. The node `sales` also happens to be the global coordinator because it coordinates all the nodes involved in the transaction.

A local coordinator is responsible for coordinating the transaction among the nodes it communicates directly with by:

- Receiving and relaying transaction status information to and from those nodes
- Passing queries to those nodes
- Receiving queries from those nodes and passing them on to other nodes
- Returning the results of queries to the nodes that initiated them

Global Coordinator

The node where the distributed transaction originates is called the global coordinator. The database application issuing the distributed transaction is directly connected to the node acting as the global coordinator. For example, in Figure 31–2, the transaction issued at the node `sales` references information from the database servers `warehouse` and `finance`. Therefore, `sales.acme.com` is the global coordinator of this distributed transaction.

The global coordinator becomes the parent or root of the session tree. The global coordinator performs the following operations during a distributed transaction:

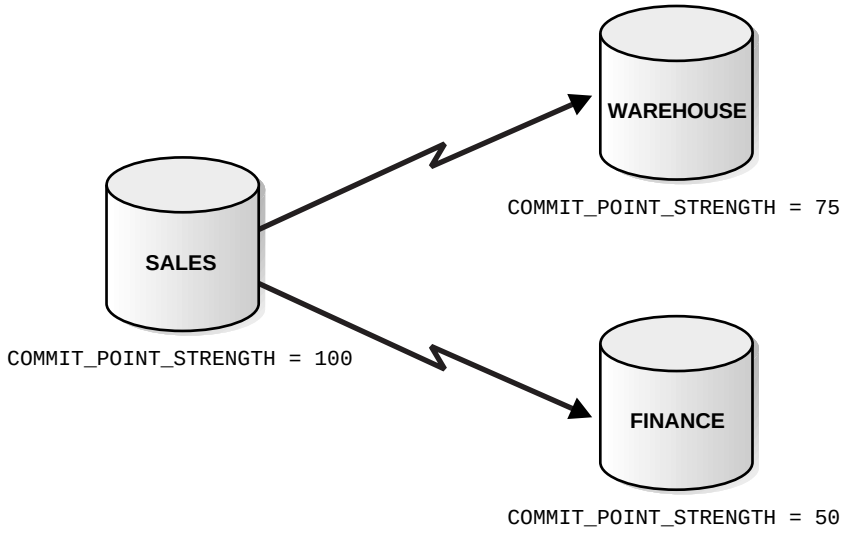
- Sends all of the distributed transaction's SQL statements, remote procedure calls, and so forth to the directly referenced nodes, thus forming the session tree
- Instructs all directly referenced nodes other than the commit point site to prepare the transaction
- Instructs the commit point site to initiate the global commit of the transaction if all nodes prepare successfully
- Instructs all nodes to initiate a global rollback of the transaction if there is an abort response

Commit Point Site

The job of the commit point site is to initiate a commit or roll back operation as instructed by the global coordinator. The system administrator always designates one node to be the commit point site in the session tree by assigning all nodes a commit point strength. The node selected as commit point site should be the node that stores the most critical data.

Figure 31–3 illustrates an example of distributed system, with `sales` serving as the commit point site:

Figure 31–3 Commit Point Site



The commit point site is distinct from all other nodes involved in a distributed transaction in these ways:

- The commit point site never enters the prepared state. Consequently, if the commit point site stores the most critical data, this data never remains in-doubt, even if a failure occurs. In failure situations, failed nodes remain in a prepared state, holding necessary locks on data until in-doubt transactions are resolved.
- The commit point site commits before the other nodes involved in the transaction. In effect, the outcome of a distributed transaction at the commit point site determines whether the transaction at all nodes is committed or rolled back: the other nodes follow the lead of the commit point site. The global coordinator ensures that all nodes complete the transaction in the same manner as the commit point site.

How a Distributed Transaction Commits

A distributed transaction is considered committed after all non-commit point sites are prepared, and the transaction has been actually committed at the commit point site. The online redo log at the commit point site is updated as soon as the distributed transaction is committed at this node.

Because the commit point log contains a record of the commit, the transaction is considered committed even though some participating nodes may still be only in

the prepared state and the transaction not yet actually committed at these nodes. In the same way, a distributed transaction is considered *not* committed if the commit has not been logged at the commit point site.

Commit Point Strength

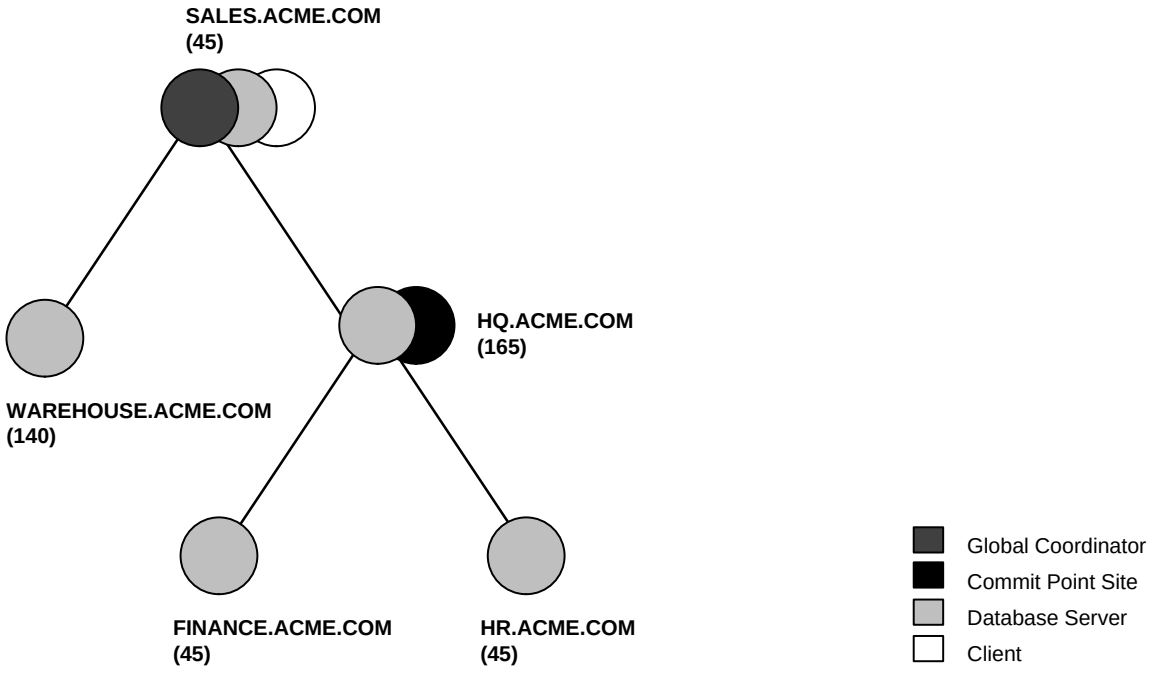
Every database server must be assigned a commit point strength. If a database server is referenced in a distributed transaction, the value of its commit point strength determines which role it plays in the two-phase commit. Specifically, the commit point strength determines whether a given node is the commit point site in the distributed transaction and thus commits before all of the other nodes. This value is specified using the initialization parameter `COMMIT_POINT_STRENGTH`. This section explains how Oracle determines the commit point site.

The commit point site, which is determined at the beginning of the prepare phase, is selected only from the nodes participating in the transaction. The following sequence of events occurs:

1. Of the nodes directly referenced by the global coordinator, Oracle selects the node with the highest commit point strength as the commit point site.
2. The initially-selected node determines if any of the nodes from which it has to obtain information for this transaction has a higher commit point strength.
3. Either the node with the highest commit point strength directly referenced in the transaction or one of its servers with a higher commit point strength becomes the commit point site.
4. After the final commit point site has been determined, the global coordinator sends prepare responses to all nodes participating in the transaction.

Figure 31–4 shows in a sample session tree the commit point strengths of each node (in parentheses) and shows the node chosen as the commit point site:

Figure 31–4 Commit Point Strengths and Determination of the Commit Point Site



The following conditions apply when determining the commit point site:

- A read-only node cannot be the commit point site.
- If multiple nodes directly referenced by the global coordinator have the same commit point strength, then Oracle designates one of these as the commit point site.
- If a distributed transaction ends with a rollback, then the prepare and commit phases are not needed. Consequently, Oracle never determines a commit point site. Instead, the global coordinator sends a ROLLBACK statement to all nodes and ends the processing of the distributed transaction.

As Figure 31–4 illustrates, the commit point site and the global coordinator can be different nodes of the session tree. The commit point strength of each node is communicated to the coordinators when the initial connections are made. The coordinators retain the commit point strengths of each node they are in direct communication with so that commit point sites can be efficiently selected during

two-phase commits. Therefore, it is not necessary for the commit point strength to be exchanged between a coordinator and a node each time a commit occurs.

See Also:

- "Specifying the Commit Point Strength of a Node" on page 32-3 to learn how to set the commit point strength of a node
- *Oracle9i Database Reference* for more information about the initialization parameter `COMMIT_POINT_STRENGTH`

Two-Phase Commit Mechanism

Unlike a transaction on a local database, a distributed transaction involves altering data on multiple databases. Consequently, distributed transaction processing is more complicated, because Oracle must coordinate the committing or rolling back of the changes in a transaction as a self-contained unit. In other words, the entire transaction commits, or the entire transaction rolls back.

Oracle ensures the integrity of data in a distributed transaction using the **two-phase commit mechanism**. In the **prepare phase**, the initiating node in the transaction asks the other participating nodes to promise to commit or roll back the transaction. During the **commit phase**, the initiating node asks all participating nodes to commit the transaction. If this outcome is not possible, then all nodes are asked to roll back.

All participating nodes in a distributed transaction should perform the same action: they should either all commit or all perform a rollback of the transaction. Oracle automatically controls and monitors the commit or rollback of a distributed transaction and maintains the integrity of the **global database** (the collection of databases participating in the transaction) using the two-phase commit mechanism. This mechanism is completely transparent, requiring no programming on the part of the user or application developer.

The commit mechanism has the following distinct phases, which Oracle performs automatically whenever a user commits a distributed transaction:

Prepare phase	The initiating node, called the **global coordinator**, asks participating nodes other than the commit point site to promise to commit or roll back the transaction, even if there is a failure. If any node cannot prepare, the transaction is rolled back.

Commit phase	If all participants respond to the coordinator that they are prepared, then the coordinator asks the commit point site to commit. After it commits, the coordinator asks all other nodes to commit the transaction.
Forget phase	The global coordinator forgets about the transaction.

This section contains the following topics:

- Prepare Phase
- Commit Phase
- Forget Phase

Prepare Phase

The first phase in committing a distributed transaction is the prepare phase. In this phase, Oracle does not actually commit or roll back the transaction. Instead, all nodes referenced in a distributed transaction (except the commit point site, described in the "Commit Point Site" on page 31-7) are told to prepare to commit. By preparing, a node:

- Records information in the online redo logs so that it can subsequently either commit or roll back the transaction, regardless of intervening failures
- Places a distributed lock on modified tables, which prevents reads

When a node responds to the global coordinator that it is prepared to commit, the prepared node *promises* to either commit or roll back the transaction later—but does not make a unilateral decision on whether to commit or roll back the transaction. The promise means that if an instance failure occurs at this point, the node can use the redo records in the online log to recover the database back to the prepare phase.

Note: Queries that start after a node has prepared cannot access the associated locked data until all phases complete. The time is insignificant unless a failure occurs (see "Deciding How to Handle In-Doubt Transactions" on page 32-9).

Types of Responses in the Prepare Phase

When a node is told to prepare, it can respond in the following ways:

Prepared	Data on the node has been modified by a statement in the distributed transaction, and the node has successfully prepared.
Read-only	No data on the node has been, or can be, modified (only queried), so no preparation is necessary.
Abort	The node cannot successfully prepare.

Prepared Response When a node has successfully prepared, it issues a **prepared message**. The message indicates that the node has records of the changes in the online log, so it is prepared either to commit or perform a rollback. The message also guarantees that locks held for the transaction can survive a failure.

Read-Only Response When a node is asked to prepare, and the SQL statements affecting the database do not change the node's data, the node responds with a **read-only message**. The message indicates that the node will not participate in the commit phase.

There are three cases in which all or part of a distributed transaction is read-only:

Case	Conditions	Consequence
Partially read-only	Any of the following occurs: ■ Only queries are issued at one or more nodes. ■ No data is changed. ■ Changes rolled back due to triggers firing or constraint violations.	The read-only nodes recognize their status when asked to prepare. They give their local coordinators a read-only response. Thus, the commit phase completes faster because Oracle eliminates read-only nodes from subsequent processing.
Completely read-only with prepare phase	All of following occur: ■ No data changes. ■ Transaction is *not* started with `SET TRANSACTION READ ONLY` statement.	All nodes recognize that they are read-only during prepare phase, so no commit phase is required. The global coordinator, not knowing whether all nodes are read-only, must still perform the prepare phase.

Case	Conditions	Consequence
Completely read-only without two-phase commit	All of following occur: ■ No data changes. ■ Transaction *is* started with `SET TRANSACTION READ ONLY` statement.	Only queries are allowed in the transaction, so global coordinator does not have to perform two-phase commit. Changes by other transactions do not degrade global transaction-level read consistency because of global SCN coordination among nodes. The transaction does not use rollback segments.

Note that if a distributed transaction is set to read-only, then it does not use rollback segments. If many users connect to the database and their transactions are *not* set to `READ ONLY`, then they allocate rollback space even if they are only performing queries.

Abort Response When a node cannot successfully prepare, it performs the following actions:

1. Releases resources currently held by the transaction and rolls back the local portion of the transaction.
2. Responds to the node that referenced it in the distributed transaction with an abort message.

These actions then propagate to the other nodes involved in the distributed transaction so that they can roll back the transaction and guarantee the integrity of the data in the global database. This response enforces the primary rule of a distributed transaction: *all nodes involved in the transaction either all commit or all roll back the transaction at the same logical time*.

Steps in the Prepare Phase

To complete the prepare phase, each node excluding the commit point site performs the following steps:

1. The node requests that its **descendants**, that is, the nodes subsequently referenced, prepare to commit.
2. The node checks to see whether the transaction changes data on itself or its descendants. If there is no change to the data, then the node skips the remaining steps and returns a read-only response (see "Read-Only Response" on page 31-13).

3. The node allocates the resources it needs to commit the transaction if data is changed.
4. The node saves redo records corresponding to changes made by the transaction to its online redo log.
5. The node guarantees that locks held for the transaction are able to survive a failure.
6. The node responds to the initiating node with a prepared response (see "Prepared Response" on page 31-13) or, if its attempt or the attempt of one of its descendents to prepare was unsuccessful, with an abort response (see "Abort Response" on page 31-14).

These actions guarantee that the node can subsequently commit or roll back the transaction on the node. The prepared nodes then wait until a `COMMIT` or `ROLLBACK` request is received from the global coordinator.

After the nodes are prepared, the distributed transaction is said to be **in-doubt** (see "In-Doubt Transactions" on page 31-17). It retains in-doubt status until all changes are either committed or rolled back.

Commit Phase

The second phase in committing a distributed transaction is the commit phase. Before this phase occurs, *all* nodes other than the commit point site referenced in the distributed transaction have guaranteed that they are prepared, that is, they have the necessary resources to commit the transaction.

Steps in the Commit Phase

The commit phase consists of the following steps:

1. The global coordinator instructs the commit point site to commit.
2. The commit point site commits.
3. The commit point site informs the global coordinator that it has committed.
4. The global and local coordinators send a message to all nodes instructing them to commit the transaction.
5. At each node, Oracle commits the local portion of the distributed transaction and releases locks.
6. At each node, Oracle records an additional redo entry in the local redo log, indicating that the transaction has committed.

7. The participating nodes notify the global coordinator that they have committed.

When the commit phase is complete, the data on all nodes of the distributed system is consistent.

Guaranteeing Global Database Consistency

Each committed transaction has an associated system change number (SCN) to uniquely identify the changes made by the SQL statements within that transaction. The SCN functions as an internal Oracle timestamp that uniquely identifies a committed version of the database.

In a distributed system, the SCNs of communicating nodes are coordinated when all of the following actions occur:

- A connection occurs using the path described by one or more database links
- A distributed SQL statement executes
- A distributed transaction commits

Among other benefits, the coordination of SCNs among the nodes of a distributed system ensures global read-consistency at both the statement and transaction level. If necessary, global time-based recovery can also be completed.

During the prepare phase, Oracle determines the highest SCN at all nodes involved in the transaction. The transaction then commits with the high SCN at the commit point site. The commit SCN is then sent to all prepared nodes with the commit decision.

> **See Also:** "Managing Read Consistency" on page 32-27 for information about managing time lag issues in read consistency

Forget Phase

After the participating nodes notify the commit point site that they have committed, the commit point site can forget about the transaction. The following steps occur:

1. After receiving notice from the global coordinator that all nodes have committed, the commit point site erases status information about this transaction.
2. The commit point site informs the global coordinator that it has erased the status information.
3. The global coordinator erases its own information about the transaction.

In-Doubt Transactions

The two-phase commit mechanism ensures that all nodes either commit or perform a rollback together. What happens if any of the three phases fails because of a system or network error? The transaction becomes in-doubt.

Distributed transactions can become in-doubt in the following ways:

- A server machine running Oracle software crashes
- A network connection between two or more Oracle databases involved in distributed processing is disconnected
- An unhandled software error occurs

The RECO process automatically resolves in-doubt transactions when the machine, network, or software problem is resolved. Until RECO can resolve the transaction, the data is locked for both reads and writes. Oracle blocks reads because it cannot determine which version of the data to display for a query.

This section contains the following topics:

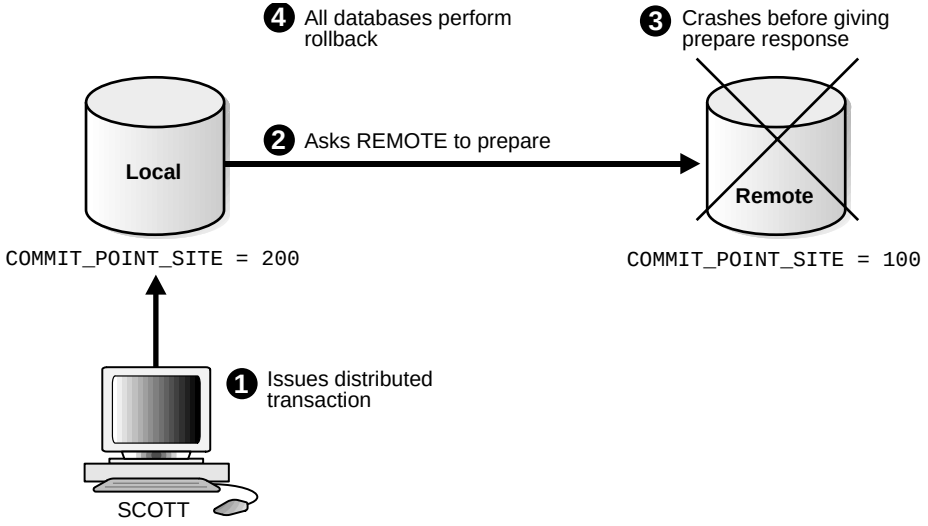
Automatic Resolution of In-Doubt Transactions

In the majority of cases, Oracle resolves the in-doubt transaction automatically. Assume that there are two nodes, `local` and `remote`, in the following scenarios. The local node is the commit point site. User `scott` connects to `local` and executes and commits a distributed transaction that updates `local` and `remote`.

Failure During the Prepare Phase

Figure 31–5 illustrates the sequence of events when there is a failure during the prepare phase of a distributed transaction:

Figure 31–5 Failure During Prepare Phase



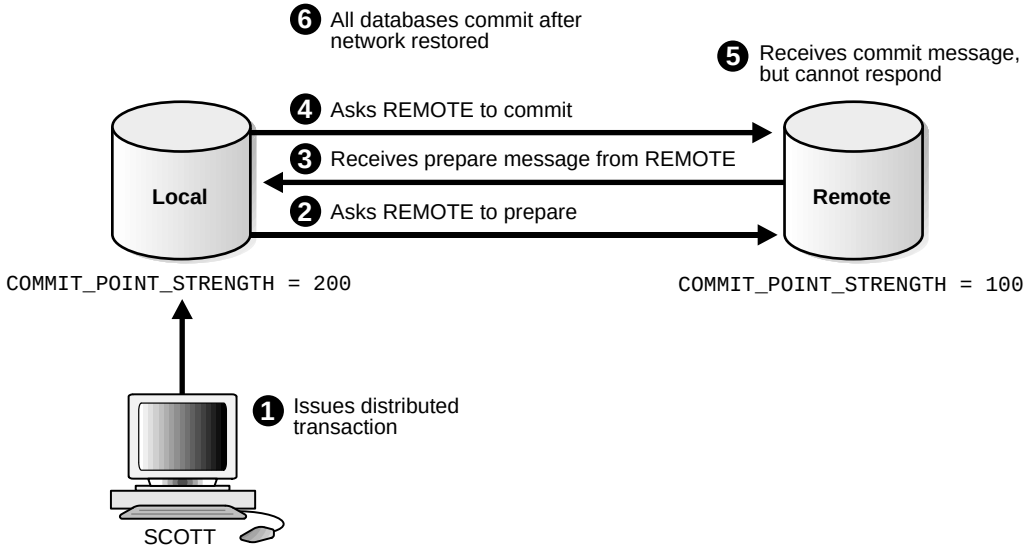
The following steps occur:

1. Scott connects to `local` and executes a distributed transaction.
2. The global coordinator, which in this example is also the commit point site, requests all databases other than the commit point site to promise to commit or roll back when told to do so.
3. The `remote` database crashes before issuing the prepare response back to `local`.
4. The transaction is ultimately rolled back on each database by the RECO process when the remote site is restored.

Failure During the Commit Phase

Figure 31–6 illustrates the sequence of events when there is a failure during the commit phase of a distributed transaction:

Figure 31–6 Failure During Commit Phase



The following steps occur:

1. Scott connects to `local` and executes a distributed transaction.
2. The global coordinator, which in this case is also the commit point site, requests all databases other than the commit point site to promise to commit or roll back when told to do so.
3. The commit point site receives a prepared message from `remote` saying that it will commit.
4. The commit point site commits the transaction locally, then sends a commit message to `remote` asking it to commit.
5. The `remote` database receives the commit message, but cannot respond because of a network failure.
6. The transaction is ultimately committed on the remote database by the RECO process after the network is restored.

> **See Also:** "Deciding How to Handle In-Doubt Transactions" on page 32-9 for a description of failure situations and how Oracle resolves intervening failures during two-phase commit

Manual Resolution of In-Doubt Transactions

You should only need to resolve an in-doubt transaction in the following cases:

- The in-doubt transaction has locks on critical data or rollback segments.
- The cause of the machine, network, or software failure cannot be repaired quickly.

Resolution of in-doubt transactions can be complicated. The procedure requires that you do the following:

- Identify the transaction identification number for the in-doubt transaction.
- Query the `DBA_2PC_PENDING` and `DBA_2PC_NEIGHBORS` views to determine whether the databases involved in the transaction have committed.
- If necessary, force a commit using the `COMMIT FORCE` statement or a rollback using the `ROLLBACK FORCE` statement.

> **See Also:** The following sections explain how to resolve in-doubt transactions:
>
> - "Deciding How to Handle In-Doubt Transactions" on page 32-9
> - "Manually Overriding In-Doubt Transactions" on page 32-12

Relevance of System Change Numbers for In-Doubt Transactions

A **system change number** (SCN) is an internal timestamp for a committed version of the database. The Oracle database server uses the SCN clock value to guarantee transaction consistency. For example, when a user commits a transaction, Oracle records an SCN for this commit in the online redo log.

Oracle uses SCNs to coordinate distributed transactions among different databases. For example, Oracle uses SCNs in the following way:

1. An application establishes a connection using a database link.
2. The distributed transaction commits with the highest global SCN among all the databases involved.
3. The commit global SCN is sent to all databases involved in the transaction.

SCNs are important for distributed transactions because they function as a synchronized commit timestamp of a transaction—even if the transaction fails. If a transaction becomes in-doubt, an administrator can use this SCN to coordinate changes made to the global database. The global SCN for the transaction commit

can also be used to identify the transaction later, for example, in distributed recovery.

Distributed Transaction Processing: Case Study

In this scenario, a company has separate Oracle database servers, `sales.acme.com` and `warehouse.acme.com`. As users insert sales records into the `sales` database, associated records are being updated at the `warehouse` database.

This case study of distributed processing illustrates:

- The definition of a session tree
- How a commit point site is determined
- When prepare messages are sent
- When a transaction actually commits
- What information is stored locally about the transaction

Stage 1: Client Application Issues DML Statements

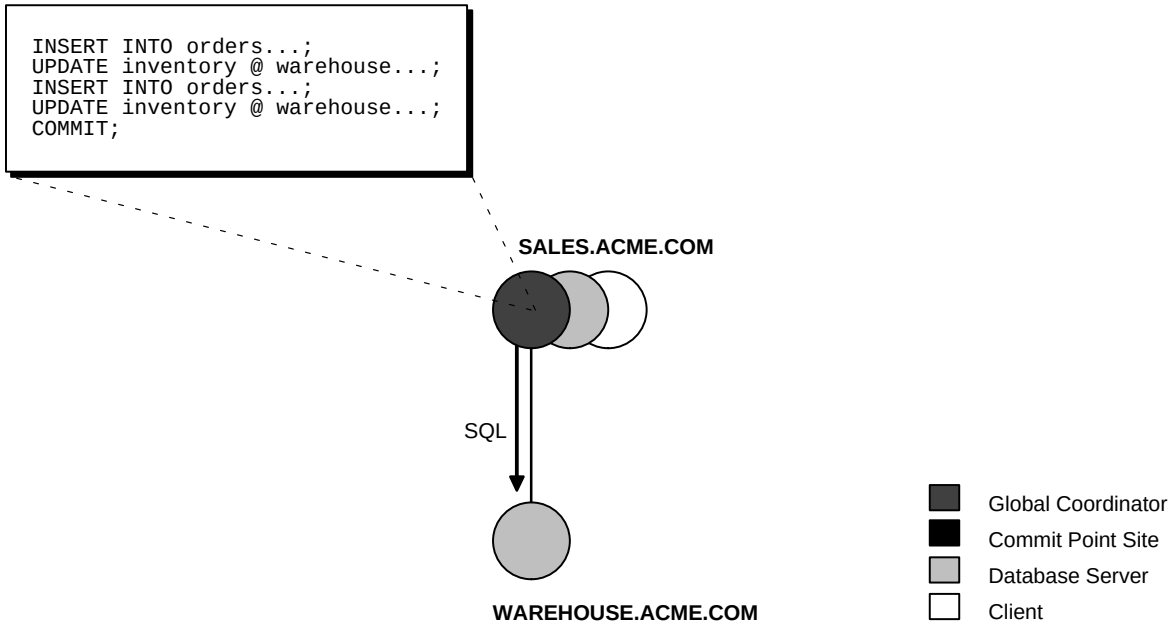
At the Sales department, a salesperson uses SQL*Plus to enter a sales order and then commit it. The application issues a number of SQL statements to enter the order into the `sales` database and update the inventory in the `warehouse` database:

```
CONNECT scott/tiger@sales.acme.com ...;
INSERT INTO orders ...;
UPDATE inventory@warehouse.acme.com ...;
INSERT INTO orders ...;
UPDATE inventory@warehouse.acme.com ...;
COMMIT;
```

These SQL statements are part of a single distributed transaction, guaranteeing that all issued SQL statements succeed or fail as a unit. Treating the statements as a unit prevents the possibility of an order being placed and then inventory not being updated to reflect the order. In effect, the transaction guarantees the consistency of data in the global database.

As each of the SQL statements in the transaction executes, the session tree is defined, as shown in Figure 31–7.

Figure 31–7 Defining the Session Tree



Note the following aspects of the transaction:

- An order entry application running on the `sales` database initiates the transaction. Therefore, `sales.acme.com` is the global coordinator for the distributed transaction.
- The order entry application inserts a new sales record into the `sales` database and updates the inventory at the warehouse. Therefore, the nodes `sales.acme.com` and `warehouse.acme.com` are both database servers.
- Because `sales.acme.com` updates the inventory, it is a client of `warehouse.acme.com`.

This stage completes the definition of the session tree for this distributed transaction. Each node in the tree has acquired the necessary data locks to execute the SQL statements that reference local data. These locks remain even after the SQL statements have been executed until the two-phase commit is completed.

Stage 2: Oracle Determines Commit Point Site

Oracle determines the commit point site immediately following the `COMMIT` statement. `sales.acme.com`, the global coordinator, is determined to be the commit point site, as shown in Figure 31–8.

> **See Also:** "Commit Point Strength" on page 31-9 for more information about how the commit point site is determined

Figure 31–8 Determining the Commit Point Site

Stage 3: Global Coordinator Sends Prepare Response

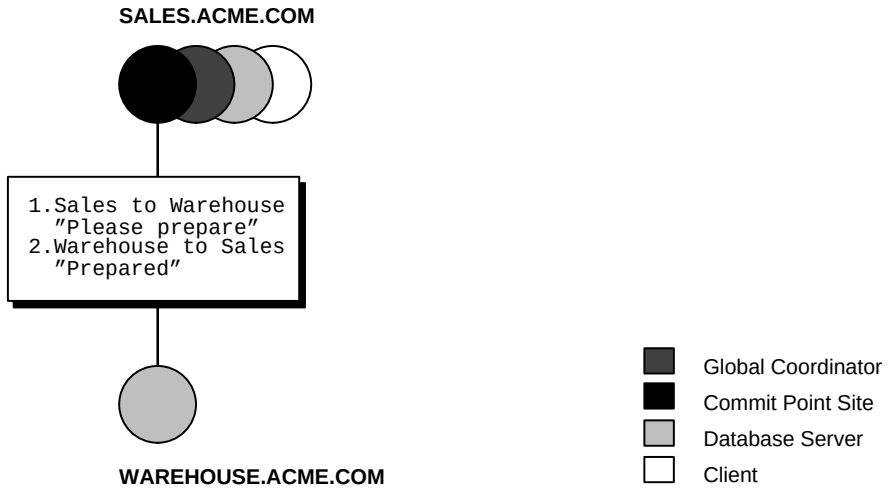
The prepare stage involves the following steps:

1. After Oracle determines the commit point site, the global coordinator sends the prepare message to all directly referenced nodes of the session tree, *excluding* the commit point site. In this example, `warehouse.acme.com` is the only node asked to prepare.
2. Node `warehouse.acme.com` tries to prepare. If a node can guarantee that it can commit the locally dependent part of the transaction and can record the commit information in its local redo log, then the node can successfully prepare. In this example, only `warehouse.acme.com` receives a prepare message because `sales.acme.com` is the commit point site.
3. Node `warehouse.acme.com` responds to `sales.acme.com` with a prepared message.

As each node prepares, it sends a message back to the node that asked it to prepare. Depending on the responses, one of the following can happen:

- If *any* of the nodes asked to prepare responds with an abort message to the global coordinator, then the global coordinator tells all nodes to roll back the transaction, and the operation is completed.
- If *all* nodes asked to prepare respond with a prepared or a read-only message to the global coordinator, that is, they have successfully prepared, then the global coordinator asks the commit point site to commit the transaction.

Figure 31–9 Sending and Acknowledging the Prepare Message



Stage 4: Commit Point Site Commits

The committing of the transaction by the commit point site involves the following steps:

1. Node `sales.acme.com`, receiving acknowledgment that `warehouse.acme.com` is prepared, instructs the commit point site to commit the transaction.
2. The commit point site now commits the transaction locally and records this fact in its local redo log.

Even if `warehouse.acme.com` has not yet committed, the outcome of this transaction is predetermined. In other words, the transaction *will* be committed at all nodes even if a given node's ability to commit is delayed.

Stage 5: Commit Point Site Informs Global Coordinator of Commit

This stage involves the following steps:

1. The commit point site tells the global coordinator that the transaction has committed. Because the commit point site and global coordinator are the same node in this example, no operation is required. The commit point site knows that the transaction is committed because it recorded this fact in its online log.
2. The global coordinator confirms that the transaction has been committed on all other nodes involved in the distributed transaction.

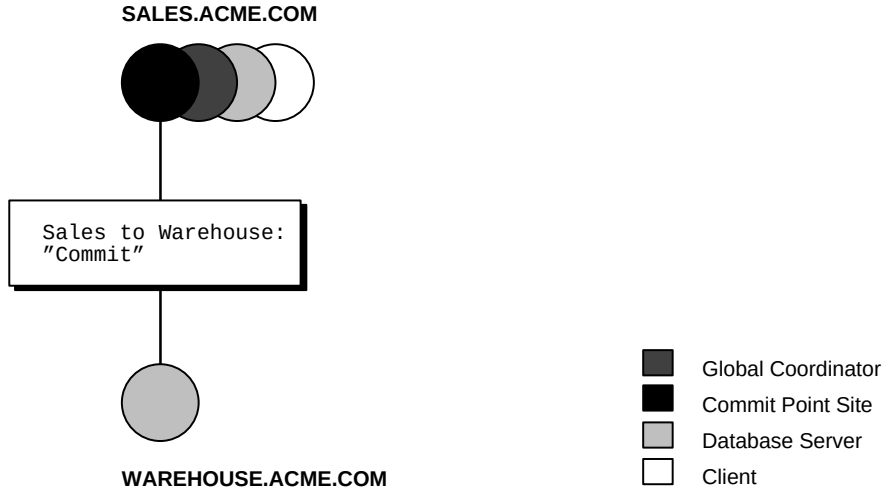
Stage 6: Global and Local Coordinators Tell All Nodes to Commit

The committing of the transaction by all the nodes in the transaction involves the following steps:

1. After the global coordinator has been informed of the commit at the commit point site, it tells all other directly referenced nodes to commit.
2. In turn, any local coordinators instruct their servers to commit, and so on.
3. Each node, including the global coordinator, commits the transaction and records appropriate redo log entries locally. As each node commits, the resource locks that were being held locally for that transaction are released.

In Figure 31–10, `sales.acme.com`, which is both the commit point site and the global coordinator, has already committed the transaction locally. `sales` now instructs `warehouse.acme.com` to commit the transaction.

Figure 31–10 Instructing Nodes to Commit



Stage 7: Global Coordinator and Commit Point Site Complete the Commit

The completion of the commit of the transaction occurs in the following steps:

1. After all referenced nodes and the global coordinator have committed the transaction, the global coordinator informs the commit point site of this fact.
2. The commit point site, which has been waiting for this message, erases the status information about this distributed transaction.
3. The commit point site informs the global coordinator that it is finished. In other words, the commit point site forgets about committing the distributed transaction. This action is permissible because all nodes involved in the two-phase commit have committed the transaction successfully, so they will never have to determine its status in the future.
4. The global coordinator finalizes the transaction by forgetting about the transaction itself.

   After the completion of the `COMMIT` phase, the distributed transaction is itself complete. The steps described above are accomplished automatically and in a fraction of a second.

32

Managing Distributed Transactions

This chapter describes how to manage and troubleshoot distributed transactions. The following topics are included in this chapter:

Setting Distributed Transaction Initialization Parameters

You can set initialization parameters that control the behavior of distributed transaction processing. The following tables describes initialization parameters relevant for distributed transaction processing:

Parameter	Description
DISTRIBUTED_TRANSACTIONS	Specifies the maximum number of distributed transactions in which this database can concurrently participate.
COMMIT_POINT_STRENGTH	Specifies the value used to determine the commit point site in a distributed transaction.

This section contains the following topics:

- Limiting the Number of Distributed Transactions
- Specifying the Commit Point Strength of a Node

Limiting the Number of Distributed Transactions

The initialization parameter DISTRIBUTED_TRANSACTIONS limits the number of distributed transactions in which a given instance can concurrently participate, both as a client and a server. The default value for this parameter is operating system-dependent.

If Oracle reaches this limit and a subsequent user issues a SQL statement referencing a remote database, then the system rolls back the statement and returns the following error message:

```
ORA-2042: too many global transactions
```

For example, assume that you set the parameter as follows for a given instance:

```
DISTRIBUTED_TRANSACTIONS = 10
```

In this case, a maximum of 10 sessions can concurrently process a distributed transaction. If an additional session attempts to issue a DML statement requiring distributed access, then Oracle returns an error message to the session and rolls back the statement.

Note: Oracle recommends setting the value for DISTRIBUTED_TRANSACTIONS equal to the total number of distributed database sites in your environment.

Increasing the Transaction Limit

Consider increasing the value of the DISTRIBUTED_TRANSACTIONS when an instance regularly participates in numerous distributed transactions and the ORA-2042 is frequently returned. Increasing the limit allows more users to concurrently issue distributed transactions.

Decreasing the Transaction Limit

If your site is experiencing an abnormally high number of network failures, you can temporarily decrease the value of DISTRIBUTED_TRANSACTIONS. This operation limits the number of in-doubt transactions in which your site takes part, and thereby limits the amount of locked data at your site, and the number of in-doubt transactions you might have to resolve

Disabling Distributed Transaction Processing

If DISTRIBUTED_TRANSACTIONS is set to zero, no distributed SQL statements can be issued in any session. Also, the RECO background process is not started at startup of the local instance. In-doubt distributed transactions that may be present cannot be automatically resolved by Oracle. Therefore, only set this initialization parameter to zero to prevent distributed transactions when a new instance is started and when it is certain that no in-doubt distributed transactions remained after the last instance shut down.

See Also: *Oracle9i Database Reference* for more information about the DISTRIBUTED_TRANSACTIONS initialization parameter

Specifying the Commit Point Strength of a Node

The database with the highest commit point strength determines which node commits first in a distributed transaction. When specifying a commit point strength for each node, ensure that the most critical server will be non-blocking if a failure occurs during a prepare or commit phase. The following initialization parameter determines a node's commit point strength:

COMMIT_POINT_STRENGTH

The default value is operating system-dependent. The range of values is any integer from 0 to 255. For example, to set the commit point strength of a database to 200, include the following line in that database's initialization parameter file:

```
COMMIT_POINT_STRENGTH = 200
```

The commit point strength is only used to determine the commit point site in a distributed transaction.

When setting the commit point strength for a database, note the following considerations:

- Because the commit point site stores information about the status of the transaction, the commit point site should not be a node that is frequently unreliable or unavailable in case other nodes need information about the transaction's status.
- Set the commit point strength for a database relative to the amount of critical shared data in the database. For example, a database on a mainframe computer usually shares more data among users than a database on a PC. Therefore, set the commit point strength of the mainframe to a higher value than the PC.

See Also: "Commit Point Site" on page 31-7 for a conceptual overview of commit points

Viewing Information About Distributed Transactions

The data dictionary of each database stores information about all open distributed transactions. You can use data dictionary tables and views to gain information about the transactions. This section contains the following topics:

Transaction Naming

Starting with Oracle9*i* you can name a transaction. This is useful for identifying a specific distributed transaction and replaces the use of the `COMMIT COMMENT` statement for this purpose.

To name a transaction, use the `SET TRANSACTION ... NAME` statement. For example:

```
SET TRANSACTION ISOLATION LEVEL SERIALIZABLE
     NAME 'update inventory checkpoint 0';
```

This example shows that the user started a new transaction with isolation level equal to SERIALIZABLE and named it 'update inventory checkpoint 0'.

For distributed transactions, the name is sent to participating sites when a transaction is committed. If a COMMIT COMMENT exists, it is ignored when a transaction name exists.

The transaction name is displayed in the NAME column of the V$TRANSACTION view, and is placed in the TRAN_COMMENT column of the view when the transaction is committed.

Determining the ID Number and Status of Prepared Transactions

The following view shows the database links that have been defined at the local database and stored in the data dictionary:

View	Purpose
DBA_2PC_PENDING	Lists all in-doubt distributed transactions. The view is empty until populated by an in-doubt transaction. After the transaction is resolved, the view is purged.

Use this view to determine the global commit number for a particular transaction ID. You can use this global commit number when manually resolving an in-doubt transaction.

The following table shows the most relevant columns (for a description of all the columns in the view, see *Oracle9i Database Reference*):

Table 32–1 DBA_2PC_PENDING

Column	Description
LOCAL_TRAN_ID	Local transaction identifier in the format *integer.integer.integer.* **Note:** When the LOCAL_TRAN_ID and the GLOBAL_TRAN_ID for a connection are the same, the node is the global coordinator of the transaction.

Table 32–1 DBA_2PC_PENDING

Column	Description
GLOBAL_TRAN_ID	Global database identifier in the format *global_db_name*.*db_hex_id*.*local_tran_id*, where *db_hex_id* is an eight-character hexadecimal value used to uniquely identify the database. This common transaction ID is the same on every node for a distributed transaction. **Note:** When the LOCAL_TRAN_ID and the GLOBAL_TRAN_ID for a connection are the same, the node is the global coordinator of the transaction.
STATE	See Table 32–2, "STATE Column of DBA_2PC_PENDING".
MIXED	YES means that part of the transaction was committed on one node and rolled back on another node.
TRAN_COMMENT	Transaction comment or, if using transaction naming, the transaction name is placed here when the transaction is committed.
HOST	Name of the host machine.
COMMIT#	Global commit number for committed transactions.

Table 32–2 STATE Column of DBA_2PC_PENDING

Collecting	This category normally applies only to the global coordinator or local coordinators. The node is currently collecting information from other database servers before it can decide whether it can prepare.
Prepared	The node has prepared and may or may not have acknowledged this to its local coordinator with a prepared message. However, no commit request has been received. The node remains prepared, holding any local resource locks necessary for the transaction to commit.
Committed	The node (any type) has committed the transaction, but other nodes involved in the transaction may not have done the same. That is, the transaction is still pending at one or more nodes.
Forced commit	A pending transaction can be forced to commit at the discretion of a database administrator. This entry occurs if a transaction is manually committed at a local node by a database administrator.
Forced abort (rollback)	A pending transaction can be forced to roll back at the discretion of a database administrator. This entry occurs if this transaction is manually rolled back at a local node by a database administrator.

Execute the following script to query pertinent information in DBA_2PC_PENDING (sample output included):

```
COL LOCAL_TRAN_ID FORMAT A13
COL GLOBAL_TRAN_ID FORMAT A30
COL STATE FORMAT A8
COL MIXED FORMAT A3
COL HOST FORMAT A10
COL COMMIT# FORMAT A10

SELECT LOCAL_TRAN_ID, GLOBAL_TRAN_ID, STATE, MIXED, HOST, COMMIT#
FROM DBA_2PC_PENDING
/

SQL> @pending_txn_script

LOCAL_TRAN_ID GLOBAL_TRAN_ID                  STATE    MIX HOST       COMMIT#
------------- ------------------------------ -------- --- ---------- ----------
1.15.870      HQ.ACME.COM.ef192da4.1.15.870  commit   no  dlsun183   115499
```

This output indicates that local transaction 1.15.870 has been committed on this node, but it may be pending on one or more other nodes. Because LOCAL_TRAN_ID and the local part of GLOBAL_TRAN_ID are the same, the node is the global coordinator of the transaction.

Tracing the Session Tree of In-Doubt Transactions

The following view shows which in-doubt transactions are incoming from a remote client and which are outgoing to a remote server:

View	Purpose
DBA_2PC_NEIGHBORS	Lists all incoming (from remote client) and outgoing (to remote server) in-doubt distributed transactions. It also indicates whether the local node is the commit point site in the transaction. The view is empty until populated by an in-doubt transaction. After the transaction is resolved, the view is purged.

When a transaction is in-doubt, you may need to determine which nodes performed which roles in the session tree. Use to this view to determine:

- All the incoming and outgoing connections for a given transaction

- Whether the node is the commit point site in a given transaction
- Whether the node is a global coordinator in a given transaction (because its local transaction ID and global transaction ID are the same)

The following table shows the most relevant columns (for an account of all the columns in the view, see *Oracle9i Database Reference*):

Table 32–3 DBA_2PC_NEIGHBORS

Column	Description
LOCAL_TRAN_ID	Local transaction identifier with the format *integer.integer.integer*. **Note:** When LOCAL_TRAN_ID and GLOBAL_TRAN_ID.DBA_2PC_PENDING for a connection are the same, the node is the global coordinator of the transaction.
IN_OUT	IN for incoming transactions; OUT for outgoing transactions.
DATABASE	For incoming transactions, the name of the client database that requested information from this local node; for outgoing transactions, the name of the database link used to access information on a remote server.
DBUSER_OWNER	For incoming transactions, the local account used to connect by the remote database link; for outgoing transactions, the owner of the database link.
INTERFACE	C is a commit message; N is either a message indicating a prepared state or a request for a read-only commit. When IN_OUT is OUT, C means that the child at the remote end of the connection is the commit point site and knows whether to commit or abort. N means that the local node is informing the remote node that it is prepared. When IN_OUT is IN, C means that the local node or a database at the remote end of an outgoing connection is the commit point site. N means that the remote node is informing the local node that it is prepared.

Execute the following script to query pertinent information in DBA_2PC_PENDING (sample output included):

```
COL LOCAL_TRAN_ID FORMAT A13
COL IN_OUT FORMAT A6
COL DATABASE FORMAT A25
COL DBUSER_OWNER FORMAT A15
COL INTERFACE FORMAT A3
```

```
SELECT LOCAL_TRAN_ID, IN_OUT, DATABASE, DBUSER_OWNER, INTERFACE
FROM DBA_2PC_NEIGHBORS
/

SQL> CONNECT SYS/password@hq.acme.com
SQL> @neighbors_script

LOCAL_TRAN_ID IN_OUT DATABASE                  DBUSER_OWNER    INT
------------- ------ ------------------------- --------------- ---
1.15.870      out    SALES.ACME.COM            SYS             C
```

This output indicates that the local node sent an outgoing request to remote server `sales` to commit transaction `1.15.870`. If `sales` committed the transaction but no other node did, then you know that `sales` is the commit point site—because the commit point site always commits first.

Deciding How to Handle In-Doubt Transactions

A transaction is in-doubt when there is a failure during any aspect of the two-phase commit. Distributed transactions become in-doubt in the following ways:

- A server machine running Oracle software crashes
- A network connection between two or more Oracle databases involved in distributed processing is disconnected
- An unhandled software error occurs

> **See Also:** "In-Doubt Transactions" on page 31-17 for a conceptual overview of in-doubt transactions

You can manually force the commit or rollback of a local, in-doubt distributed transaction. Because this operation can generate consistency problems, perform it only when specific conditions exist.

This section contains the following topics:

- Discovering Problems with a Two-Phase Commit
- Determining Whether to Perform a Manual Override
- Analyzing the Transaction Data

Discovering Problems with a Two-Phase Commit

The user application that commits a distributed transaction is informed of a problem by one of the following error messages:

```
ORA-02050: transaction ID rolled back,
           some remote dbs may be in-doubt
ORA-02051: transaction ID committed,
           some remote dbs may be in-doubt
ORA-02054: transaction ID in-doubt
```

A robust application should save information about a transaction if it receives any of the above errors. This information can be used later if manual distributed transaction recovery is desired.

No action is required by the administrator of any node that has one or more in-doubt distributed transactions due to a network or system failure. The automatic recovery features of Oracle transparently complete any in-doubt transaction so that the same outcome occurs on all nodes of a session tree (that is, all commit or all roll back) after the network or system failure is resolved.

In extended outages, however, you can force the commit or rollback of a transaction to release any locked data. Applications must account for such possibilities.

Determining Whether to Perform a Manual Override

Override a specific in-doubt transaction manually *only* when one of the following situations exists:

- The in-doubt transaction locks data that is required by other transactions. This situation occurs when the ORA-01591 error message interferes with user transactions.
- An in-doubt transaction prevents the extents of a rollback segment from being used by other transactions. The first portion of an in-doubt distributed transaction's local transaction ID corresponds to the ID of the rollback segment, as listed by the data dictionary views DBA_2PC_PENDING and DBA_ROLLBACK_SEGS.
- The failure preventing the two-phase commit phases to complete cannot be corrected in an acceptable time period. Examples of such cases include a telecommunication network that has been damaged or a damaged database that requires a long recovery time.

Normally, you should make a decision to locally force an in-doubt distributed transaction in consultation with administrators at other locations. A wrong decision can lead to database inconsistencies that can be difficult to trace and that you must manually correct.

If the conditions above do not apply, *always* allow the automatic recovery features of Oracle to complete the transaction. If any of the above criteria are met, however, consider a local override of the in-doubt transaction.

Analyzing the Transaction Data

If you decide to force the transaction to complete, analyze available information with the following goals in mind.

Find a Node That Committed or Rolled Back

Use the DBA_2PC_PENDING view to find a node that has either committed or rolled back the transaction. If you can find a node that has already resolved the transaction, then you can follow the action taken at that node.

Look For Transaction Comments

See if any information is given in the TRAN_COMMENT column of DBA_2PC_PENDING for the distributed transaction. Comments are included in the COMMENT clause of the COMMIT statement, or if transaction naming is used, the transaction name is placed in the TRAN_COMMENT field when the transaction is committed.

For example, an in-doubt distributed transaction's comment can indicate the origin of the transaction and what type of transaction it is:

```
COMMIT COMMENT 'Finance/Accts_pay/Trans_type 10B';
```

A SET TRANSACTION ... NAME statement could also have been used (and is preferable) to provide this information in a transaction name.

See Also: "Transaction Naming" on page 32-4

Look For Transaction Advice

See if any information is given in the ADVICE column of DBA_2PC_PENDING for the distributed transaction. An application can prescribe advice about whether to force the commit or force the rollback of separate parts of a distributed transaction with the ADVISE clause of the ALTER SESSION statement.

The advice sent during the prepare phase to each node is the advice in effect at the time the most recent DML statement executed at that database in the current transaction.

For example, consider a distributed transaction that moves an employee record from the emp table at one node to the emp table at another node. The transaction can

protect the record—even when administrators independently force the in-doubt transaction at each node—by including the following sequence of SQL statements:

```
ALTER SESSION ADVISE COMMIT;
INSERT INTO emp@hq ... ;    /*advice to commit at HQ */
ALTER SESSION ADVISE ROLLBACK;
DELETE FROM emp@sales ... ; /*advice to roll back at SALES*/

ALTER SESSION ADVISE NOTHING;
```

If you manually force the in-doubt transaction following the given advice, the worst that can happen is that each node has a copy of the employee record; the record cannot disappear.

Manually Overriding In-Doubt Transactions

Use the COMMIT or ROLLBACK statement with the FORCE option and a text string that indicates either the local or global transaction ID of the in-doubt transaction to commit.

> **Note:** In all examples, the transaction is committed or rolled back on the local node, and the local pending transaction table records a value of forced commit or forced abort for the STATE column of this transaction's row.

This section contains the following topics:

- Manually Committing an In-Doubt Transaction
- Manually Rolling Back an In-Doubt Transaction

Manually Committing an In-Doubt Transaction

Before attempting to commit the transaction, ensure that you have the proper privileges. Note the following requirements:

If the transaction was committed by...	Then you must have this privilege...
You	FORCE TRANSACTION
Another user	FORCE ANY TRANSACTION

Committing Using Only the Transaction ID

The following SQL statement commits an in-doubt transaction:

```
COMMIT FORCE 'transaction_id';
```

The variable *transaction_id* is the identifier of the transaction as specified in either the LOCAL_TRAN_ID or GLOBAL_TRAN_ID columns of the DBA_2PC_PENDING data dictionary view.

For example, assume that you query DBA_2PC_PENDING and determine the local transaction ID for a distributed transaction:

```
LOCAL_TRAN_ID           1.45.13
```

You then issue the following SQL statement to force the commit of this in-doubt transaction:

```
COMMIT FORCE '1.45.13';
```

Committing Using an SCN

Optionally, you can specify the SCN for the transaction when forcing a transaction to commit. This feature allows you to commit an in-doubt transaction with the SCN assigned when it was committed at other nodes.

Consequently, you maintain the synchronized commit time of the distributed transaction even if there is a failure. Specify an SCN only when you can determine the SCN of the same transaction already committed at another node.

For example, assume you want to manually commit a transaction with the following global transaction ID:

```
SALES.ACME.COM.55d1c563.1.93.29
```

First, query the DBA_2PC_PENDING view of a remote database also involved with the transaction in question. Note the SCN used for the commit of the transaction at that node. Specify the SCN when committing the transaction at the local node. For example, if the SCN is 829381993, issue:

```
COMMIT FORCE 'SALES.ACME.COM.55d1c563.1.93.29', 829381993;
```

> **See Also:** *Oracle9i SQL Reference* for more information about using the COMMIT statement

Manually Rolling Back an In-Doubt Transaction

Before attempting to roll back the in-doubt distributed transaction, ensure that you have the proper privileges. Note the following requirements:

If the transaction was committed by...	Then you must have this privilege...
You	FORCE TRANSACTION
Another user	FORCE ANY TRANSACTION

The following SQL statement rolls back an in-doubt transaction:

```
ROLLBACK FORCE 'transaction_id';
```

The variable *transaction_id* is the identifier of the transaction as specified in either the LOCAL_TRAN_ID or GLOBAL_TRAN_ID columns of the DBA_2PC_PENDING data dictionary view.

For example, to roll back the in-doubt transaction with the local transaction ID of 2.9.4, use the following statement:

```
ROLLBACK FORCE '2.9.4';
```

Note: You cannot roll back an in-doubt transaction to a savepoint.

See Also: *Oracle9i SQL Reference* for more information about using the ROLLBACK statement

Purging Pending Rows from the Data Dictionary

Before RECO recovers an in-doubt transaction, the transaction appears in DBA_2PC_PENDING.STATE as COLLECTING, COMMITTED, or PREPARED. If you force an in-doubt transaction using COMMIT FORCE or ROLLBACK FORCE, then the states FORCED COMMIT or FORCED ROLLBACK may appear.

Automatic recovery normally deletes entries in these states. The only exception is when recovery discovers a forced transaction that is in a state inconsistent with other sites in the transaction. In this case, the entry can be left in the table and the MIXED column in DBA_2PC_PENDING has a value of YES. These entries can be cleaned up with the DBMS_TRANSACTION.PURGE_MIXED procedure.

If automatic recovery is not possible because a remote database has been permanently lost, then recovery cannot identify the re-created database because it receives a new database ID when it is re-created. In this case, you must use the PURGE_LOST_DB_ENTRY procedure in the DBMS_TRANSACTION package to clean up the entries. The entries do not hold up database resources, so there is no urgency in cleaning them up.

Executing the PURGE_LOST_DB_ENTRY Procedure

To manually remove an entry from the data dictionary, use the following syntax (where *trans_id* is the identifier for the transaction):

```
DBMS_TRANSACTION.PURGE_LOST_DB_ENTRY('trans_id');
```

For example, to purge pending distributed transaction `1.44.99`, enter the following statement in SQL*Plus:

```
EXECUTE DBMS_TRANSACTION.PURGE_LOST_DB_ENTRY('1.44.99');
```

Execute this procedure only if significant reconfiguration has occurred so that automatic recovery cannot resolve the transaction. Examples include:

- Total loss of the remote database
- Reconfiguration in software resulting in loss of two-phase commit capability
- Loss of information from an external transaction coordinator such as a TPMonitor

> **See Also:** *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the DBMS_TRANSACTION package

Determining When to Use DBMS_TRANSACTION

The following tables indicates what the various states indicate about the distributed transaction what the administrator's action should be:

STATE Column	State of Global Transaction	State of Local Transaction	Normal Action	Alternative Action
Collecting	Rolled back	Rolled back	None	PURGE_LOST_DB_ENTRY (only if autorecovery cannot resolve transaction)

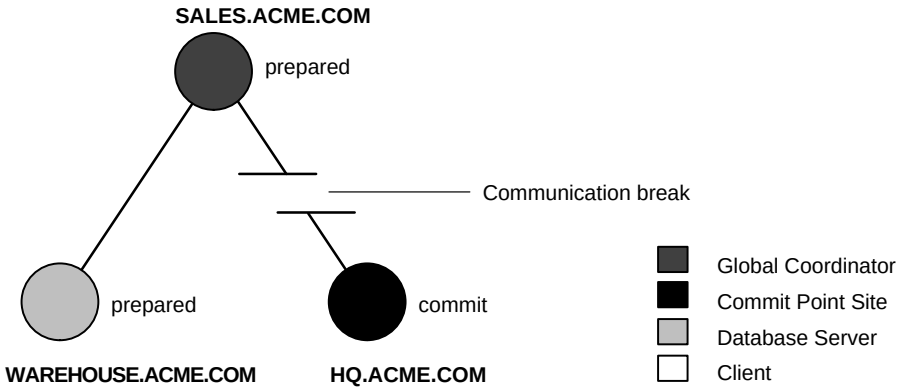
STATE Column	State of Global Transaction	State of Local Transaction	Normal Action	Alternative Action
Committed	Committed	Committed	None	PURGE_LOST_DB_ENTRY (only if autorecovery cannot resolve transaction)
Prepared	Unknown	Prepared	None	Force commit or rollback
Forced commit	Unknown	Committed	None	PURGE_LOST_DB_ENTRY (only if autorecovery cannot resolve transaction)
Forced rollback	Unknown	Rolled back	None	PURGE_LOST_DB_ENTRY (only if autorecovery cannot resolve transaction)
Forced commit	Mixed	Committed	Manually remove inconsistencies then use PURGE_MIXED	
Forced rollback	Mixed	Rolled back	Manually remove inconsistencies then use PURGE_MIXED	

See Also: *Oracle9i Supplied PL/SQL Packages and Types Reference* for more information about the DBMS_TRANSACTION package

Manually Committing an In-Doubt Transaction: Example

The following example, illustrated in Figure 32–1, shows a failure during the commit of a distributed transaction. It explains how to go about gaining information before manually forcing the commit or rollback of the local portion of an in-doubt distributed transaction.

Figure 32–1 Example of an In-Doubt Distributed Transaction



In this failure case, the prepare phase completes. During the commit phase, however, the commit point site's commit confirmation never reaches the global coordinator, even though the commit point site committed the transaction.

You are the `warehouse` database administrator. The inventory data locked because of the in-doubt transaction is critical to other transactions. The data cannot be accessed, however, because the locks must be held until the in-doubt transaction either commits or rolls back. Furthermore, you understand that the communication link between sales and headquarters cannot be resolved immediately.

Therefore, you decide to manually force the local portion of the in-doubt transaction using the following steps:

1. Record user feedback.
2. Query the local `DBA_2PC_PENDING` view to obtain the global transaction ID and get other information about the in-doubt transaction.
3. Query the local `DBA_2PC_NEIGHBORS` view to begin tracing the session tree so that you can find a node that resolved the in-doubt transaction.
4. Check the mixed outcome flag after normal communication is reestablished.

The following sections explain each step in detail for this example:

Step 1: Record User Feedback

Step 2: Query DBA_2PC_PENDING

Step 3: Query DBA_2PC_NEIGHBORS on Local Node

Step 1: Record User Feedback

The users of the local database system that conflict with the locks of the in-doubt transaction receive the following error message:

```
ORA-01591: lock held by in-doubt distributed transaction 1.21.17
```

In this case, `1.21.17` is the local transaction ID of the in-doubt distributed transaction. You should request and record this ID number from users that report problems to identify which in-doubt transactions should be forced.

Step 2: Query DBA_2PC_PENDING

After connecting with SQL*Plus to `warehouse`, query the local `DBA_2PC_PENDING` data dictionary view to gain information about the in-doubt transaction:

```
CONNECT SYS/password@warehouse.acme.com
SELECT * FROM DBA_2PC_PENDING WHERE LOCAL_TRAN_ID = '1.21.17';
```

Oracle returns the following information:

```
Column Name          Value
-------------------- -----------------------------------
LOCAL_TRAN_ID        1.21.17
GLOBAL_TRAN_ID       SALES.ACME.COM.55d1c563.1.93.29
STATE                prepared
MIXED                no
ADVICE
TRAN_COMMENT         Sales/New Order/Trans_type 10B
FAIL_TIME            31-MAY-91
FORCE_TIME
RETRY_TIME           31-MAY-91
OS_USER              SWILLIAMS
OS_TERMINAL          TWA139:
HOST                 system1
DB_USER              SWILLIAMS
COMMIT#
```

Determining the Global Transaction ID

The global transaction ID is the common transaction ID that is the same on every node for a distributed transaction. It is of the form:

```
global_database_name.hhhhhhhh.local_transaction_id
```

where:

`global_database_name`	is the database name of the global coordinator.
`hhhhhhh`	is the internal database identifier of the global coordinator (in hexadecimal).
`local_transaction_id`	is the corresponding local transaction ID assigned on the global coordinator.

Note that the last portion of the global transaction ID and the local transaction ID match at the global coordinator. In the example, you can tell that `warehouse` is *not* the global coordinator because these numbers do not match:

```
LOCAL_TRAN_ID          1.21.17
GLOBAL_TRAN_ID         ... 1.93.29
```

Determining the State of the Transaction

The transaction on this node is in a prepared state:

```
STATE                  prepared
```

Therefore, `warehouse` waits for its coordinator to send either a commit or a rollback request.

Looking For Comments or Advice

The transaction's comment or advice can include information about this transaction. If so, use this comment to your advantage. In this example, the origin and transaction type is in the transaction's comment:

```
TRAN_COMMENT           Sales/New Order/Trans_type 10B
```

It could also be provided as a transaction name with a `SET TRANSACTION ... NAME` statement.

This information can reveal something that helps you decide whether to commit or rollback the local portion of the transaction. If useful comments do not accompany an in-doubt transaction, you must complete some extra administrative work to trace the session tree and find a node that has resolved the transaction.

Step 3: Query DBA_2PC_NEIGHBORS on Local Node

The purpose of this step is to climb the session tree so that you find coordinators, eventually reaching the global coordinator. Along the way, you may find a coordinator that has resolved the transaction. If not, you can eventually work your way to the commit point site, which will always have resolved the in-doubt transaction. To trace the session tree, query the DBA_2PC_NEIGHBORS view on each node.

In this case, you query this view on the warehouse database:

```
CONNECT SYS/password@warehouse.acme.com
SELECT * FROM DBA_2PC_NEIGHBORS
  WHERE LOCAL_TRAN_ID = '1.21.17'
  ORDER BY SESS#, IN_OUT;

Column Name           Value
--------------------- -------------------------------------
LOCAL_TRAN_ID         1.21.17
IN_OUT                in
DATABASE              SALES.ACME.COM
DBUSER_OWNER          SWILLIAMS
INTERFACE             N
DBID                  000003F4
SESS#                 1
BRANCH                0100
```

Obtaining Database Role and Database Link Information

The DBA_2PC_NEIGHBORS view provides information about connections associated with an in-doubt transaction. Information for each connection is different, based on whether the connection is **inbound** (IN_OUT = in) or **outbound** (IN_OUT = out):

IN_OUT	Meaning	DATABASE	DBUSER_OWNER
in	Your node is a server of another node.	Lists the name of the client database that connected to your node.	Lists the local account for the database link connection that corresponds to the in-doubt transaction.
out	Your node is a client of other servers.	Lists the name of the database link that connects to the remote node.	Lists the owner of the database link for the in-doubt transaction.

In this example, the IN_OUT column reveals that the warehouse database is a server for the sales client, as specified in the DATABASE column:

```
IN_OUT                  in
DATABASE                SALES.ACME.COM
```

The connection to warehouse was established through a database link from the swilliams account, as shown by the DBUSER_OWNER column:

```
DBUSER_OWNER            SWILLIAMS
```

Determining the Commit Point Site

Additionally, the INTERFACE column tells whether the local node or a subordinate node is the commit point site:

```
INTERFACE               N
```

Neither warehouse nor any of its descendants is the commit point site, as shown by the INTERFACE column.

Step 4: Querying Data Dictionary Views on All Nodes

At this point, you can contact the administrator at the located nodes and ask each person to repeat Steps 2 and 3 using the global transaction ID.

> **Note:** If you can directly connect to these nodes with another network, you can repeat Steps 2 and 3 yourself.

For example, the following results are returned when Steps 2 and 3 are performed at sales and hq.

Checking the Status of Pending Transactions at sales

At this stage, the sales administrator queries the DBA_2PC_PENDING data dictionary view:

```
SQL> CONNECT SYS/password@sales.acme.com
SQL> SELECT * FROM DBA_2PC_PENDING
  > WHERE GLOBAL_TRAN_ID = 'SALES.ACME.COM.55d1c563.1.93.29';

Column Name             Value
----------------------- ------------------------------------
LOCAL_TRAN_ID           1.93.29
```

```
GLOBAL_TRAN_ID          SALES.ACME.COM.55d1c563.1.93.29
STATE                   prepared
MIXED                   no
ADVICE
TRAN_COMMENT            Sales/New Order/Trans_type 10B
FAIL_TIME               31-MAY-91
FORCE_TIME
RETRY_TIME              31-MAY-91
OS_USER                 SWILLIAMS
OS_TERMINAL             TWA139:
HOST                    system1
DB_USER                 SWILLIAMS
COMMIT#
```

Determining the Coordinators and Commit Point Site at sales

Next, the `sales` administrator queries `DBA_2PC_NEIGHBORS` to determine the global and local coordinators as well as the commit point site:

```
SELECT * FROM DBA_2PC_NEIGHBORS
   WHERE GLOBAL_TRAN_ID = 'SALES.ACME.COM.55d1c563.1.93.29'
   ORDER BY SESS#, IN_OUT;
```

This query returns three rows:

- The connection to `warehouse`
- The connection to `hq`
- The connection established by the user

Reformatted information corresponding to the rows for the `warehouse` connection appears below:

```
Column Name           Value
--------------------- -------------------------------------
LOCAL_TRAN_ID         1.93.29
IN_OUT                OUT
DATABASE              WAREHOUSE.ACME.COM
DBUSER_OWNER          SWILLIAMS
INTERFACE             N
DBID                  55d1c563
SESS#                 1
BRANCH                1
```

Reformatted information corresponding to the rows for the `hq` connection appears below:

```
Column Name          Value
-------------------- -------------------------------------
LOCAL_TRAN_ID        1.93.29
IN_OUT               OUT
DATABASE             HQ.ACME.COM
DBUSER_OWNER         ALLEN
INTERFACE            C
DBID                 00000390
SESS#                1
BRANCH               1
```

The information from the previous queries reveal the following:

- `sales` is the global coordinator because the local transaction ID and global transaction ID match.
- Two outbound connections are established from this node, but no inbound connections. `sales` is not the server of another node.
- `hq` or one of its servers is the commit point site.

Checking the Status of Pending Transactions at HQ:

At this stage, the `hq` administrator queries the `DBA_2PC_PENDING` data dictionary view:

```
SELECT * FROM DBA_2PC_PENDING@hq.acme.com
   WHERE GLOBAL_TRAN_ID = 'SALES.ACME.COM.55d1c563.1.93.29';

Column Name          Value
-------------------- -------------------------------------
LOCAL_TRAN_ID        1.45.13
GLOBAL_TRAN_ID       SALES.ACME.COM.55d1c563.1.93.29
STATE                COMMIT
MIXED                NO
ACTION
TRAN_COMMENT         Sales/New Order/Trans_type 10B
FAIL_TIME            31-MAY-91
FORCE_TIME
RETRY_TIME           31-MAY-91
OS_USER              SWILLIAMS
OS_TERMINAL          TWA139:
HOST                 SYSTEM1
DB_USER              SWILLIAMS
COMMIT#              129314
```

At this point, you have found a node that resolved the transaction. As the view reveals, it has been committed and assigned a commit ID number:

```
STATE                COMMIT
COMMIT#              129314
```

Therefore, you can force the in-doubt transaction to commit at your local database. It is a good idea to contact any other administrators you know that could also benefit from your investigation.

Step 5: Commit the In-Doubt Transaction

You contact the administrator of the `sales` database, who manually commits the in-doubt transaction using the global ID:

```
SQL> CONNECT SYS/password@sales.acme.com
SQL> COMMIT FORCE 'SALES.ACME.COM.55d1c563.1.93.29';
```

As administrator of the `warehouse` database, you manually commit the in-doubt transaction using the global ID:

```
SQL> CONNECT SYS/password@warehouse.acme.com
SQL> COMMIT FORCE 'SALES.ACME.COM.55d1c563.1.93.29';
```

Step 6: Check for Mixed Outcome Using DBA_2PC_PENDING

After you manually force a transaction to commit or roll back, the corresponding row in the pending transaction table remains. The state of the transaction is changed depending on how you forced the transaction.

Every Oracle database has a **pending transaction table**. This is a special table that stores information about distributed transactions as they proceed through the two-phase commit phases. You can query a database's pending transaction table through the `DBA_2PC_PENDING` data dictionary view (see Table 32–1, "DBA_2PC_PENDING").

Also of particular interest in the pending transaction table is the mixed outcome flag as indicated in `DBA_2PC_PENDING.MIXED`. You can make the wrong choice if a pending transaction is forced to commit or roll back. For example, the local administrator rolls back the transaction, but the other nodes commit it. Incorrect decisions are detected automatically, and the damage flag for the corresponding pending transaction's record is set (`MIXED=yes`).

The RECO (Recoverer) background process uses the information in the pending transaction table to finalize the status of in-doubt transactions. You can also use the

information in the pending transaction table to manually override the automatic recovery procedures for pending distributed transactions.

All transactions automatically resolved by RECO are removed from the pending transaction table. Additionally, all information about in-doubt transactions correctly resolved by an administrator (as checked when RECO reestablishes communication) are automatically removed from the pending transaction table. However, all rows resolved by an administrator that result in a mixed outcome across nodes remain in the pending transaction table of all involved nodes until they are manually deleted using `DBMS_TRANSACTIONS.PURGE_MIXED`.

Data Access Failures Due To Locks

When you issue a SQL statement, Oracle attempts to lock the resources needed to successfully execute the statement. If the requested data is currently held by statements of other uncommitted transactions, however, and remains locked for a long time, a timeout occurs.

Consider the following scenarios involving data access failure:

- Transaction Timeouts
- Locks fenables you torom In-Doubt Transactions

Transaction Timeouts

A DML statement that requires locks on a remote database can be blocked if another transaction own locks on the requested data. If these locks continue to block the requesting SQL statement, then the following sequence of events occurs:

1. A timeout occurs.
2. Oracle rolls back the statement.
3. Oracle returns this error message to the user:

```
ORA-02049: time-out: distributed transaction waiting for lock
```

Because the transaction did not modify data, no actions are necessary as a result of the timeout. Applications should proceed as if a deadlock has been encountered. The user who executed the statement can try to reexecute the statement later. If the lock persists, then the user should contact an administrator to report the problem.

Locks fenables you torom In-Doubt Transactions

A query or DML statement that requires locks on a local database can be blocked indefinitely due to the locked resources of an in-doubt distributed transaction. In this case, Oracle issues the following error message:

```
ORA-01591: lock held by in-doubt distributed transaction identifier
```

In this case, Oracle rolls back the SQL statement immediately. The user who executed the statement can try to reexecute the statement later. If the lock persists, the user should contact an administrator to report the problem, *including* the ID of the in-doubt distributed transaction.

The chances of the above situations occurring are rare considering the low probability of failures during the critical portions of the two-phase commit. Even if such a failure occurs, and assuming quick recovery from a network or system failure, problems are automatically resolved without manual intervention. Thus, problems usually resolve before they can be detected by users or database administrators.

Simulating Distributed Transaction Failure

You can force the failure of a distributed transaction for the following reasons:

- To observe RECO automatically resolving the local portion of the transaction
- To practice manually resolving in-doubt distributed transactions and observing the results

The RECO background process of an Oracle instance automatically resolves failures involving distributed transactions. At exponentially growing time intervals, the RECO background process of a node attempts to recover the local portion of an in-doubt distributed transaction.

RECO can use an existing connection or establish a new connection to other nodes involved in the failed transaction. When a connection is established, RECO automatically resolves all in-doubt transactions. Rows corresponding to any resolved in-doubt transactions are automatically removed from each database's pending transaction table.

You can enable and disable RECO using the `ALTER SYSTEM` statement with the `ENABLE/DISABLE DISTRIBUTED RECOVERY` options. For example, you can temporarily disable RECO to force the failure of a two-phase commit and manually resolve the in-doubt transaction.

The following statement disables RECO:

```
ALTER SYSTEM DISABLE DISTRIBUTED RECOVERY;
```

Alternatively, the following statement enables RECO so that in-doubt transactions are automatically resolved:

```
ALTER SYSTEM ENABLE DISTRIBUTED RECOVERY;
```

Note: Single-process instances (for example, a PC running MS-DOS) have no separate background processes, and therefore no RECO process. Therefore, when a single-process instance that participates in a distributed system is started, you must manually enable distributed recovery using the statement above.

See Also: Your Oracle operating system specific documentation for more information about distributed transaction recovery for single-process instances

Managing Read Consistency

An important restriction exists in Oracle's implementation of distributed read consistency. The problem arises because each system has its own SCN, which you can view as the database's internal timestamp. The Oracle database server uses the SCN to decide which version of data is returned from a query.

The SCNs in a distributed transaction are synchronized at the end of each remote SQL statement and at the start and end of each transaction. Between two nodes that have heavy traffic and especially distributed updates, the synchronization is frequent. Nevertheless, no practical way exists to keep SCNs in a distributed system absolutely synchronized: a window always exists in which one node may have an SCN that is somewhat in the past with respect to the SCN of another node.

Because of the SCN gap, you can execute a query that uses a slightly old snapshot, so that the most recent changes to the remote database are not seen. In accordance with read consistency, a query can therefore retrieve consistent, but out-of-date data. Note that all data retrieved by the query will be from the old SCN, so that if a locally executed update transaction updates two tables at a remote node, then data selected from both tables in the next remote access contain data prior to the update.

One consequence of the SCN gap is that two consecutive SELECT statements can retrieve different data even though no DML has been executed between the two

statements. For example, you can issue an update statement and then commit the update on the remote database. When you issue a SELECT statement on a view based on this remote table, the view does not show the update to the row. The next time that you issue the SELECT statement, the update is present.

You can use the following techniques to ensure that the SCNs of the two machines are synchronized just before a query:

- Because SCNs are synchronized at the end of a remote query, precede each remote query with a dummy remote query to the same site, for example, SELECT * FROM DUAL@REMOTE.
- Because SCNs are synchronized at the start of every remote transaction, commit or roll back the current transaction before issuing the remote query.

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