Oracle Database 10*g*: Administration Workshop II

Electronic Presentation

D17092GC30
Edition 3.0
January 2006
D44163

ORACLE®

Authors

Tom Best
M.J. Billings

Technical Contributors and Reviewers

Herbert Bradbury
Howard Bradley
Harald van Breederode
M.J. Bryksa
Donna Cooksey
Joe Fong
Andy Fortunak
Gerlinde Frenzen
Joel Goodman
Sushma Jagannath
Christine Jeal
Pierre Labrousse
Jerry Lee
Stefan Lindblad
Wendy Lo
Yi Lu
Andreas Reinhardt
Ira Singer
James Spiller
Janet Stern
Jean-Francois Verrier

Editors

Aju Kumar
Nita Pavitran

Graphic Designers

Steve Elwood
Sanjeev Sharma

Publisher

Sujatha Nagendra

Preface

Profile

Before You Begin This Course

Before you begin this course, you should have the following qualifications:

- Working experience with SQL and knowledge of basic Unix commands

Prerequisites

Oracle Database 10g: Administration Workshop I (D17090GC30)

How This Course Is Organized

Oracle Database 10g: Administration Workshop I is an instructor-led course featuring lecture and hands-on exercises. Online demonstrations and written practice sessions reinforce the concepts and skills introduced.

Suggested Next Courses

- *Oracle Database 10g: SQL Tuning Workshop* (D17265GC10)
- *Oracle Enterprise Manager 10g Grid Control* (D17244GC11)
- *Oracle Database 10g: Real Application Clusters* (D17276GC10)
- *Oracle Database 10g: Implement Streams* (D17333GC10)
- *Oracle Database 10g: Data Guard Administration* (D17316GC11)

Related Publications

Oracle Publications

Title	Part Number
Oracle Database 2 Day DBA 10g Release 2 (10.2)	B14196-02
Oracle Database Administrator's Guide 10g Release 2 (10.2)	B14231-01
Oracle Database Application Developer's Guide - Large Objects 10g Release 2 (10.2)	B14249-01
Oracle Database Backup and Recovery Advanced User's Guide 10g Release 2 (10.2)	B14191-02
Oracle Database Backup and Recovery Basics 10g Release 2 (10.2)	B14192-03
Oracle Database Concepts 10g Release 2 (10.2)	B14220-02
Oracle Database Data Warehousing Guide 10g Release 2 (10.2)	B14223-02
Oracle Database Globalization Support Guide 10g Release 2 (10.2)	B14225-01
Oracle Database Licensing Information 10g Release 2 (10.2)	B14199-02
Oracle Database Net Services Administrator's Guide 10g Release 2 (10.2)	B14212-02
Oracle Database Net Services Reference 10g Release 2 (10.2)	B14213-01
Oracle Database New Features Guide 10g Release 2 (10.2)	B14214-02
Oracle Database Performance Tuning Guide 10g Release 2 (10.2)	B14211-01
Oracle Database PL/SQL Packages and Types Reference 10g Release 2 (10.2)	B14258-01
Oracle Database PL/SQL User's Guide and Reference 10g Release 2 (10.2)	B14261-01
Oracle Database Recovery Manager Quick Start Guide 10g Release 2 (10.2)	B14193-03
Oracle Database Recovery Manager Reference 10g Release 2 (10.2)	B14194-03
Oracle Database Reference 10g Release 2 (10.2)	B14237-02
Oracle Database Security Guide 10g Release 2 (10.2)	B14266-01
Oracle Database SQL Quick Reference 10g Release 2 (10.2)	B14195-02
Oracle Database SQL Reference 10g Release 2 (10.2)	B14200-02
Oracle Database Utilities 10g Release 2 (10.2)	B14215-01
Oracle Streams Advanced Queuing User's Guide and Reference	B14257-01
Oracle Streams Concepts and Administration	B14229-01

Additional Publications

- System release bulletins
- Installation and user guides
- *read.me* files
- International Oracle Users Group (IOUG) articles
- *Oracle Magazine*

Typographic Conventions

Typographic Conventions in Text

Convention	Element	Example
Bold	Emphasized words and phrases in Web content only	To navigate within this application, do **not** click the Forward and Back buttons.
Bold italic	Glossary term (if there is a glossary)	The ***algorithm*** inserts the new key.
Brackets	Key names	Press [Enter].
Caps and lowercase	Buttons, check boxes, application triggers, windows	Click the Executable button. Select the Can't Delete Card check box. Assign a When-Validate-Item trigger to the ORD block. Open the Master Schedule window.
Angle brackets	Menu paths	Select File > Save.
Commas	Key sequences	Press and release the following keys one at a time: [Alt], [F], [D]
Courier new, case sensitive (default is lowercase)	Code output, directory names, file names, passwords, path names, user input, usernames	Code output: `debug.set ('I', 300);` Directory: `bin` (DOS), `$FMHOME` (UNIX) File name: Locate the `init.ora` file. Password: Use `tiger` as your password. Path name: Open `c:\my_docs\projects`. User input: Enter `300`. Username: Log in as `HR`.
Initial cap	Graphics labels (unless the term is a proper noun)	Customer address (*but* Oracle Payables)
Italic	Emphasized words and phrases, titles of books and courses, variables	Do *not* save changes to the database. For further information, see *Oracle Database SQL Reference 10g Release 2(10.2).* Enter *`user_id`*`@us.oracle.com`, where *`user_id`* is the name of the user.

Typographic Conventions (continued)

Typographic Conventions in Text (continued)

Convention	Element	Example
Quotation marks	Interface elements with long names that have only initial caps; lesson and chapter titles in cross-references	Select “Include a reusable module component” and click Finish. This subject is covered in the lesson titled, “Working with Objects.”
Uppercase	SQL column names, commands, functions, schemas, table names, database trigger names	Use the `SELECT` command to view information stored in the `LAST_NAME` column of the `EMPLOYEES` table.

Typographic Conventions in Code

Convention	Element	Example

Lowercase	Column names, table names, database trigger names	`SELECT last_name`
		`FROM employees;`
		
		CREATE OR REPLACE TRIGGER `secure_employees`

	Passwords	`CREATE USER scott` `IDENTIFIED BY tiger;`
	PL/SQL objects	`items.DELETE(3);`
Lowercase italic	Syntax variables	`CREATE ROLE` *`role`*
Uppercase	SQL commands and functions	`SELECT first_name` `FROM employees;`

Typographic Conventions (continued)

Typographic Conventions in Navigation Paths

This course uses simplified navigation paths, such as the following example, to direct you through Oracle applications.

Example:

Invoice Batch Summary

(N) Invoice > Entry > Invoice Batches Summary (M) Query > Find (B) Approve

This simplified path translates to the following:

1. (N) From the Navigator window, select Invoice > Entry > Invoice Batches Summary.
2. (M) From the menu, select Query > Find.
3. (B) Click the Approve button.

Notation:

(N) = Navigator	(I) = Icon
(M) = Menu	(H) = Hyperlink
(T) = Tab	(B) = Button

Contents

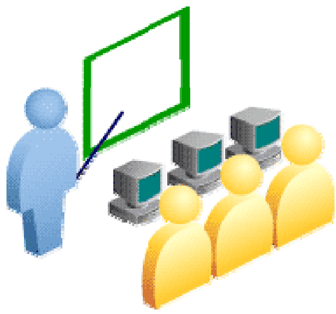
1

Introduction

Lesson Objectives

After completing this lesson, you should be able to do the following:

- List the course objectives and explain the class structure
- Review the Oracle Database 10*g* architecture



ORACLE

1-2

Course Objectives

In this course, you gain experience in:

- Using Recovery Manager (RMAN) for advanced backup and recovery
- Employing database monitoring practices for memory, performance, and storage
- Managing resources, job schedules, security, and globalization issues

Suggested Schedule

1

- 1: Introduction
- 2: Configuring RMAN
- 3: Using RMAN
- 4: Non-Critical Recovery

2

- 5: Recovery
- 6: Flashback
- 7: Corruption
- 8: Memory

3

- 9: Performance
- 10: Schema
- 11: Storage
- 12: ASM

4

- 13: Resources
- 14: Scheduler
- 15: Security

5

- 16: Globalization
- 17: Workshop
- Appendixes

ORACLE

What Is Covered in the DBAI Course

1. Introduction
2. Installation
3. DB Creation
4. Instance

5. Storage
6. Users
7. Schema
8. Data & Concurrency

9. Undo
10. Security
11. Network
12. Proactive Maintenance

13. Performance
14. Backup & Recovery Concepts
15. Backup

16. Recovery
17. Flashback
18. Moving Data

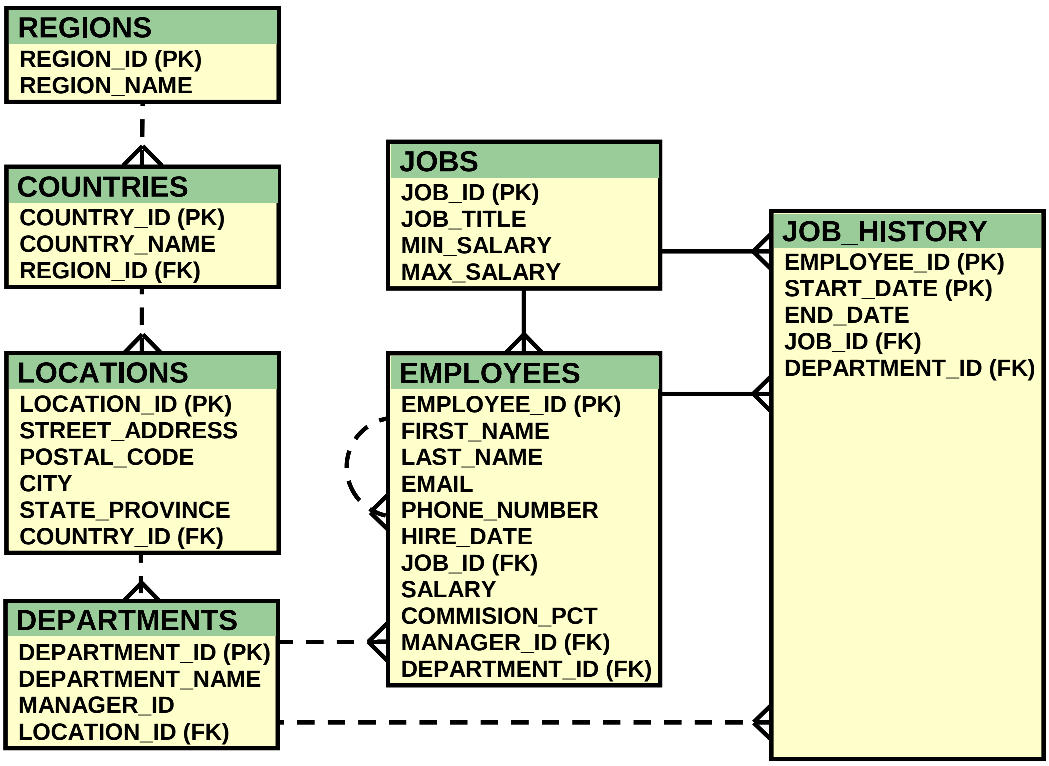
ORACLE

1-5

What Is Covered in the DBAI Course

DBAI refers to the *Oracle Database 10g: Administration Workshop I* (Release 2) course.

Course Examples: The HR Schema



Course Examples: The HR Sample Schema

The examples used in this course are from a human resources (HR) application, which can be created as part of the starter database.

The following are some principal business rules of the HR application:

- Each department may be the employer of one or more employees. Each employee may be assigned to one and only one department.
- Each job must be a job for one or more employees. Each employee must be currently assigned to one and only one job.
- When an employee changes his or her department or job, a record in the `JOB_HISTORY` table records the start and end dates of the past assignments.
- `JOB_HISTORY` records are identified by a composite primary key (PK): the `EMPLOYEE_ID` and the `START_DATE` columns.

Notation: PK = primary key, FK = foreign key

Solid lines represent mandatory foreign key (FK) constraints and dashed lines represent optional FK constraints.

The `EMPLOYEES` table also has an FK constraint with itself. This is an implementation of the business rule: Each employee may be reporting directly to one and only one manager. The FK is optional because the top employee does not report to another employee.

Oracle Database 10*g*: The Database for the Grid

- Automatic Storage Management
- Portable clusterware
- Real Application Clusters and automatic workload management
- Resource Manager
- Oracle Streams
- Centralized management with Enterprise Manager Grid Control
- Oracle Database 10*g* new self-management features

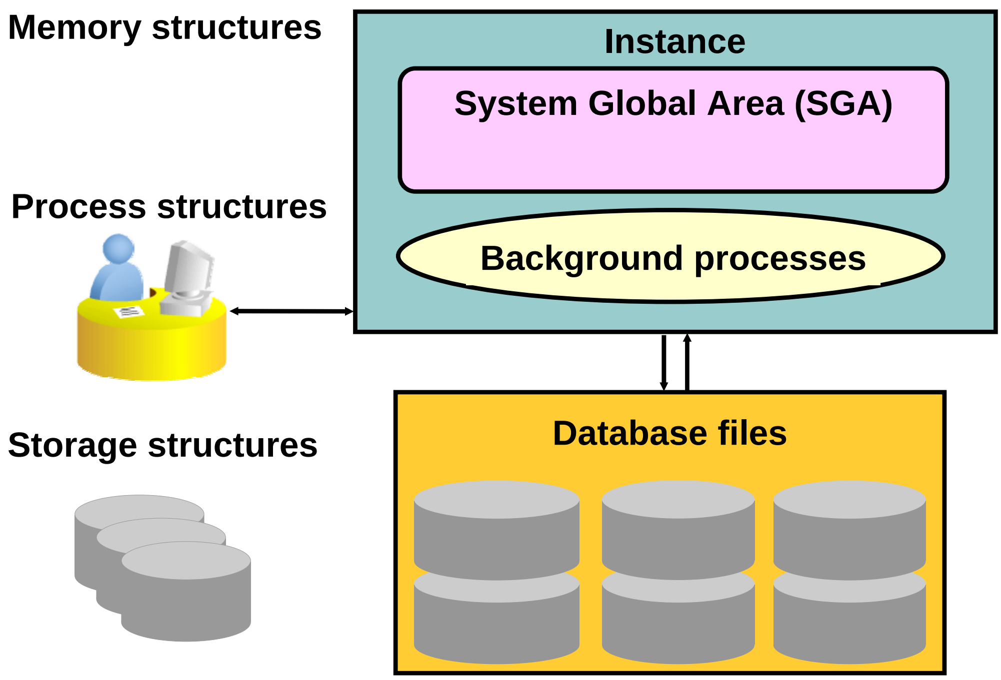
ORACLE

Oracle Database 10*g*: The Database for the Grid

Oracle Database 10*g* is the first database that is designed for grid computing. To summarize, some of the most important features are the following:

- Automatic Storage Management (ASM) virtualizes your storage and provides easy provisioning of your database storage.
- Oracle Database 10*g* offers portable clusterware that runs on all platforms.
- Oracle Database 10*g* offers automatic workload management for services within a RAC database.
- Oracle Database 10*g* provides additional mappings for consumer groups based on user host machine, application, OS username, or service.
- Oracle Streams can stream data between databases, nodes, or blade farms in a grid. It provides a unified framework for information sharing, combining message queuing, replication, events, and data warehouse loading into a single technology.
- Enterprise Manager Grid Control provides a single tool can monitor and manage not only every Oracle software element (Oracle Application Server 10*g* and Oracle Database 10*g*) in your grid but also Web applications via Application Performance Management (APM), hosts, storage devices, and server load balancers.

Database Architecture: Review



Database Architecture: Review

The following pages are a basic review of the Oracle database architecture. In this course, you enhance your knowledge of Oracle's database structures, processes, and utilities.

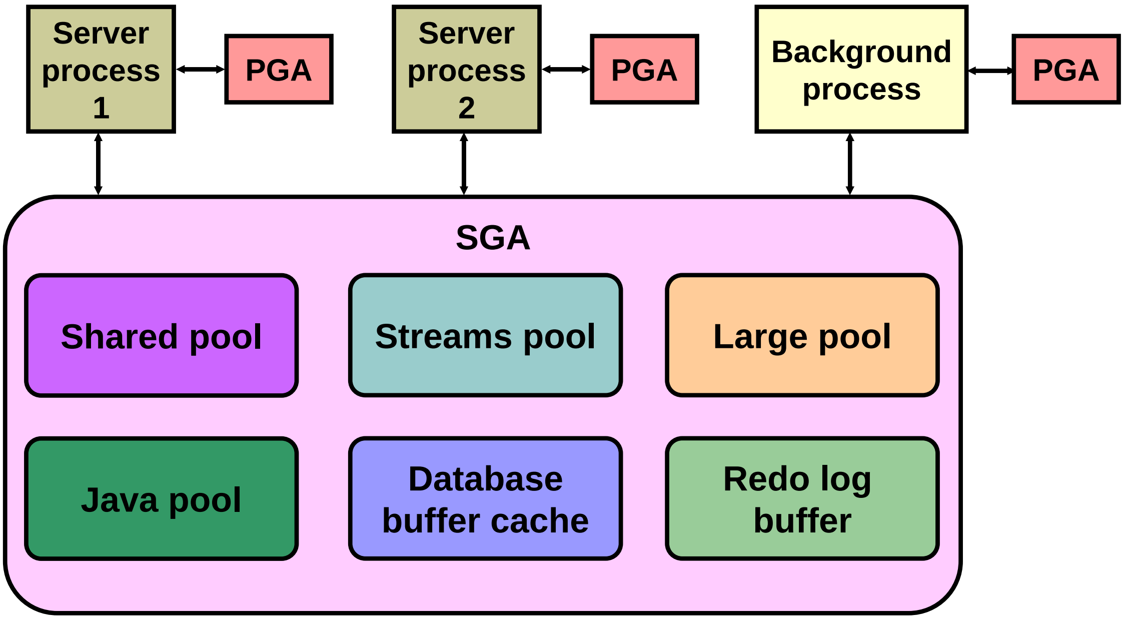
Each running Oracle database is associated with an Oracle instance. When a database is started on a database server, the Oracle software allocates a shared memory area called the System Global Area (SGA) and starts several Oracle background processes. This combination of the SGA and the Oracle processes is called an Oracle instance.

After starting an instance, the Oracle software associates the instance with a specific database. This is called mounting the database. The database is then ready to be opened, which makes it accessible to authorized users. Multiple instances can execute concurrently on the same computer, each accessing its own physical database.

You can look at the Oracle database architecture as various interrelated structural components.

An Oracle database uses memory structures and processes to manage and access the database. All memory structures exist in the main memory of the computers that constitute the database server. Processes are jobs that work in the memory of these computers. A process is defined as
a "thread of control" or a mechanism in an operating system that can run a series of steps.

Oracle Memory Structures



Oracle Memory Structures

The basic memory structures associated with an Oracle instance include:

- **System Global Area (SGA):** Shared by all server and background processes
- **Program Global Area (PGA):** Private to each server and background process; there is one PGA for each process

The SGA is a memory area that contains data and control information for the instance.

The SGA includes the following data structures:

- **Database buffer cache:** Caches blocks of data retrieved from the database
- **Redo log buffer:** Caches redo information (used for instance recovery) until it can be written to the physical redo log files stored on the disk
- **Shared pool:** Caches various constructs that can be shared among users
- **Large pool:** Is an optional area that provides large memory allocations for certain large processes, such as Oracle backup and recovery operations, and I/O server processes
- **Java pool:** Is used for all session-specific Java code and data within the Java Virtual Machine (JVM)
- **Streams pool:** Is used by Oracle Streams

When you start the instance by using Enterprise Manager or SQL*Plus, the amount of memory allocated for the SGA is displayed.

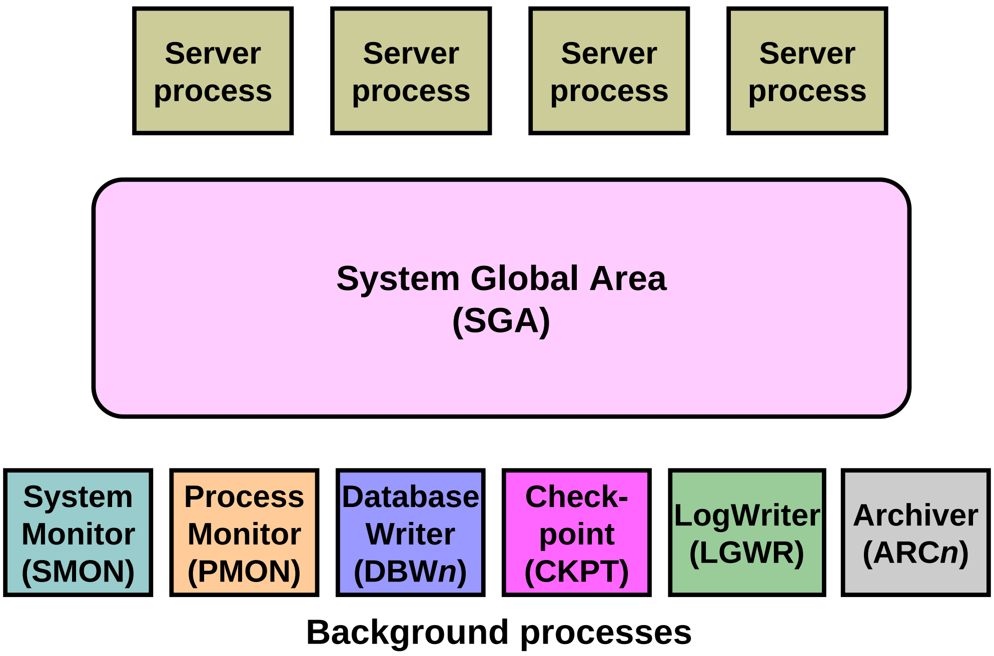
Oracle Memory Structures (continued)

A Program Global Area (PGA) is a memory region that contains data and control information for each server process. An Oracle server process services a client's requests. Each server process has its own private PGA that is created when the server process is started. Access to the PGA is exclusive to that server process, and the PGA is read and written only by the Oracle code acting on its behalf.

With the dynamic SGA infrastructure, the size of the database buffer cache, the shared pool, the large pool, the Java pool, and the Streams pool changes without shutting down the instance.

The Oracle database uses initialization parameters to create and configure memory structures. For example, the `SGA_TARGET` parameter specifies the total amount of space available to the SGA. If you set `SGA_TARGET` to 0, Automatic Shared Memory Management is disabled.

Oracle Processes

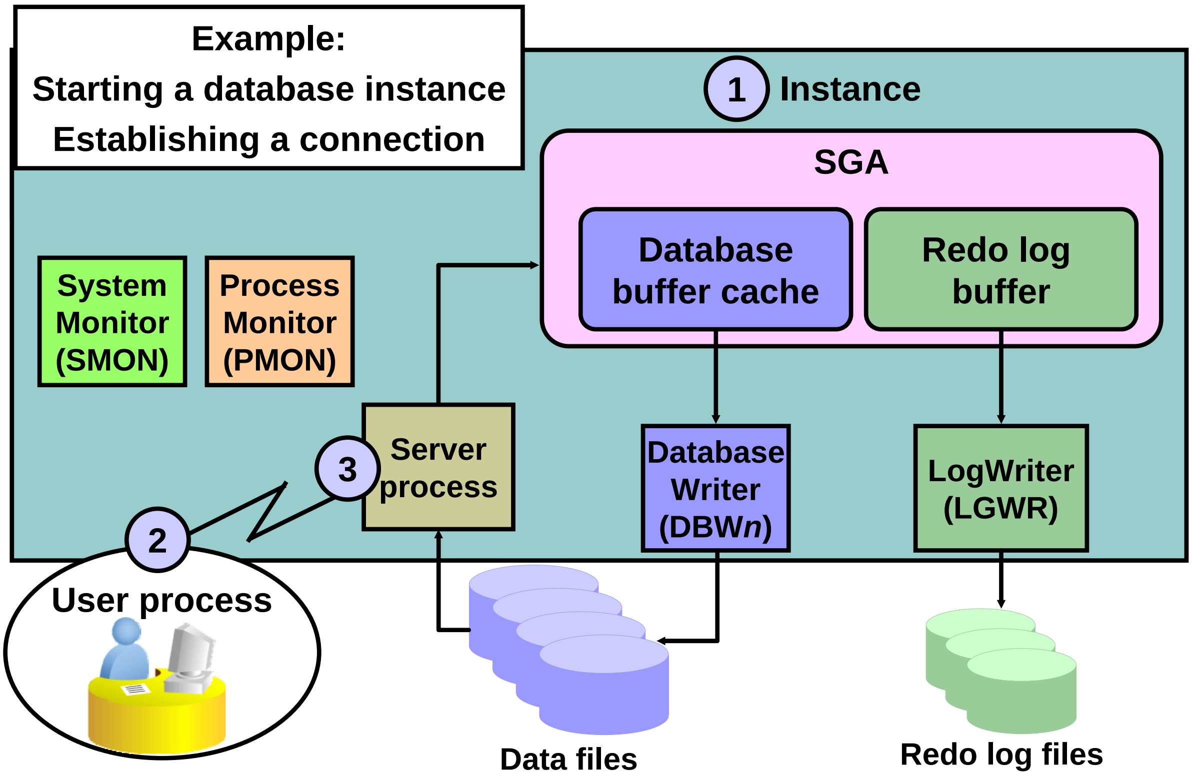


Oracle Processes

When you invoke an application program or an Oracle tool, such as Enterprise Manager, the Oracle server creates a server process to execute the commands issued by the application. The Oracle server also creates a set of background processes for an instance that interact with each other and with the operating system to manage the memory structures, asynchronously perform I/O to write data to disk, and perform other required tasks. Which background processes are present depends on the features that are being used in the database. The most common background processes are the following:

- **System Monitor (SMON):** Performs crash recovery when the instance is started following a failure
- **Process Monitor (PMON):** Performs process cleanup when a user process fails
- **Database Writer (DBW*n*):** Writes modified blocks from the database buffer cache to the data files on the disk
- **Checkpoint (CKPT):** Updates all the data files and control files of the database to indicate the most recent checkpoint
- **LogWriter (LGWR):** Writes redo log entries to the disk
- **Archiver (ARC*n*):** Copies redo log files to an archival storage when a log switch occurs

Reviewing Oracle Instance Management

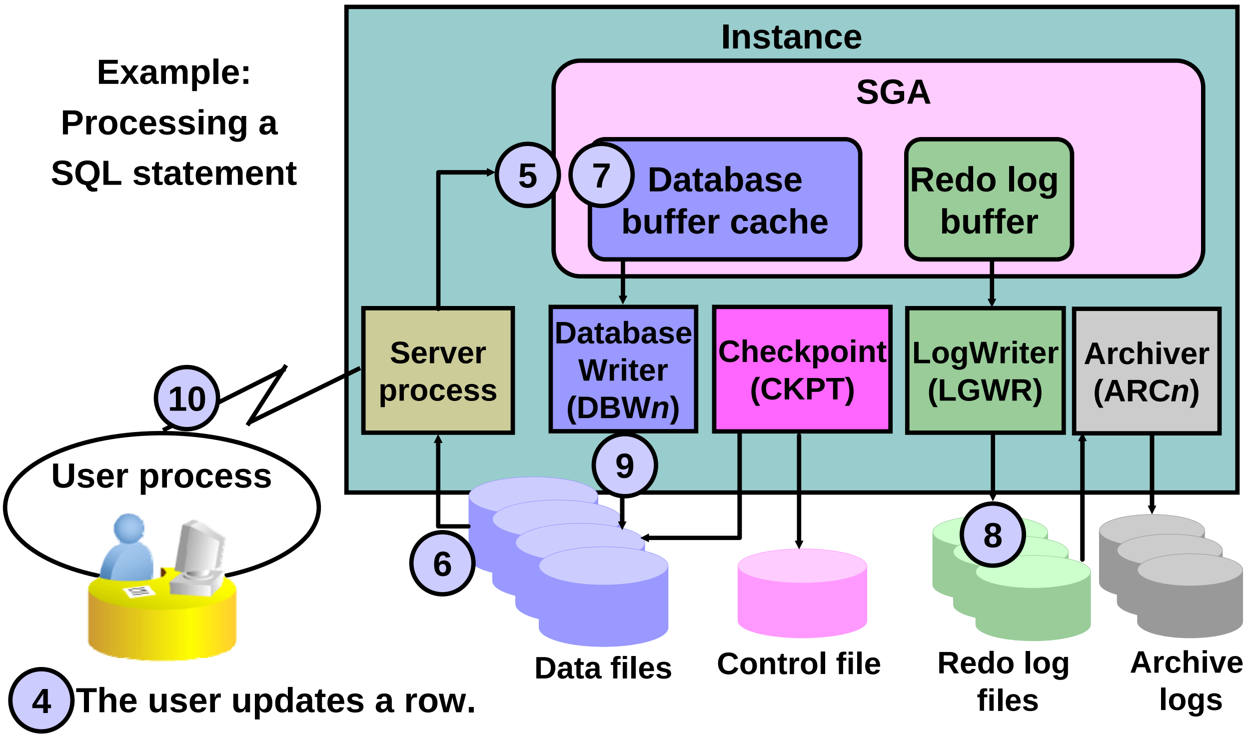


Reviewing Oracle Instance Management

The following example describes the most basic level of operations that the Oracle database performs. It illustrates an Oracle configuration where the user and associated server processes are on separate computers (connected through a network).

1. An instance has started on the computer running Oracle (often called the host or database server).
2. A computer running an application (a local computer or client workstation) runs the application in a user process. The client application attempts to establish a connection to the instance by using the Oracle Net Services driver.
3. The instance detects the connection request from the application and connects to a server process on behalf of the user process.

Reviewing Oracle Instance Management

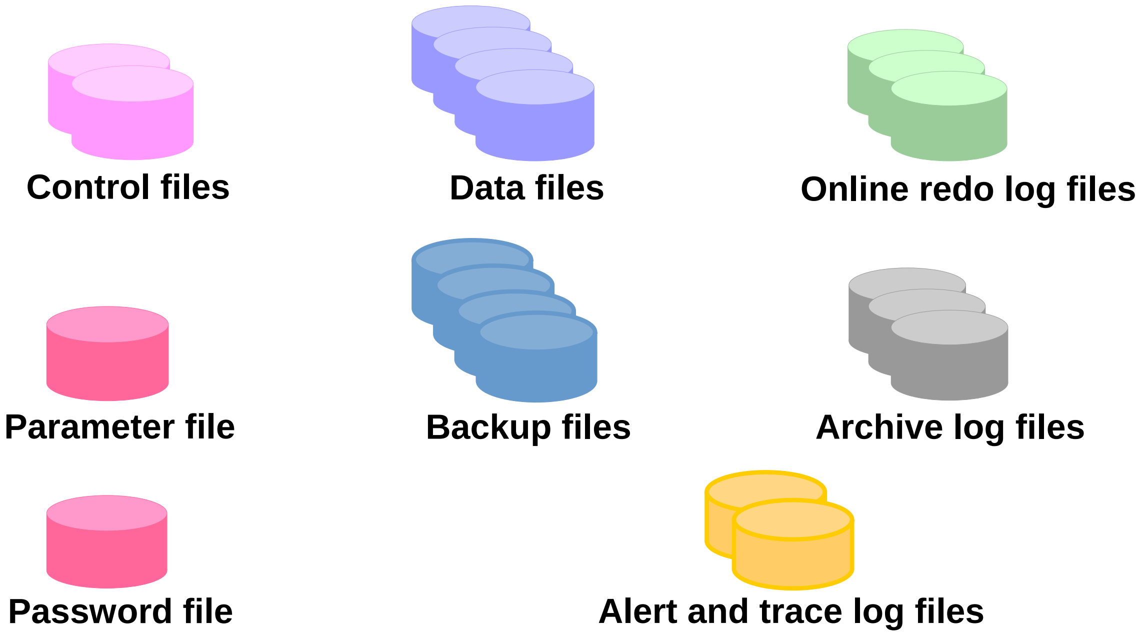


Reviewing Oracle Instance Management (continued)

4. The user updates a row.
5. The server process receives the statement and checks whether it is already in the shared pool of the SGA. If a shared SQL area is found, the server process checks the user's access privileges to the requested data, and the previously existing shared SQL area is used to process the statement. If the statement is not in the shared pool, then a new shared SQL area is allocated for the statement, so that it can be parsed and processed.
6. The server process retrieves any necessary data values from the actual data file (table) or from data blocks that are stored in the SGA.
7. The server process modifies the table data in the SGA.
8. When the transaction is committed, the LGWR process immediately records the transaction in the redo log file.
9. The DBW*n* process writes modified blocks to the disk when doing so is efficient.
10. The server process sends a success or error message across the network to the application.

Throughout this entire procedure, the other background processes run, watching for conditions that require intervention.

Physical Database Structure



Physical Database Structure

The files that constitute an Oracle database are organized into the following:

- **Control files:** Contain data about the database itself (that is, physical database structure information). These files are critical to the database. Without them, you cannot open data files to access the data within the database.
- **Data files:** Contain the user or application data of the database
- **Online redo log files:** Allow for instance recovery of the database. If the database crashes and does not lose any data files, then the instance can recover the database with the information in these files.

The following additional files are important to the successful running of the database:

- **Parameter file:** Is used to define how the instance is configured when it starts up
- **Password file:** Allows users to connect remotely to the database and perform administrative tasks
- **Backup files:** Are used for database recovery. You typically restore a backup file when a media failure or user error has damaged or deleted the original file.
- **Archive log files:** Contain an ongoing history of the data changes (redo) that are generated by the instance. Using these files and a backup of the database, you can recover a lost data file. That is, archive logs enable the recovery of restored data files.

Physical Database Structure (continued)

- **Trace files:** Each server and background process can write to an associated trace file. When an internal error is detected by a process, the process dumps information about the error to its trace file. Some of the information written to a trace file is intended for the database administrator, whereas other information is for Oracle Support Services.
- **Alert log files:** Also known as alert logs, these are special trace files. The alert log of a database is a chronological log of messages and errors. Oracle recommends reviewing these files.

Oracle Managed Files (OMF)

Specify file operations in terms of database objects rather than file names.

Parameter	Description
`DB_CREATE_FILE_DEST`	Defines the location of the default file system directory for data files and temporary files
`DB_CREATE_ONLINE_LOG_DEST_n`	Defines the location for redo log files and control file creation
`DB_RECOVERY_FILE_DEST`	Defines the location for RMAN backups

Example:

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

1-16

Oracle Managed Files (OMF)

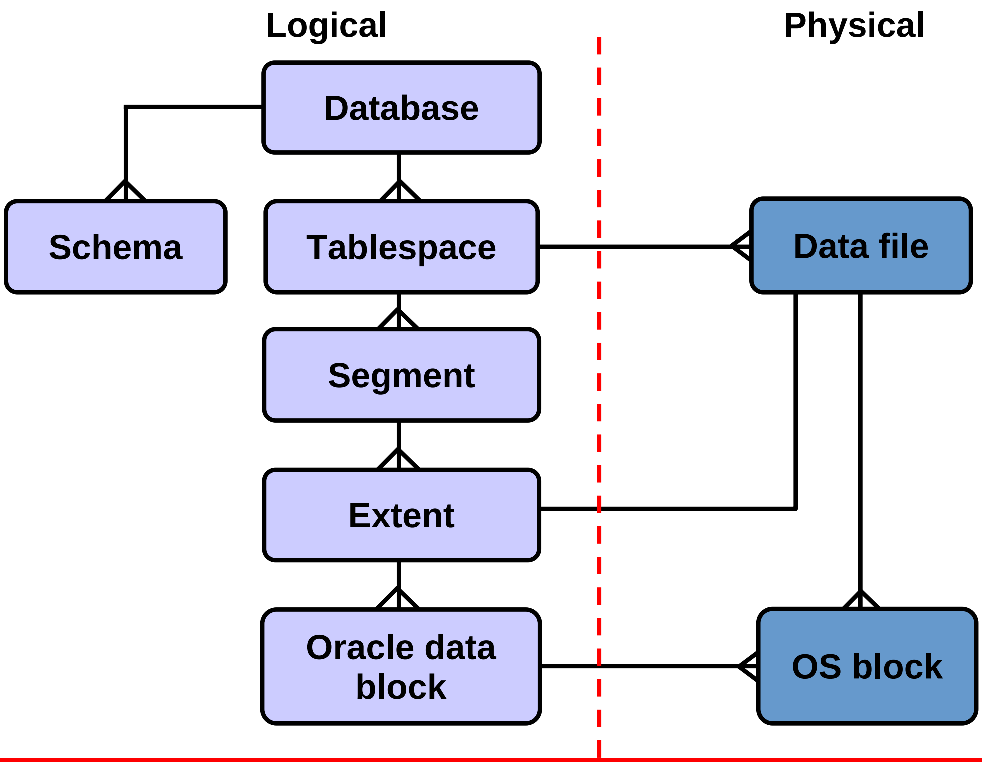
Oracle Managed Files (OMF) eliminate the need for you to directly manage the operating system files that make up an Oracle database. You specify operations in terms of database objects rather than file names. The database internally uses standard file system interfaces to create and delete files as needed for the following database structures:

- Tablespaces
- Redo log files
- Control files
- Archived logs
- Block change tracking files
- Flashback logs
- RMAN backups

A database can have a mixture of Oracle-managed and unmanaged files. The file system directory specified by either of these parameters must already exist: the database does not create it. The directory must also have permissions to allow the database to create the files in it.

The example shows that after `DB_CREATE_FILE_DEST` is set, the `DATAFILE` clause can be omitted from a `CREATE TABLESPACE` statement. The data file is created in the location specified by `DB_CREATE_FILE_DEST`.

Logical and Physical Database Structures



Logical and Physical Database Structures

An Oracle database is a collection of data that is treated as a unit. The general purpose of a database is to store and retrieve related information. The database has logical structures and physical structures.

Tablespaces

A database is divided into logical storage units called tablespaces, which group related logical structures together. For example, tablespaces commonly group all of an application's objects to simplify some administrative operations. You may have a tablespace for application data and an additional one for application indexes.

Databases, Tablespaces, and Data Files

The relationship among databases, tablespaces, and data files is illustrated in the slide. Each database is logically divided into one or more tablespaces. One or more data files are explicitly created for each tablespace to physically store the data of all logical structures in a tablespace. If it is a `TEMPORARY` tablespace, instead of a data file, the tablespace has a temporary file.

Logical and Physical Database Structures (continued)

Schemas

A schema is a collection of database objects that are owned by a database user. Schema objects are the logical structures that directly refer to the database's data. Schema objects include such structures as tables, views, sequences, stored procedures, synonyms, indexes, clusters, and database links. In general, schema objects include everything that your application creates in the database.

Data Blocks

At the finest level of granularity, an Oracle database's data is stored in data blocks. One data block corresponds to a specific number of bytes of physical database space on the disk. A data block size is specified for each tablespace when it is created. A database uses and allocates free database space in Oracle data blocks.

Extents

The next level of logical database space is called an extent. An extent is a specific number of contiguous data blocks (obtained in a single allocation) that are used to store a specific type of information.

Segments

The level of logical database storage above an extent is called a segment. A segment is a set of extents allocated for a certain logical structure. For example, the different types of segments include:

- ***Data segments*:** Each nonclustered, non-index-organized table has a data segment. All of the table's data is stored in the extents of its data segment. For a partitioned table, each partition has a data segment. Each cluster has a data segment. The data of every table in the cluster is stored in the cluster's data segment.
- ***Index segments*:** Each index has an index segment that stores all of its data. For a partitioned index, each partition has an index segment.
- ***Undo segments*:** One `UNDO` tablespace is created by the database administrator to temporarily store *undo* information. The information in an undo segment is used to generate read-consistent database information and, during database recovery, to roll back uncommitted transactions for users.
- ***Temporary segments*:** Temporary segments are created by the Oracle database when a SQL statement needs a temporary work area to complete execution. When the statement finishes execution, the temporary segment's extents are returned to the instance for future use. Specify a default temporary tablespace for every user or a default temporary tablespace, which is used databasewide.

The Oracle database dynamically allocates space. When the existing extents of a segment are full, additional extents are added. Because extents are allocated as needed, the extents of a segment may or may not be contiguous on the disk.

Database Architecture: Summary of Structural Components

- Memory structures
  - System Global Area (SGA): Database buffer cache, redo buffer, and various pools
  - Program Global Area (PGA)
- Process structures
  - User process and server process
  - Background processes: SMON, PMON, DBW*n*, CKPT, LGWR, ARC*n*, and so on
- Storage structures
  - Logical: Database, schema, tablespace, segment, extent, and Oracle block
  - Physical: Files for data, parameters, redo, and OS block

ORACLE

1-19

Database Architecture: Summary of Structural Components

You reviewed at a high level the structural components of the Oracle database: memory, process structures, and storage structures. An understanding of Oracle's database architecture is a prerequisite for this course.

Summary

In this lesson, you should have learned how to:

- List the course objectives
- Review the Oracle Database 10*g* architecture

1-20

Configuring Recovery Manager

Objectives

After completing this lesson, you should be able to do the following:

- Describe the RMAN repository and recovery catalog
- Describe the Media Management Library interface
- Configure database parameters that affect RMAN operations
- Connect to the three different types of databases by using RMAN
- Configure two types of retention policies
- Change RMAN default settings with `CONFIGURE`

2-2

Objectives

Recovery Manager (RMAN) is the component of the Oracle database used to perform backup and recovery operations. Enterprise Manager (EM) supplies a graphical interface to the most commonly used RMAN functionality.

The *Oracle Database 10g: Administration Workshop I* course demonstrates basic RMAN operations using the EM Database Control Console, so the graphical interface to RMAN is not covered in detail in this lesson.

Backup and Recovery: Review

The major backup and recovery–related topics covered in the Database Administration I Course are:

- **Types of failure that can happen**
  - **Statement, session, instance, media, and so on**
- **How to configure `ARCHIVELOG` mode**
- **How to automate backups**
- **How to do incremental backups**
- **How to perform and tune instance recovery**

2-3

Backup and Recovery: Review

The *Oracle Database 10g: Administration Workshop I* course covered the backup and recovery–related topics listed in the slide. The following lessons cover some of these topics in greater detail.

Features of Recovery Manager

RMAN provides a flexible way to:

- **Back up the database including data files, control files, and archived redo logs**
- **Manage backup and recovery tasks**
- **Perform incremental block-level backup and block-level media recovery**
- **Detect corrupted blocks during backup**
- **Use binary compression when creating backups**

2-4

Features of Recovery Manager

RMAN is an Oracle utility that you use to manage the backup, restore, and recovery operations on Oracle databases. RMAN has a powerful command language that is independent of the operating system.

RMAN provides several features not available when you make user-managed backups with operating system–commands.

- You can store frequently executed operations as scripts in the database.
- With block change tracking enabled in the database, RMAN can limit incremental backups to recording only those blocks that have changed since the previous backup. This improves the performance of backups and may also reduce the time it takes to perform recovery operations in `ARCHIVELOG` mode.
- You can use RMAN to manage the size of backup pieces and save time by parallelizing the backup operation.
- RMAN can recover an individual corrupt data block or set of data blocks within a data file rather than restoring and recovering the entire data file.

Features of Recovery Manager (continued)

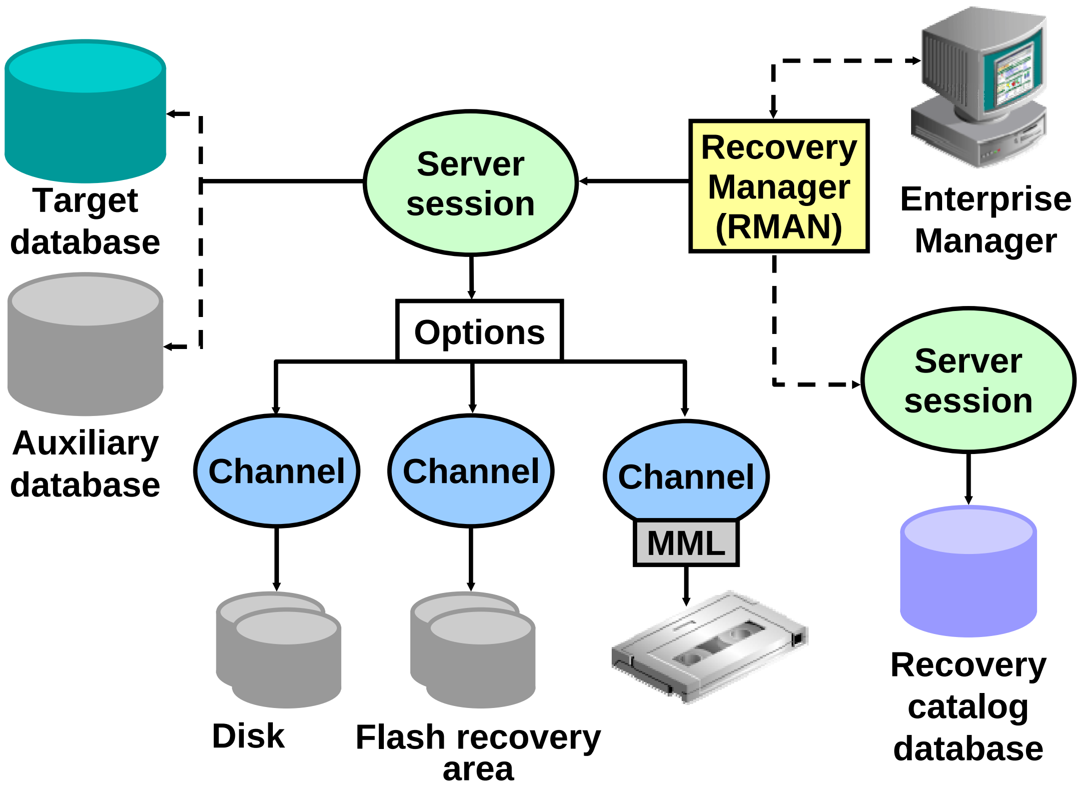
- RMAN operations can be integrated with the Scheduler to automate backup operations. The Scheduler is covered in the lesson titled "Automating Tasks with the Scheduler."
- You can use RMAN to detect block corruption. The information relating to the block corruption that is detected during backup can be obtained by using the `V$BACKUP_CORRUPTION` and `V$COPY_CORRUPTION` dynamic views.
- RMAN provides performance enhancements such as:
  - Automatic parallelization of backup, restore, and recovery operations
  - No generation of extra redo during online database backups
  - Backups that are restricted to limit the number of reads per file per second to avoid interfering with OLTP work
  - The use of multiplexing, which can prevent flooding of any one file with reads and writes while still keeping a tape drive streaming
- RMAN has a media management API that works seamlessly with third-party media management tools interfacing with storage devices, which provides increased speed and reliability.
- Oracle Secure Backup allows RMAN to back up to tape without third-party media management tools.
- In the user-managed method, you need to keep track of all database files and backups. In a recovery situation, you must locate backups for each data file, copy them to the correct place using operating system–commands, and choose which redo log files to apply. RMAN manages these tasks automatically. The advantages of using RMAN are even greater if you use Oracle Managed Files or the flash recovery area.

Note

Not all of these features are covered in this course. For more information about:

- RMAN and its abilities, see the *Oracle Database Backup and Recovery Basics* and *Oracle Database Backup and Recovery Advanced User's Guide* documentation
- The syntax of RMAN commands, refer to the *Oracle Database Recovery Manager Reference* manual

Recovery Manager Components



Recovery Manager Components

Recovery Manager executable: The Recovery Manager command-line interface is invoked through the RMAN client application. RMAN interprets user commands and appropriately invokes server sessions to perform the desired tasks.

Enterprise Manager: The Enterprise Manager Database Control Console supplies a graphical interface to the most commonly used RMAN functionality.

Server sessions: The server processes (UNIX) or threads (Windows 2000) invoked by RMAN connect to the target database to perform the backup, restore, and recovery functions through a PL/SQL interface. These sessions read or write files from or to disk, tape, or the flash recovery area, which is a storage location specified as the default storage area for files related to database recovery.

Target database: The database for which backup and recovery operations are being performed using RMAN is called the target database. The control file of the target database contains information about its physical structure, such as the size and location of data files, online and archived redo log files, and control files. This information is used by the server sessions invoked by RMAN in backup and recovery operations.

Recovery Manager Components (continued)

Auxiliary database: An auxiliary database is used when creating a duplicate database or performing tablespace point-in-time recovery (TSPITR). For the tasks, the auxiliary database serves as the destination of the new copy of the database or the recovered tablespaces. An auxiliary database can reside on the same host as its parent or on a different host. The auxiliary database is introduced in this lesson only for completeness. For more information, refer to the *Oracle Database Backup and Recovery Advanced User's Guide*.

Channel: A channel represents one stream of data to a device type. To perform and record backup and recovery operations, RMAN requires a link to the target database. A channel establishes this link by creating a session in the target database that is able to interface with the host file system (to interface with disks) and the Media Management Library (to interface with tapes). You can allocate channels manually or preconfigure channels by using automatic channel allocation.

RMAN repository: RMAN maintains metadata about the target database and its backup and recovery operations in the RMAN repository. Among other things, RMAN stores information about its own configuration settings, the target database schema, archived redo logs, and all backup files that are on disk or tape. RMAN repository data is always stored in the control file of the target database.

Recovery catalog: The RMAN repository data can optionally be kept in a recovery catalog, which is a separate Oracle database.

Media Management Library: The Media Management Library (MML) is used by RMAN when writing to or reading from tapes. The additional media management software required for using the tape medium is provided by media and storage system vendors. Also, the Oracle Secure Backup product allows RMAN to back up to tape without requiring third-party tools.

Steps for Configuring RMAN

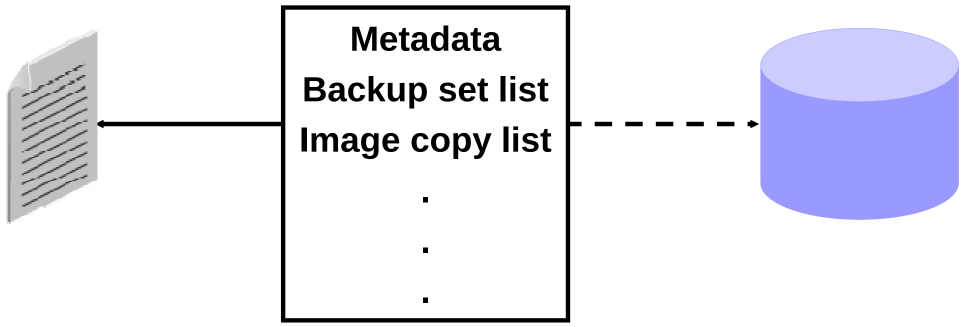
1. Determine the repository location: control file or recovery catalog.
2. Define database and environment variables.
3. Start RMAN and connect to the target and, optionally, the recovery catalog databases.
4. Configure persistent settings.

2-8

RMAN Repository Data Storage: Comparison of Options

Control file:
- Simpler administration
- Default

Recovery catalog:
- Replicates control file data
- Has room for more data
- Can service many targets
- Can store RMAN scripts



RMAN Repository Data Storage: Comparison of Options

RMAN repository data is always stored in the control file of the target database. But it can also be stored in a separate database, called a recovery catalog.

A recovery catalog preserves backup information in a separate database, which is useful in the event of a lost control file. This allows you to store a longer history of backups than what is possible with a control file–based repository. A single recovery catalog is able to store information for multiple target databases. The recovery catalog can also hold RMAN stored scripts, which are sequences of RMAN commands for common backup tasks. Centralized storage of scripts in the recovery catalog can be more convenient than working with command files.

Usage of a separate recovery catalog database is not recommended for small installations where administration of a separate recovery catalog database would be burdensome.

RMAN Repository Data Storage: Comparison of Options (continued)

How to Set Up a Recovery Catalog

1. Create the database to be used as the recovery catalog. Alternatively, identify an already existing database and use that. Because a single recovery catalog can serve more than one database, you may choose to create a single recovery catalog that services all your databases that are being backed up.
2. In the recovery catalog database, create the user that will own the recovery catalog data. For example, assume that `catdb` is the name of the catalog database, and `rcat_ts` is the name of a tablespace you have created where the catalog data is to be stored.

```
$ sqlplus sys/password@catdb as sysdba

SQL> CREATE USER rman IDENTIFIED BY cat
  2  TEMPORARY TABLESPACE temp
  3  DEFAULT TABLESPACE rcat_ts
  4  QUOTA UNLIMITED ON rcat_ts;

SQL> GRANT UNLIMITED ON rcat_ts TO rman;
```

3. Grant the `RECOVERY_CATALOG_OWNER` role to the catalog owner. This role provides the user with all privileges required to maintain and query the recovery catalog.

```
GRANT RECOVERY_CATALOG_OWNER TO rman;
```

4. Start RMAN and log in as the catalog owner.

```
$ rman catalog rman/cat@catdb
RMAN> CREATE CATALOG TABLESPACE rcat_ts;
```

5. Connect to the target database by using RMAN, and register it in the newly created recovery catalog.

```
$ rman target sys/oracle@orcl catalog rman/cat@catdb

RMAN> register database;
```

Note: It is important to back up your recovery catalog database.

Backup Destinations

Backups can be written to:

- Disk directory
- Media Management Library (tape device)
  - Typically used for disaster recovery, when disk backups are lost
- Flash recovery area
  - This is a disk area set aside for backup and recovery and flashback database purposes.
  - You define the location and the size.
  - Files are automatically named by using Oracle Managed Files.
  - Files are automatically retained and deleted as necessary.

ORACLE

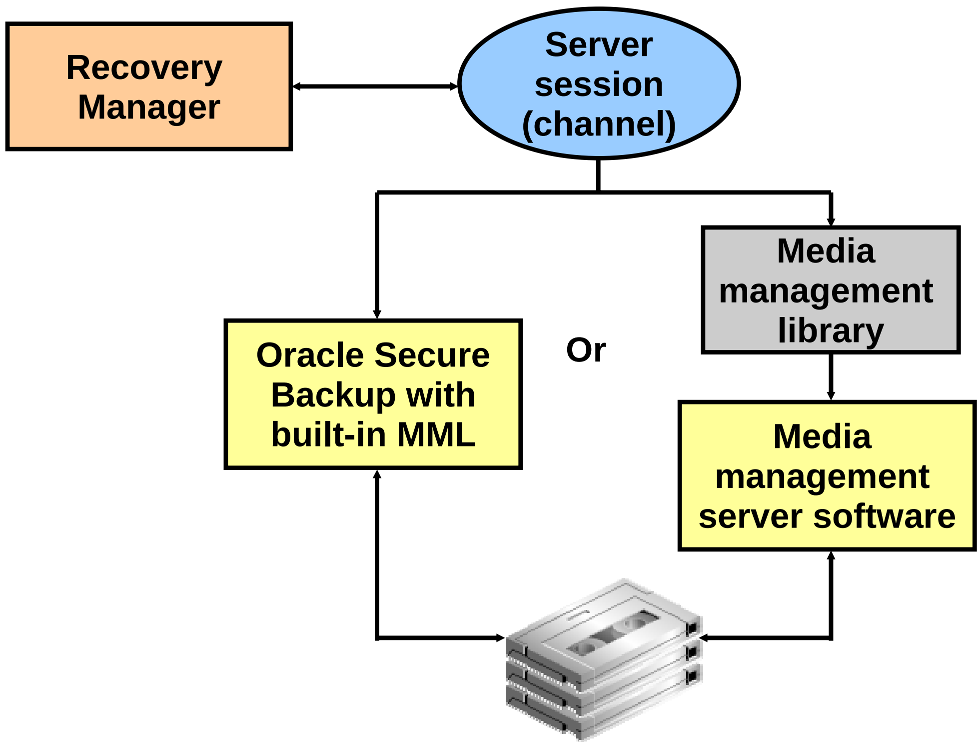
2-11

Backup Destinations

Backups can be written to a designated disk directory, a Media Management Library, or the flash recovery area. Specifying a disk directory or the flash recovery area means that backups go to hard-disk media. Typically, they are regularly moved offline to tape via the media management interface in order to maintain disk space availability. Any disk directory can be specified as the destination of a backup provided that it already exists.

If you set up a flash recovery area, many backup and recovery tasks are simplified for you. The Oracle database automatically names files for you, and deletes obsolete files when there is space pressure.

Media Management



Media Management

To use tape storage for your database backups, RMAN requires Oracle Secure Backup or a media manager. Oracle Secure Backup is covered in detail in Appendix F.

A media manager is a utility that loads, labels, and unloads sequential media, such as tape drives for the purpose of backing up, restoring, and recovering data. The Oracle database calls MML software routines to back up and restore data files to and from media that is controlled by the media manager.

Some media management products can completely manage all data movement between Oracle data files and the backup devices. Some products that use high-speed connections between storage and media subsystems can reduce much of the backup load from the primary database server.

Note that the Oracle database does not need to connect to the Media Management Library (MML) software when it backs up to disk.

Media Management (continued)

The Oracle Backup Solutions Program (BSP) provides a range of media management products that are compliant with Oracle's MML specification. Software that is compliant with the MML interface enables an Oracle database session to back up data to a media manager and request the media manager to restore backups. Check with your media vendor to determine whether it is a member of the Oracle BSP.

Before you can begin using RMAN with a media manager, you must install the media manager software and make sure that RMAN can communicate with it. Instructions for this procedure should be available in the media manager vendor's software documentation.

Depending on the product that you are installing, perform the following basic steps:

1. Install and configure the media management software on the target host or production network. No RMAN integration is required at this stage.
2. Ensure that you can make non-RMAN backups of operating system files on the target database host. This step makes it easier to troubleshoot problems at a later time. Refer to your media management documentation to learn how to back up files to the media manager.
3. Obtain and install the third-party media management module for integration with the Oracle database. This module must contain the library loaded by the Oracle database when accessing the media manager.

Backup and Restore Operations Using a Media Manager

The following Recovery Manager script performs a data file backup to a tape drive controlled by a media manager:

```
run {
# Allocating a channel of type 'sbt' for serial device
     ALLOCATE CHANNEL ch1 DEVICE TYPE sbt;
     BACKUP DATAFILE 3;
}
```

When Recovery Manager executes this command, it sends the backup request to the Oracle database session performing the backup. The Oracle database session identifies the output channel as a media management device and requests the media manager to load a tape and write the output.

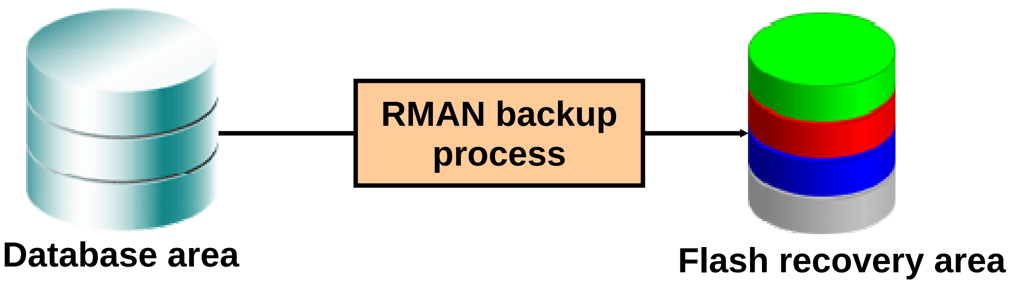
The media manager labels and keeps track of the tape and the names of the files on each tape.

The media manager also handles restore operations. When you restore a file, the following steps occur:

1. The Oracle database requests the restoration of a particular file.
2. The media manager identifies the tape containing the file and reads the tape.
3. The media manager passes the information back to the Oracle database session.
4. The Oracle database writes the file to disk.

Using a Flash Recovery Area with RMAN

You can configure RMAN to use the flash recovery area.




```
DB_RECOVERY_FILE_DEST = '/u01/oracle/fra'
DB_RECOVERY_FILE_DEST_SIZE = 2G
```


Using a Flash Recovery Area with RMAN

Although not required for RMAN operations, the flash recovery area simplifies managing disk space and files related to backup and recovery. You do not need to specify the file names for the backup files because RMAN generates the file names automatically. When the flash recovery area is used, RMAN automatically uses Oracle Managed Files (OMF) for its backup files.

Each time RMAN creates a file in the flash recovery area, the Oracle database updates the list of files that are no longer required on disk. When a file needs to be written into the flash recovery area and space is not available for that file, the Oracle database deletes a file that is on the obsolete files list and writes a notification to the alert log.

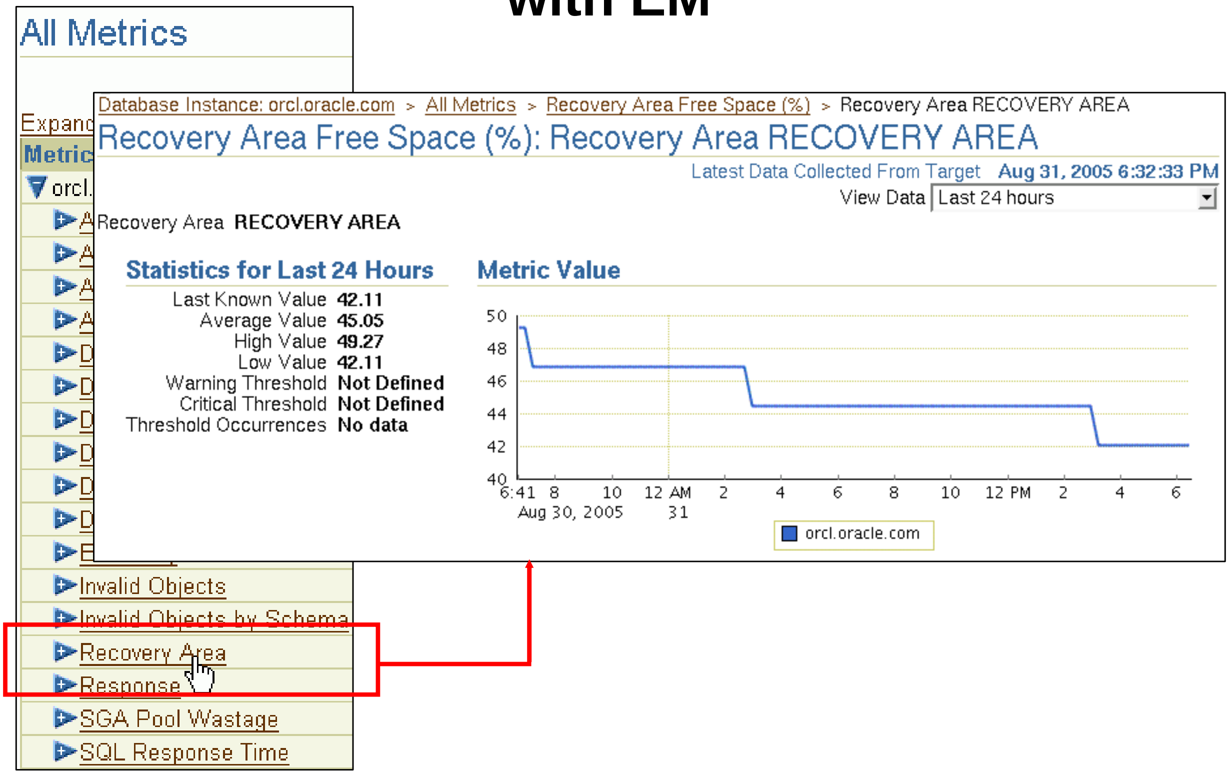
A warning is issued when the flash recovery area experiences space pressure or is low on free space because there are no files that can be deleted from the flash recovery area. To resolve the problem, you can add disk space, back up your files to a tertiary device, delete the files from the flash recovery area using RMAN, or change the RMAN retention policy. The flash recovery area is configured by setting the `DB_RECOVERY_FILE_DEST` initialization parameter. The `DB_RECOVERY_FILE_DEST_SIZE` parameter specifies its size.

Using a Flash Recovery Area with RMAN (continued)

By default, RMAN automatically places backup files into the flash recovery area, if there is one configured.

Note: A flash recovery area can be located in an Automated Storage Management (ASM) instance. A flash recovery area can also be used with Oracle Cluster File Storage (OCFS) or any local storage.

Monitoring the Flash Recovery Area with EM



Monitoring the Flash Recovery Area with EM

Real-time flash recovery area–related metrics can also be viewed through the EM Database Control Console. On the Maintenance page, scroll down to the Related Links section and select All Metrics. Scan the list and click Recovery Area.

The displayed page shows the Recovery Area Free Space (%) metric, which represents the recovery area free space as a percentage. Click the percentage number to see the graph of recovery area usage.

Flash Recovery Area Space Usage

- Configure the retention policy to the minimum value appropriate for your database.
- Back up the archive log files regularly and delete the files upon completion of the backup.
- Use the RMAN `REPORT OBSOLETE` and `DELETE OBSOLETE` commands to remove backups and file copies that are not required.

Flash Recovery Area Space Usage

To avoid running out of space in the flash recovery area, you should never store user-managed files in this area. You should also perform the following steps as needed or appropriate:

- Delete unnecessary files from the recovery area by using RMAN.
- Take frequent backups of the recovery area by using RMAN.
- Change the RMAN retention policy to retain backups for a smaller period of time.
- Change the RMAN archived log deletion policy.
- Add disk space and increase the value of the `DB_RECOVERY_FILE_DEST_SIZE` database initialization parameter if you are frequently running out of space.

For example, to back up the archived log files in the recovery area and then delete the files after they have been successfully backed up, you would use the RMAN command:

```
BACKUP ARCHIVELOG ALL DELETE ALL INPUT;
```

If you use a backup solution other than RMAN, you still have to use RMAN to remove the files from the flash recovery area. After the archived log files have been backed up and removed from disk, use the RMAN `CROSSCHECK` and `DELETE` commands to reclaim the archived log space from the flash recovery area. You should do this on a regular basis, or after every backup.

V$FLASH_RECOVERY_AREA_USAGE

You can query V$FLASH_RECOVERY_AREA_USAGE to view the flash recovery area disk space usage.

```
SQL> SELECT file_type,
  2   percent_space_used AS used,
  3   percent_space_reclaimable AS reclaimable,
  4   number_of_files AS number
  5   FROM  v$flash_recovery_area_usage ;

FILE_TYPE                   USED RECLAIMABLE FILES
----------------- --------- ----------- ------
```

V$FLASH_RECOVERY_AREA_USAGE

Output from the V$FLASH_RECOVERY_AREA_USAGE query

```
FILE_TYPE          USED RECLAIMABLE      FILES
------------ ---------- ----------- ----------
CONTROLFILE           0           0          0
ONLINELOG             0           0          0
ARCHIVELOG        69.13           0        593
BACKUPPIECE           0           0          0
IMAGECOPY             0           0          0
FLASHBACKLOG       1.77           0         37
```

ORACLE

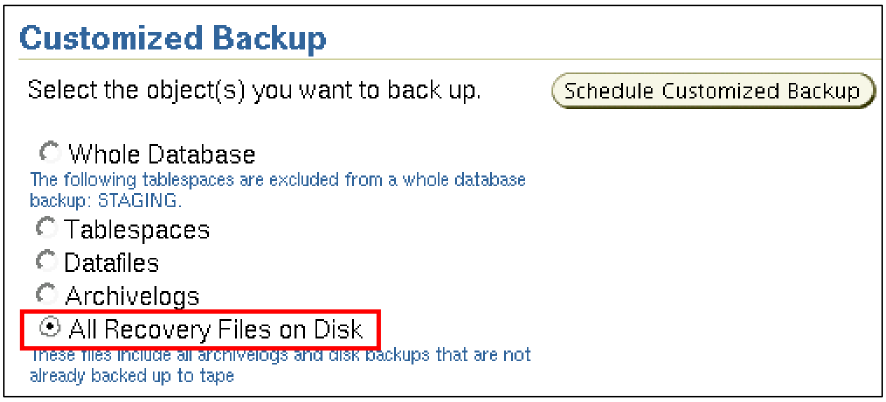
2-19

V$FLASH_RECOVERY_AREA_USAGE

The columns have the following meanings:

- **FILE_TYPE:** This is the type of the file and can have any of the following values: CONTROLFILE, ONLINELOG, ARCHIVELOG, BACKUPPIECE, IMAGECOPY, FLASHBACKLOG.
- **PERCENT_SPACE_USED:** This is the percentage of the flash recovery area that is currently being used to store files of the given type.
- **PERCENT_SPACE_RECLAIMABLE:** This is the percentage of the flash recovery area that is currently being used to store files of the given type that could be deleted because they are obsolete or redundant or have been backed up to a tertiary device.
- **NUMBER_OF_FILES:** This is the number of files of the specified file type.

Backing Up the Flash Recovery Area




```
RMAN> BACKUP RECOVERY FILES;
```


Backing Up the Flash Recovery Area

Because of the importance of the data it contains, you should back up the files in the flash recovery area on a regular basis. To do this, navigate to the **Maintenance** tabbed page. On this page, click the **Schedule Backup** link in the **Backup/Recovery** region. Select **Customized** from the **Backup Strategy** drop-down list, and then select the **All Recovery Files on Disk** option. You can also use RMAN `BACKUP` commands to back up the flash recovery area.

- `RMAN> BACKUP RECOVERY AREA;`
  This command backs up all flash recovery files created in the current flash recovery area destinations that have not previously been backed up. Files that fall into this category are full and incremental backup sets, control file autobackups, archive logs, and data file copies. Other files such as flashback logs, incremental bitmaps, current control file, and online redo log files are not backed up.
- `RMAN> BACKUP RECOVERY FILES;`
  This command backs up all recovery files on disk that have not previously been backed up. The files that fall into this category are full and incremental backup sets, control file autobackups, archive logs, and data file copies.

Benefits of Using a Flash Recovery Area

Using the flash recovery area for recovery-related files:

- Simplifies the location of database backups
- Automatically manages the disk space allocated for recovery files
- Does not require changes to existing scripts
- Puts database backups, archive logs, and control file backups in the flash recovery area

2-21

Benefits of Using a Flash Recovery Area

Using a flash recovery area for all recovery-related files simplifies the ongoing administration of your database, depending on the setting of the initialization parameters `DB_RECOVERY_FILE_DEST_SIZE` and `DB_RECOVERY_FILE_DEST`. Oracle Corporation recommends the use of the flash recovery area for all recovery-related files.

Setting Parameters That Affect RMAN

- Database initialization parameters
  - CONTROL_FILE_RECORD_KEEP_TIME
  - DB_RECOVERY_FILE_DEST and DB_RECOVERY_FILE_DEST_SIZE, if using the flash recovery area
- Environment variables
  - NLS_DATE_FORMAT
  - NLS_LANG

2-22

Setting Parameters That Affect RMAN

RMAN stores information about the target database and its backup and recovery operations in the RMAN repository. The amount of information stored can increase depending on the frequency of backups, the number of archived redo log files that are generated, and the retention period for RMAN records.

The `CONTROL_FILE_RECORD_KEEP_TIME` parameter specifies the minimum number of days RMAN information is stored in the control file before being overwritten. A low value results in information being overwritten sooner, thus minimizing control file growth. If a recovery catalog is used, a lower value should be chosen. This parameter applies only to records in the control file that are circularly reusable (such as archive log records and various backup records). It does not apply to records such as data file, tablespace, and redo thread records, which are never reused unless the corresponding object is dropped from the tablespace. The default is seven days.

Setting Parameters That Affect RMAN (continued)

If you define a flash recovery area, then, by default, that is where backup files are written. You set the flash recovery area size and location by using the DB_RECOVERY_FILE_DEST and DB_RECOVERY_FILE_DEST_SIZE initialization parameters. You also specify a retention policy that dictates when backups may be discarded. RMAN then manages your backup storage, deleting obsolete backups and backups already copied to tape when space is needed, but keeping as many backups on disk as space permits. This minimizes restores from tape during data recovery operations to shorten restore and recovery times. You can resize the flash recovery area at any time by setting the DB_RECOVERY_FILE_DEST variable, which is dynamic.

The NLS_DATE_FORMAT and NLS_LANG environment variables determine the format used for the time parameters in RMAN commands such as RESTORE, RECOVER, and REPORT.

A database that is not mounted assumes the default character set, which is US7ASCII. If your character set is different from the default, then set NLS_LANG appropriately. For example, if the character set is WE8DEC, you can set the NLS_LANG parameter as follows:

```
NLS_LANG=american_america.we8dec
```

RMAN Usage Considerations

- Resources: Shared memory, more processes
- Privileges given to users:
  - Database: SYSDBA
  - Operating system: Access to devices
- Remote operations:
  - Set up the password file
  - Ensure that the password file is backed up

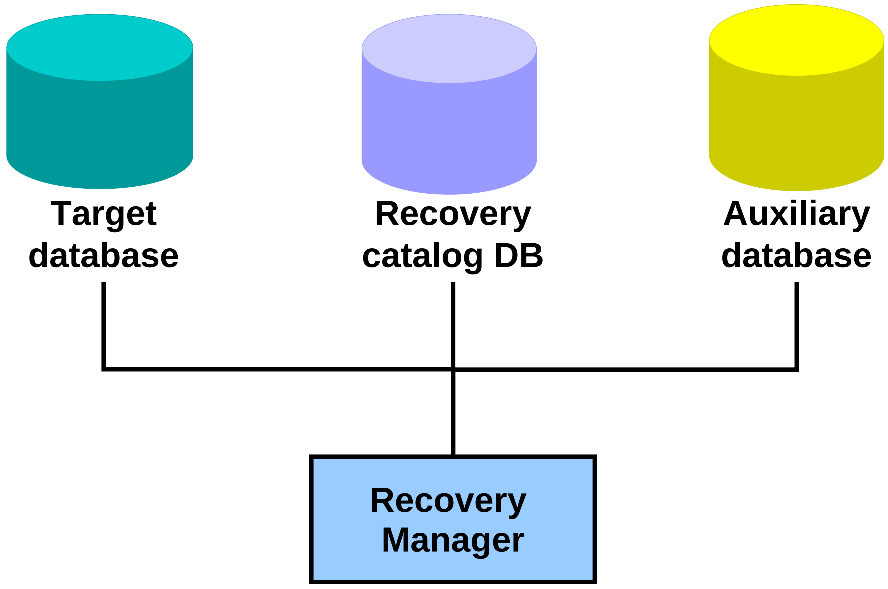
2-24

RMAN Usage Considerations

Before Recovery Manager is used, consider the following points:

- **Shared resources on the system:** Most of the work of RMAN is performed through Oracle database processes. The operations can also be performed in parallel to increase throughput. This implies that the `PROCESSES` database parameter must be sufficiently high. For the operating system–resources, this means that shared memory and semaphore settings may need to be increased.
- **Users performing privileged operations:** You must decide which users will be able to perform privileged operations. Then, grant the necessary privileges to the users' accounts at the operating system level and within the Oracle database. For example, to start up and shut down a database, a user should have the `SYSDBA` privilege.
- **Remote operations:** You need to use a password file to connect to the target database over Oracle Net to perform privileged operations, such as startup and shutdown, from a remote machine.
- **Use of the recovery catalog:** When you use a recovery catalog, RMAN can perform a wider variety of automated backup and recovery functions. Use of the recovery catalog involves storage space and maintenance efforts. You should decide whether to have a database dedicated to maintaining the recovery catalogs of several target databases.

Connection Types with RMAN



ORACLE

2-25

Connection Types with RMAN

You can use Recovery Manager to connect to the following types of databases:

- **Target database:** RMAN connects you to the target database with the `SYSDBA` privilege. You must have this privilege for the connection to succeed. The target database is the instance where you want to perform typical RMAN operations.
- **Recovery catalog database:** This is an optional database that is configured for the RMAN repository. You connect to the recovery catalog database when you want to retrieve information stored within it, such as backup information or stored scripts.
- **Auxiliary database:** An auxiliary database can be a database that is:
  - Created using the `RMAN DUPLICATE` command
  - A temporary database that is used during tablespace point-in-time recovery (TSPITR)
  - A standby database, or a copy of your production database that can be used for disaster recovery

Starting RMAN

- Starting RMAN locally

```
UNIX: $ ORACLE_SID=DB01; export ORACLE_SID
      $ rman target /
```

```
Windows NT: C:\> set ORACLE_SID=DB01
            C:\> rman target /
```

- Starting RMAN remotely

```
rman target sys/password@DB01
```

2-26

Starting RMAN

Local Connection

For a local RMAN connection, at an operating system prompt, enter the following:

UNIX:
```
$ ORACLE_SID=DB01; export ORACLE_SID
$ rman target /
```
Windows:
```
C:\> SET ORACLE_SID=DB01
C:\> rman target /
```

If you do not specify a user ID or password when connecting to the target database, then a slash establishes a connection as user SYS by using operating system authentication.

Optionally, you can specify the NOCATALOG keyword as follows:

```
$ rman target / nocatalog
```

NOCATALOG is the default mode and is used to indicate that you are using RMAN without a recovery catalog.

Remote Connection

To connect from another server, use the Oracle Net service name for the target database:

```
$ rman target sys/target_pwd@DB01
```

Additional RMAN Command-Line Arguments

- Writing RMAN output to a log file

```
$ rman TARGET sys/oracle
  LOG=$HOME/oradata/u03/rman.log APPEND
```

- Executing a command file when RMAN is invoked

```
$ rman TARGET sys/oracle
  CMDFILE=$HOME/scripts/my_rman_script.rcv
```

- Establishing database connections on RMAN startup

```
$ rman TARGET SYS/sys_pwd@orcl CATALOG
rman/rman@rcat
```


Additional RMAN Command-Line Arguments

The `LOG=`*`filename`* argument specifies the file where RMAN output will be recorded. If not specified, then RMAN writes its message log file to standard output.

The `APPEND` keyword specifies that new output should be appended to the end of the message log file.

You can use `CMDFILE=`*`filename`* to run a file containing RMAN commands. RMAN terminates after running the command file.

Any file names specified on the command line that do not begin with an alphabetic character must be enclosed in single quotation marks.

You can specify connection options for RMAN, such as:

- **`AUXILIARY`:** Specifies a connect string to an auxiliary database
- **`CATALOG`:** Specifies a connect string to the database containing the recovery catalog
- **`NOCATALOG`:** Indicates that you are using RMAN without a recovery catalog
- **`TARGET`:** Specifies a connect string to the target database

When you use the `SCRIPT` clause, after you are connected to the target database and recovery catalog (specified using the `TARGET` and `CATALOG` clauses), RMAN runs the named stored script from the recovery catalog against the target database.

Configuring Persistent Settings for RMAN

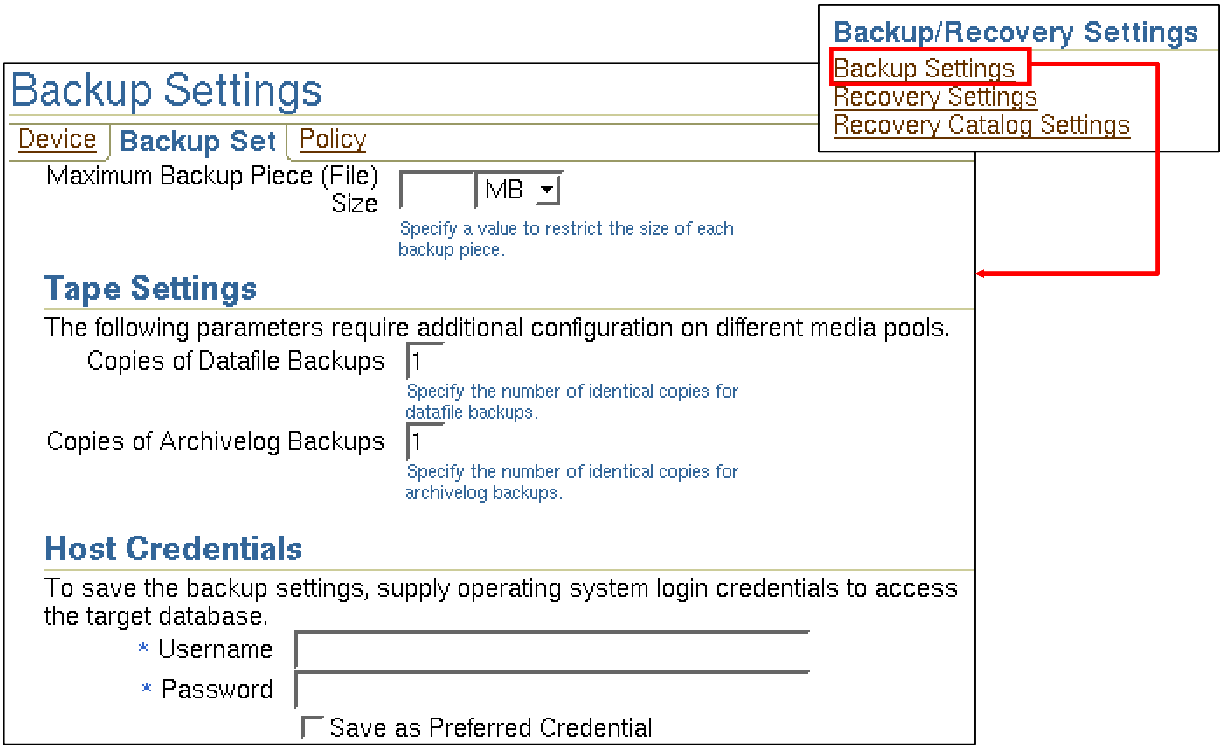
- **RMAN is preset with default configuration settings**
- **Use the `CONFIGURE` command to:**
  - **Configure automatic channels**
  - **Specify the backup retention policy**
  - **Specify the number of backup copies to be created**
  - **Set the default backup type to `BACKUPSET` or `COPY`**
  - **Limit the size of backup sets**
  - **Exempt a tablespace from backup**
  - **Enable and disable backup optimization**
  - **Configure automatic backups of control files**

Configuring Persistent Settings for RMAN

To simplify ongoing use of RMAN for backup and recovery, RMAN enables you to set a number of persistent configuration settings for each target database. These settings control many aspects of RMAN's behavior when working with that database. You can save persistent configuration information such as channel parameters, parallelism, and the default device type in the RMAN repository (which is stored in either the control file or a recovery catalog database).

These settings have default values, which allow you to use RMAN immediately. However, as you develop a more advanced backup and recovery strategy, you will have to change these settings to implement that strategy. You can use the `CONFIGURE` command to configure persistent settings for RMAN backup, restore, duplication, and maintenance jobs. These settings are in effect for any RMAN session until the configuration is cleared or changed.

Configuring RMAN Settings by Using EM



2-29

Configuring RMAN Settings by Using EM

You can use Oracle Enterprise Manager to specify the backup settings for an instance. To specify backup settings, on the **Maintenance** page, select **Backup Settings** in the Backup/Recovery Settings section.

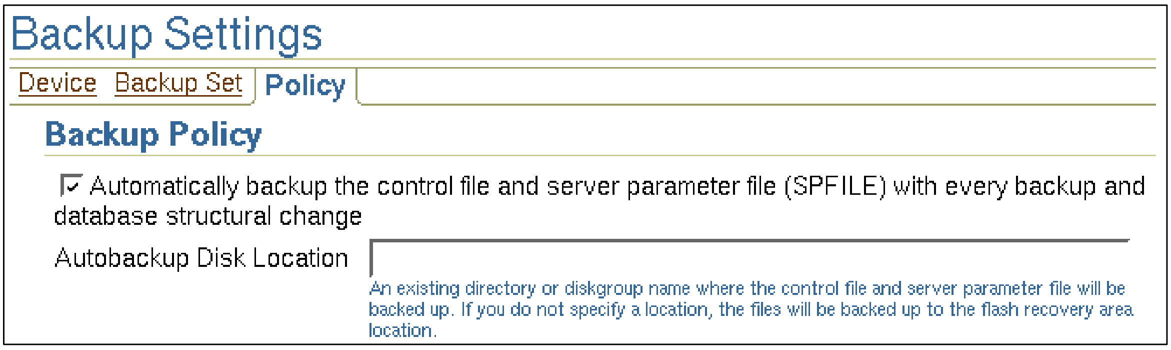
The Backup Settings property page consists of three tabs that cover Device, Backup Set, and Policy parameters. You can access the:

- **Device** page to set the disk and tape configuration settings, including the Media Management Library (MML) settings
- **Backup Set** page (shown in the slide) to specify parameters for backup sets and to enter host credentials
- **Policy** page to set various backup and retention policies before you initiate a backup, such as automatically backing up the control file and SPFILE. The Policy page also allows you to configure block change tracking support, a feature that provides faster incremental backups.

Note: Backup settings change the databasewide settings and apply to any backups that do not override settings at the backup level.

Control File Autobackups

```
RMAN> CONFIGURE CONTROLFILE AUTOBACKUP ON;
```



Best practice: Oracle recommends that you enable control file autobackup.

2-30

Control File Autobackups

To avoid losing a copy of the current control file, you should configure RMAN to take automatic backups of the control file. The automatic backup of the control file occurs independently of any backup of the current control file explicitly requested as part of your backup command. If you are running RMAN in `NOCATALOG` mode, it is highly recommended that you activate control file autobackup. Otherwise, if you lose your control file, your database may be unrecoverable.

To configure control file autobackup, modify the backup policy for your database by using Enterprise Manager or use the following RMAN command:

```
CONFIGURE CONTROLFILE AUTOBACKUP ON;
```

By default, control file autobackups are turned off. If you enable control file autobackups, then RMAN automatically backs up the control file and the current server parameter file (if used to start up the database) in one of two circumstances:

- A successful backup is recorded in the RMAN repository.
- A structural change to the database affects the contents of the control file, which, therefore, must be backed up.

Control File Autobackups (continued)

The control file autobackup file name has a default format of `%F` for all device types, so that RMAN can guess the file location and restore it without a repository. This variable format translates into `c-IIIIIIIIII-YYYYMMDD-QQ`, where:

- `IIIIIIIIII` stands for the DBID
- `YYYYMMDD` is a time stamp of the day the backup is generated
- `QQ` is the hex sequence that starts with `00` and has a maximum of `FF`

You can change the default format by using the `CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE` *`type`* `TO` *`'string'`* command. The value of string must contain the substitution variable `%F` and cannot contain other substitution variables. For example:

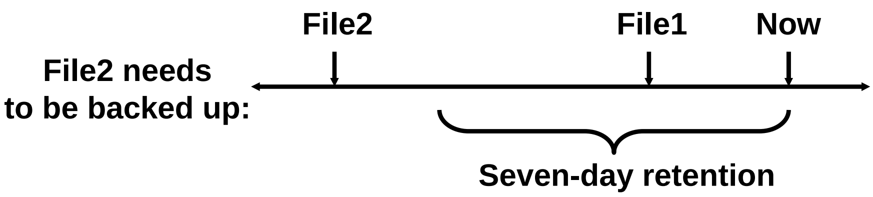
```
CONFIGURE CONTROLFILE AUTOBACKUP FORMAT
FOR DEVICE TYPE DISK TO '/u01/oradata/cf_ORCL_auto_%F';
```

Control file autobackups are stored in the flash recovery area, unless otherwise specified.

With a control file autobackup, RMAN can recover the database even if the current control file, recovery catalog, and server parameter file are inaccessible. Because the path used to store the autobackup follows a well-known format, RMAN can search for and restore the server parameter file or control file from that autobackup.

Retention Policies

- A retention policy describes which backups will be kept and for how long.
- There are two types of retention policies:
  - Recovery window: Establishes a period of time within which point-in-time recovery must be possible



  - Redundancy: Establishes a fixed number of backups that must be kept
- These policies are mutually exclusive and can be set with the `CONFIGURE` command.

Retention Policies

A retention policy describes which backups will be kept and for how long. The value of the retention policy is set by the `CONFIGURE` command. The best practice is to establish a period of time during which it will be possible to discover logical errors and fix the affected objects by doing a point-in-time recovery to just before the error occurred. This period of time is called the recovery window. This policy is specified in number of days. For each data file, there must always exist one backup which satisfies the following condition:

```
SYSDATE - checkpoint_time <= recovery_window
```

For example, if the policy were to be set as follows:

```
RMAN> CONFIGURE RETENTION POLICY
 2    TO RECOVERY WINDOW OF 7 DAYS;
```

Then, for each file there must be a backup that satisfies:

```
SYSDATE - (SELECT checkpoint_time
           FROM V$DATAFILE WHERE file#= …) >= 7
```

In the example in the slide, File1 has a backup that is within the seven-day retention period. File2 does not, so it needs to be backed up in order to satisfy the retention policy.

Retention Policies (continued)

You should keep the recovery window time period less than or equal to the value of the control file parameter `CONTROL_FILE_RECORD_KEEP_TIME` to prevent the record of older backups from being overwritten in the control file.

If you require a certain number of backups to be retained, then you can set the retention policy on the basis of the redundancy option. This option requires that a specified number of backups be cataloged before any backup is identified as obsolete. The default retention policy has a redundancy of 1, which means that only one backup of a file must exist at any given time. A backup is deemed obsolete when a more recent version of the same files has been backed up.

Managing Persistent Settings

- Use the SHOW command to list current settings:

```
RMAN> SHOW CONTROLFILE AUTOBACKUP FORMAT;
RMAN> SHOW EXCLUDE;
RMAN> SHOW ALL;
```

- Use the CLEAR command to reset any persistent setting to its default value:

```
RMAN> CONFIGURE BACKUP OPTIMIZATION CLEAR;
RMAN> CONFIGURE MAXSETSIZE CLEAR;
RMAN> CONFIGURE DEFAULT DEVICE TYPE CLEAR;
```

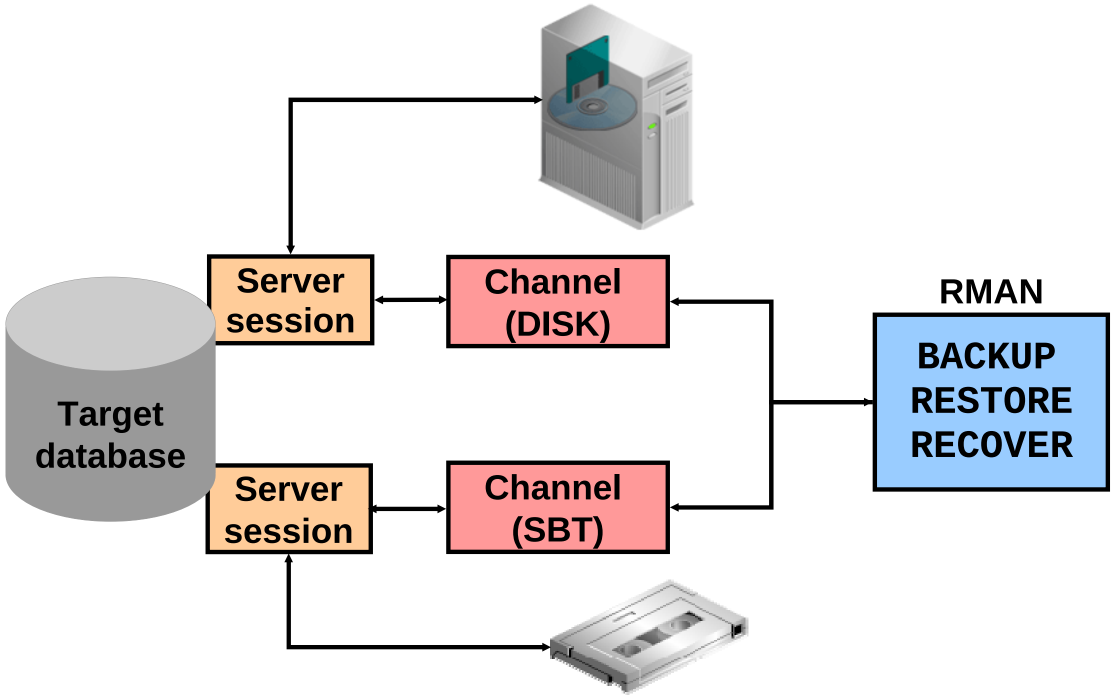
2-34

Managing Persistent Settings

Using the RMAN SHOW command, you can view the RMAN configuration settings. If SHOW ALL is executed when connected to a target database, only node-specific configurations and database configurations are displayed.

You can return to the default value for any CONFIGURE command by running the same command with the CLEAR option.

Channel Allocation



Channel Allocation

A channel represents one stream of data to a device type. A channel must be allocated before you execute backup and recovery commands. Each allocated channel establishes a connection from the RMAN executable to a target database instance. An Oracle database process for the target database is created for every channel allocated.

Every `BACKUP`, `COPY`, `RESTORE`, or `RECOVER` command issued in Recovery Manager requires at least one channel. The type of media desired determines the type of channel allocated. The number of channels allocated is the maximum degree of parallelization that is used during backup, restore, or recovery.

You can query the `V$BACKUP_DEVICE` view to determine supported device types.

Automatic and Manual Channel Allocation

- An automatic channel is one that is preconfigured and used for subsequent commands. To change the default device type for automatic channel allocation, use:

```
RMAN> CONFIGURE DEFAULT DEVICE TYPE TO sbt;
```

- A manually allocated channel is one that overrides the automatic channel setting. This channel overrides the automatic channel for this run block:

```
RMAN> RUN {
  2> ALLOCATE CHANNEL c1 DEVICE TYPE disk;
  3> BACKUP DATAFILE '/u01/oradata/user01.dbf';
  4> }
```

ORACLE

2-36

Automatic and Manual Channel Allocation

With the `CONFIGURE` command, you can preconfigure channels for use in all RMAN sessions using automatic channel allocation. Automatic channels apply to any RMAN job in which you do *not* manually allocate channels.

By default, RMAN has preconfigured a disk channel so that you can back up to disk without doing any manual configuration. Therefore, if you are backing up to disk rather than to a media manager, you can immediately begin backing up to disk.

The `ALLOCATE CHANNEL` command with a `RUN` command and the `ALLOCATE CHANNEL FOR MAINTENANCE` command issued at the RMAN prompt are used to allocate a channel manually. Manual channel allocation overrides automatic allocation.

You can use manually allocated channels to issue commands (such as the `CHANGE`, `DELETE`, and `CROSSCHECK` commands) that delete or change the status of existing backups. Note that if you use `CONFIGURE` to set up automatic channels, then RMAN can use these automatic channels for maintenance operations; you do not have to manually allocate them. Manually allocated maintenance channels cannot be used for any other I/O operation, such as backup or copy.

The automatic channel feature is mutually exclusive with the manual channel feature: RMAN uses one or the other for a given job.

Channel Control Options

- **Configure parallelism:**

```
RMAN> CONFIGURE DEVICE TYPE DISK PARALLELISM 3;
```

- **Specify the maximum backup piece size:**

```
RMAN> CONFIGURE CHANNEL DEVICE TYPE DISK
   2> MAXPIECESIZE 2G;
```

- **Format the name of generated backup files:**

```
RMAN> RUN {
   2> ALLOCATE CHANNEL d1 DEVICE TYPE DISK
   3> FORMAT '/disk1/backups/%U';
   4> BACKUP DATABASE PLUS ARCHIVELOG; }
```


Channel Control Options

You can specify control options for the allocated channel to change its default behavior. The configurable control options for manually and automatically allocated channels are:

- **`CONNECT`:** The connect string for the target instance
- **`FORMAT`:** The format to use for backup piece names created on this channel
- **`MAXOPENFILES`:** The maximum number of input files that a `BACKUP` command can have open at any given time (the default is 8)
- **`MAXPIECESIZE`:** The maximum size of each backup piece created on this channel, specified in bytes (default), kilobytes (K), megabytes (M), or gigabytes (G)
- **`DURATION`:** **T**he amount of time to run the backup job, defined in hours and minutes. The duration can be further specified as:
  - **`PARTIAL`:** No error is signaled if the backup is not complete at the end of the specified duration.
  - **`MINIMIZE TIME`:** The backup runs at full speed, possibly completing within the allotted time.
  - **`MINIMIZE LOAD`:** RMAN monitors the backup speed and automatically reduces the processing speed if it detects that the backup will complete in less than the allotted time. This option is not allowed when writing to tape because it is desirable to drive the tapes as fast as possible.

Channel Control Options (continued)

If the channel device type is `SBT` or `SBT_TAPE`, you can also specify:

- **`PARMS="ENV(…)":`** Set environment variables for the server session corresponding to this RMAN client.
- **`PARMS="SBT_LIBRARY=…":`** Specify the location of the MML to be used by the channel.

For automatic channels, you can also configure the default parallelism level and the default backup type for disk or tape backups to `BACKUPSET`, `COMPRESSED BACKUPSET`, or `COPY`.

Summary

In this lesson, you should have learned how to:

- Use either the control file or a recovery catalog for the RMAN repository
- Change RMAN default settings with `CONFIGURE`
- Use the flash recovery area for RMAN operations
- Monitor the flash recovery area by using v$ views and Enterprise Manager
- Implement recovery window and redundancy retention policies
- Implement manual and automatic channel allocation

ORACLE

2-39

Practice Overview: Configuring RMAN

This practice covers the following topics:

- Using Recovery Manager to connect to a target database in default `NOCATALOG` mode
- Displaying the default RMAN configuration settings
- Configuring control file autobackups
- Altering the backup retention policy for a database

3

Using Recovery Manager

Objectives

Commands
BACKUP
Block C.T.
Inc. Update
LIST
REPORT
DELETE

After completing this lesson, you should be able to do the following:

- **Use the RMAN `BACKUP` command to create backup sets and image copies**
- **Manage the backups and image copies taken with RMAN**

3-2

Objectives

Recovery Manager (RMAN) is the component of the Oracle database used to perform backup and recovery operations. Enterprise Manager (EM) supplies a graphical interface to the most commonly used RMAN functionality.

The *Oracle Database 10g: Administration Workshop I* class demonstrates basic RMAN operations using the EM Database Control Console; therefore, the graphical interface to RMAN is not covered in detail in this lesson.

Issuing Recovery Manager Commands

- Interactive client
  - Enter commands at RMAN prompt.
  - Use when performing analysis, or when running reports or stored scripts.
- Batch mode
  - Use with automated jobs.
  - Specify a command file when starting RMAN.
  - Specify the log file name to capture session log.
- Pipe interface
  - Specify the `PIPE` command-line argument.
  - Use to communicate data between sessions or between RMAN and an external application.

ORACLE

Issuing Recovery Manager Commands

Recovery Manager has its own command language. There are multiple ways of entering commands for RMAN by using the command-line interface (CLI).

To run RMAN commands interactively, start RMAN and then enter commands into the command-line interface. For example:

```
$ rman TARGET sys/sys_pwd@db1
RMAN> BACKUP DATABASE;
```

You can enter RMAN commands into a file, and then run the command file by specifying its name on the command line. This is referred to as batch mode processing. The contents of the command file should be identical to commands that would be entered at the command line. For example:

```
$ rman TARGET SYS/sys_pwd@prod1 @'/oracle/backup_all_l0.rcv'
```

When running in batch mode, RMAN reads input from a command file and writes output messages to a log file (if specified). RMAN parses the command file in its entirety before compiling it or executing any commands. There is no need to place an exit command in the file because RMAN terminates when the end of the file is reached.

The RMAN pipe interface is an alternative method for issuing commands to RMAN and receiving the output from those commands. RMAN obtains commands and sends output by using the `DBMS_PIPE` PL/SQL package.

Issuing Recovery Manager Commands (continued)

The pipe interface is invoked by using the PIPE command-line parameter. RMAN uses two private pipes: one for receiving commands and the other for sending output. The names of the pipes are derived from the value of the PIPE parameter.

For example:

```
% rman PIPE abc TARGET SYS/pwd@trgt
```

RMAN opens the two pipes in the target database: ORA$RMAN_ABC_IN, which RMAN uses to receive user commands, and ORA$RMAN_ABC_OUT, which RMAN uses to send all output back to RMAN. All messages on both the input and output pipes are of the VARCHAR2 type.

When the pipe interface is used, RMAN does not read or write any data by using the operating system shell. You can use pipes to communicate with another session in the same instance or a waiting application such as a UNIX program. By using this interface, it is possible to write a portable programmatic interface to RMAN.

See the *Oracle Database Backup and Recovery Advanced User’s Guide* for more information about using pipes with RMAN.

Refer to the *PL/SQL Packages and Types Reference* for more information about the DBMS_PIPE package and creating pipes within the Oracle database.

Types of RMAN Commands

RMAN commands are of the following types:

- **Stand-alone command:**
  - **Is executed individually at the RMAN prompt**
  - **Cannot appear as subcommands within `RUN`**
- **Job command:**
  - **Must be within the braces of a `RUN` command**
  - **Is executed as a group**

Some commands can be executed as either a stand-alone or a job command.

Types of RMAN Commands

You can issue two basic types of RMAN commands: stand-alone and job commands.

Stand-alone commands are executed at the RMAN prompt and are generally self-contained. Some of the stand-alone commands are:

- `CHANGE`
- `CONNECT`
- `CREATE CATALOG`, `RESYNC CATALOG`
- `CREATE SCRIPT`, `DELETE SCRIPT`, `REPLACE SCRIPT`

Job commands are usually grouped and executed sequentially inside a command block. If any command within the block fails, RMAN ceases processing; no further commands within the block are executed. The effects of any already executed commands still remain, though; they are not undone in any way.

An example of a command that can be run only as a job command is `ALLOCATE CHANNEL`. The channel is allocated only for the execution of the job, so it cannot be issued as a stand-alone command. There are some commands that can be issued either at the prompt or within a `RUN` command block, such as `BACKUP DATABASE`. If you issue stand-alone commands, RMAN allocates any needed channels by using the automatic channel allocation feature.

You can execute stand-alone and job commands in interactive mode or batch mode.

Job Commands: Example

Job commands appear inside a `RUN` command block:

```
RMAN> RUN {
   2> BACKUP AS BACKUPSET
   3> FORMAT '/u01/db01/backup/%d_%s_%p'
   4> DURATION 10:00 MINIMIZE LOAD
   5> (DATABASE);
   6> SQL 'alter system archive log current';
   7> }
```

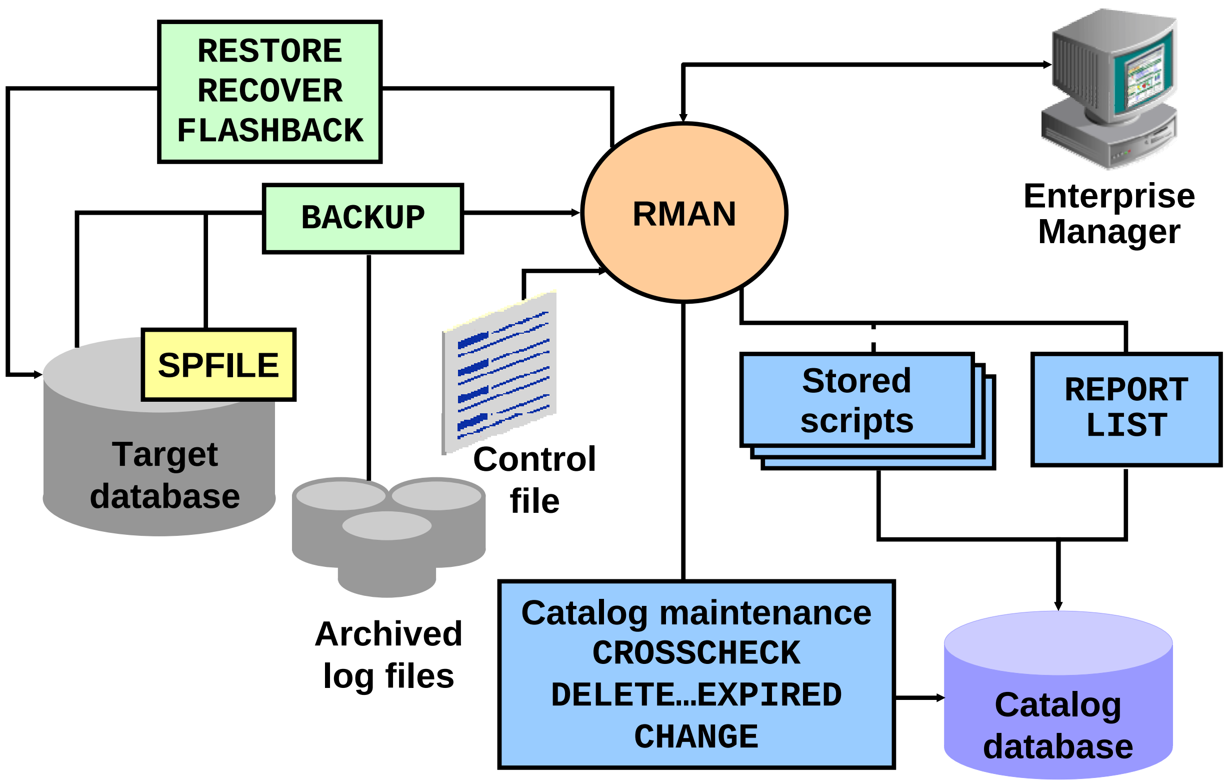

Job Commands: Example

Unlike stand-alone commands, job commands must appear within the braces of a `RUN` command. The following are examples of job commands:

- `ALLOCATE CHANNEL`
- `SWITCH`

RMAN executes the job commands inside a `RUN` command block sequentially. If any command within the block fails, then RMAN ceases processing; no further commands within the block are executed. In effect, the `RUN` command defines a unit of command execution. When the last command within a `RUN` block completes, the Oracle database releases any server-side resources such as I/O buffers or I/O slave processes allocated within the block.

RMAN Commands: Overview



RMAN Commands: Overview

The typical RMAN commands that you run against the target database include:

- `BACKUP` to back up a database, tablespace, data file (current or copy), control file (current or copy), SPFILE, archived log, or backup set for a target or standby database. Backing up a backup set is an easy way to move a backup from disk to tape.
- `DUPLICATE` to create a clone database or a standby database from backups (backup sets or image copies) of the target database
- `FLASHBACK` to perform a Flashback Database operation, returning the database to (or to just before) a target time, as specified by time, SCN, or log sequence number
- `RECOVER` to recover, and `RESTORE` to restore files from backups or image copies

The RMAN reporting commands include:

- `LIST` for querying the recovery catalog or control file and producing a list of the backups, copies, archived redo logs, and database incarnations recorded there
- `REPORT` for performing detailed analysis of the recovery catalog or control file

RMAN Commands: Overview (continued)

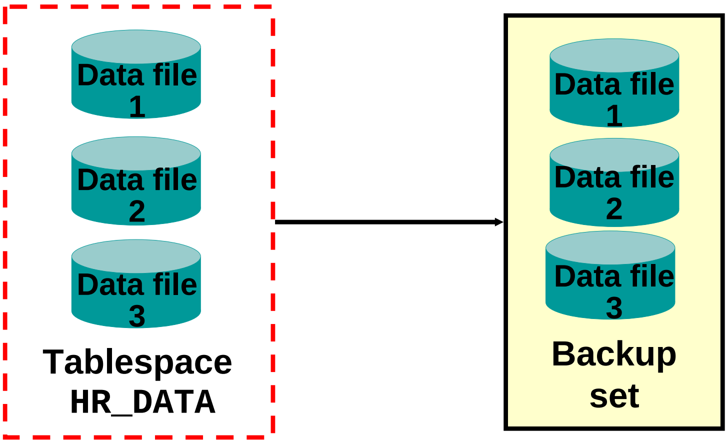
RMAN provides the following command sets for catalog maintenance:

- `CROSSCHECK` checks the status of a backup or a copy on disk or tape.
- `DELETE` lists specified backup objects and prompts for confirmation to remove them.
- `CHANGE` alters the status of backup objects in the repository.
- `LIST` shows what `CROSSCHECK/DELETE EXPIRED` would process if run.

BACKUP Command

Commands
> BACKUP
Block C.T.
Inc. Update
LIST
REPORT
DELETE

```
RMAN> BACKUP AS BACKUPSET
   2>    FORMAT '/BACKUP/df_%d_%s_%p.bus'
   3>    TABLESPACE hr_data;
```



BACKUP Command

A backup is a copy of data from your database that can be used to reconstruct that data. The results of a backup created through RMAN can be either image copies or backup sets. An image copy is a bit-for-bit identical copy of a database file. RMAN can also store its backups in an RMAN-exclusive format called a backup set. A backup set is a collection of files called backup pieces, each of which may contain one or more database file backups.

When performing a backup using RMAN, you can specify:

- The type of backup to be performed. You can perform backups of the entire database to include every used data block in the files (a `FULL` backup) or incremental backups (`INCREMENTAL`). If `CONFIGURE CONTROLFILE AUTOBACKUP` is enabled, RMAN automatically backs up the control file and the current server parameter file after `BACKUP` commands.
- What to backup. Valid values are `DATABASE`, `DATAFILE`, `TABLESPACE`, `ARCHIVELOG`, `CURRENT CONTROLFILE`, or `SPFILE`.
- Whether an image copy (`AS COPY`) or backup set (`AS BACKUPSET`) is created
- The file name format and location for backup pieces (`FORMAT`)
- Which data files or archived redo logs should be excluded from the backup set (`SKIP`)
- A maximum size for a backup set (`MAXSETSIZE`)
- That the input files should be deleted upon the successful creation of the backup set (`DELETE INPUT`)

Backup Constraints

- **The database must be mounted or open.**
- **You cannot back up online redo logs.**
- **Only "clean" backups are usable in `NOARCHIVELOG` mode.**
- **Only "current" data file backups are usable in `ARCHIVELOG` mode.**

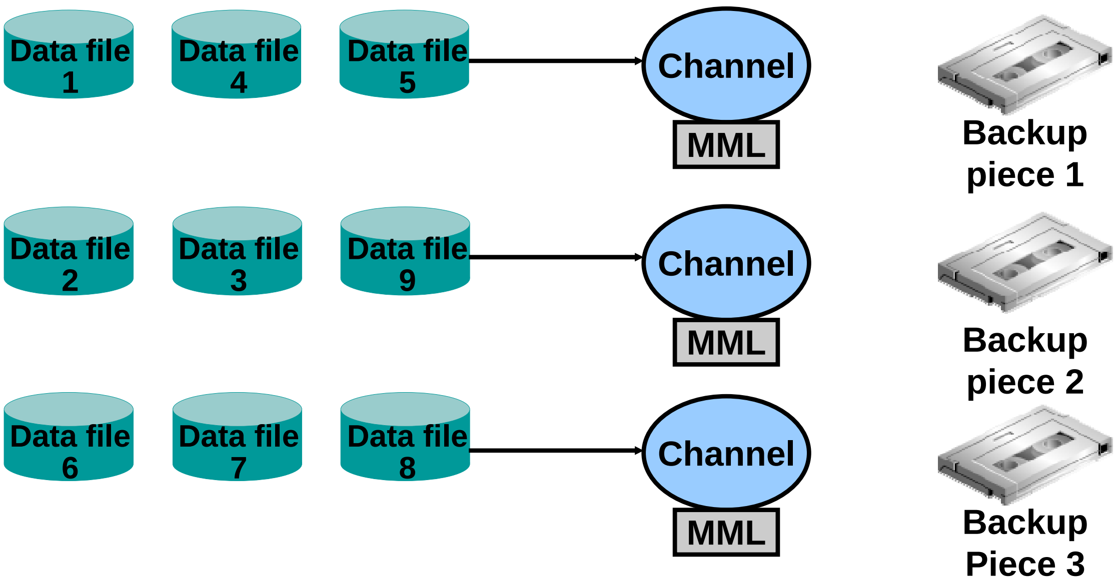
Backup Constraints

When performing a backup by using Recovery Manager, you must be aware of the following:

- The target database must be mounted for Recovery Manager to connect.
- Backups of online redo logs are not supported.
- If the target database is in `NOARCHIVELOG` mode, only "clean" tablespace and data file backups can be taken (that is, backups of "offline normal" or "read only" tablespaces). Database backups can be taken only if the database has first been shut down cleanly and restarted in `MOUNT` mode.
- If the target database is in `ARCHIVELOG` mode, only "current" data files can be backed up (restored data files are made current by recovery).
- If a recovery catalog is used, the recovery catalog database must be open.

Parallelization of Backup Sets

For performance, allocate multiple channels and assign files to specific channels.



Parallelization of Backup Sets

You can configure parallel backups by setting the `PARALLELISM` option of the `CONFIGURE` command to greater than 1 or by manually allocating multiple channels. RMAN parallelizes its operation and writes multiple backup sets in parallel. The server sessions divide the work of backing up the specified files.

Example

```
RMAN> RUN {
   2>    ALLOCATE CHANNEL c1 DEVICE TYPE sbt;
   3>    ALLOCATE CHANNEL c2 DEVICE TYPE sbt;
   4>    ALLOCATE CHANNEL c3 DEVICE TYPE sbt;
   5>    BACKUP
   6>      INCREMENTAL LEVEL = 0
   7>      FORMAT '/disk1/backup/df_%d_%s_%p.bak'
   8>      (DATAFILE 1,4,5 CHANNEL c1)
   9>      (DATAFILE 2,3,9 CHANNEL c2)
  10>      (DATAFILE 6,7,8 CHANNEL c3);
  11>    ALTER SYSTEM ARCHIVE LOG CURRENT;
  12> }
```

Parallelization of Backup Sets (continued)

When backing up data files, you can specify the files to be backed up by either their path name or their file number. For example, the following two commands perform the same action:

```
BACKUP DEVICE TYPE sbt DATAFILE '/home/oracle/system01.dbf';
BACKUP DEVICE TYPE sbt DATAFILE 1;
```

When you create multiple backup sets and allocate multiple channels, RMAN automatically parallelizes its operation and writes multiple backup sets in parallel. The allocated server sessions share the work of backing up the specified data files, control files, and archived redo logs. You cannot stripe a single backup set across multiple channels.

Parallelization of backup sets is achieved by:

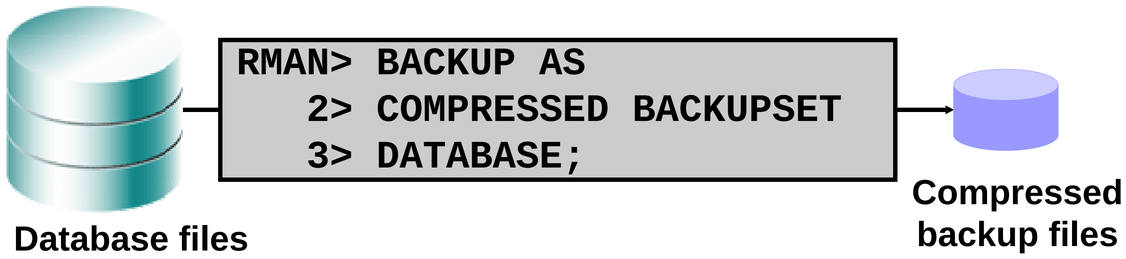
- Configuring `PARALLELISM` to greater than 1 or allocating multiple channels
- Specifying many files to back up

Example

- There are nine files that need to be backed up (data files 1 through 9).
- Assign the data files to a backup set so that each set has approximately the same number of data blocks to back up (for efficiency).
  - Data files 1, 4, and 5 are assigned to backup set 1.
  - Data files 2, 3, and 9 are assigned to backup set 2.
  - Data files 6, 7, and 8 are assigned to backup set 3.

Note: You can also use the `FILESPERSET` parameter to limit the number of data files that are included in a backup set.

Compressed Backups




```
RMAN> CONFIGURE DEVICE TYPE
   2> DISK PARALLELISM 2
   3> BACKUP TYPE TO
   4> COMPRESSED BACKUPSET;
```

3-13

Compressed Backups

Compressed backups reduce the amount of space required for storing backup sets.

You create a compressed backup of a database by using the following command:

```
RMAN> BACKUP AS COMPRESSED BACKUPSET DATABASE;
```

The compressed backup set feature cannot be used with pre–Oracle Database 10*g* databases. The database initialization parameter `COMPATIBILITY` must be set to at least 10.0.0.0. The compression applies only to backup sets, and not to image copies.

You can configure RMAN to automatically make compressed backup sets with the `CONFIGURE DEVICE TYPE` command:

```
RMAN> CONFIGURE DEVICE TYPE DISK PARALLELISM 2
   2> BACKUP TYPE TO COMPRESSED BACKUPSET;
```

By default, compression is disabled.

Image Copy

```
RMAN> BACKUP AS COPY
   2> DATAFILE '/ORADATA/users_01_db01.dbf'
   3>   FORMAT '/BACKUP/users01.dbf';
RMAN> BACKUP AS COPY
   4> ARCHIVELOG LIKE 'arch_1060.arc'
   5>     FORMAT 'arch_1060.bak';
```

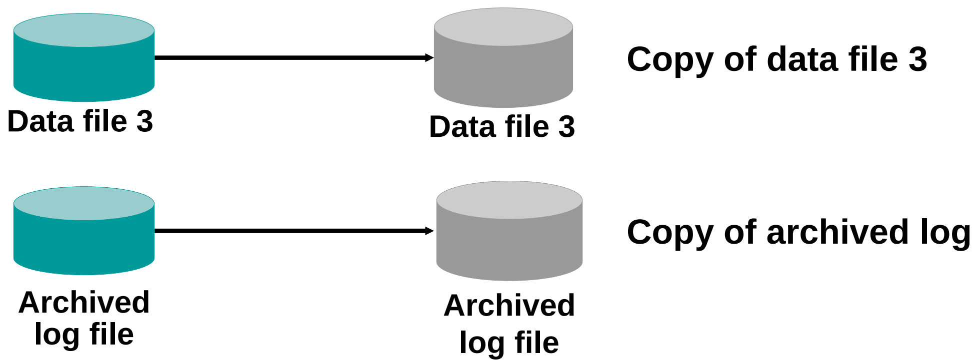


Image Copy

An image copy is a clone of a single data file, archived redo log, or control file. An image copy can be created with the `BACKUP AS COPY` command or with an OS command.

When you create the image copy with the RMAN `BACKUP AS COPY` command, the server session validates the blocks in the file and records the copy in the control file.

An image copy has the following characteristics:

- An image copy can be written only to disk. When large files are being considered, copying may take a long time, but restoration time is reduced considerably because the copy is available on the disk.
- If files are stored on disk, they can be used immediately by using the `SWITCH` command in RMAN, which is equivalent to the `ALTER DATABASE RENAME FILE` SQL statement.
- In an image copy, all blocks are copied, whether they contain data or not, because an Oracle database process copies the file and performs additional actions such as checking for corrupt blocks and registering the copy in the control file. To speed up the process of copying, you can use the `NOCHECKSUM` parameter.
- Image copy can be part of a full or incremental level 0 backup because a file copy always includes all blocks. You must use the level 0 option if the copy will be used in conjunction with an incremental backup set.

Image Copy (continued)

The example in the slide creates two image copies:

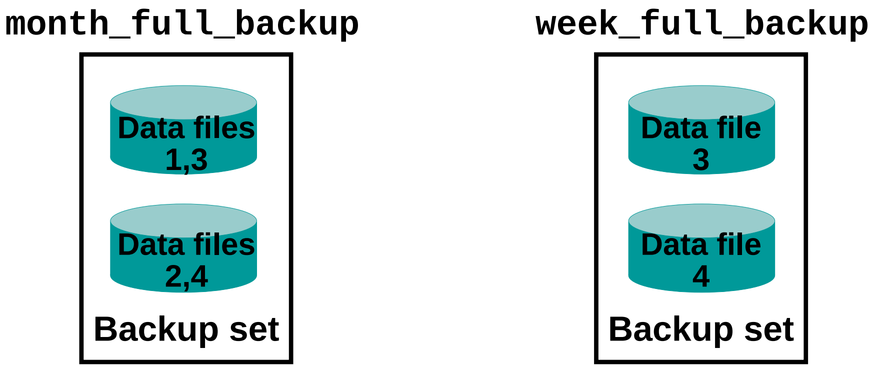
- A copy of the `users01_db01.dbf` data file, renamed as `users01.dbf`, and stored in the `BACKUP` directory
- A copy of the archived log with sequence number 1060

The example assumes that you are using automatic channel allocation. If you manually allocate channels, you must include the `COPY` command within the `RUN` statement as follows:

```
RMAN> RUN {
   2> ALLOCATE CHANNEL c1 type disk;
   3> COPY
   4> DATAFILE '/ORADATA/users_01_db01.dbf' to
   5>          '/BACKUP/users01.dbf',
   6> ARCHIVELOG 'arch_1060.arc' to
   7>            'arch_1060.bak';
   8> }
```

Tags for Backups and Image Copies

A tag is a logical name assigned to a backup set or image copy.



Tags for Backups and Image Copies

A tag is a meaningful name that you can assign to a backup set or image copy. The advantages of tags are as follows:

- Tags provide a useful reference to a collection of file copies or a backup set.
- Tags can be used in the `LIST` command to locate backed-up files easily.
- Tags can be used in the `RESTORE` and `SWITCH` commands.
- The same tag can be used for multiple backup sets or file copies.

If a nonunique tag references more than one data file, then RMAN chooses the most current available file.

Example

- Each month, a full backup of data files 1, 2, 3, and 4 is performed. The tag in the control file for this backup is `month_full_backup`, even though the physical file name generated is `df_DB00_863_1.dbf`:

```
RMAN> BACKUP TAG 'month_full_backup' DATAFILE 1,2,3,4;
```

- Each week, a full backup of data files 3 and 4 is performed. The tag name for this backup is `week_full_backup`.

```
RMAN> BACKUP TAG 'week_full_backup' DATAFILE 3,4;
```

BACKUP Command Options

- Check for physical block corruptions.
- Scan for logical corruptions and physical corruptions.
- Set a threshold on the number of detected corruptions allowed before aborting.
- Validate the target input files before performing a backup operation.
- Duplex the backup set.
- Overwrite an existing backup set or image copy.
- Pass control of the data transfer between storage devices and the data files on disk to the media management layer.
- Encrypt the backup files.

BACKUP Command Options

During the backup operation, an Oracle database process computes a checksum for each block to detect corruption. RMAN verifies the checksum when restoring the copy. This is referred to as physical corruption detection. You can use the `NOCHECKSUM` option to suppress the checksum operation and speed up the backup process. If the database is already maintaining block checksums, then this option has no effect.

You can use the `CHECK LOGICAL` option to test data and index blocks that pass physical corruption checks for logical corruption—for example, corruption of a row piece or index entry. If logical corruption is detected, the block is logged in the alert log and trace file of the server process. You can set a threshold for the allowed number of logical and physical corruptions with the `MAXCORRUPT` parameter. As long as the sum of physical and logical corruptions that is detected for a file remains below this value, the RMAN backup operation completes and the Oracle database populates the `V$DATABASE_BLOCK_CORRUPTION` view with the corrupt block ranges. If `MAXCORRUPT` is exceeded, then the operation terminates without populating the view.

You can use the `VALIDATE` option to check for physical and logical errors in database files. When using the `BACKUP` command with the `VALIDATE` option, RMAN scans the specified files and verifies their contents, testing whether this file can be backed up. This command does not actually back up the specified files.

Encryption of backup files is covered in the lesson titled “Database Security.”

BACKUP Command Options (continued)

You can create up to four identical copies of each backup piece by duplexing the backup set. Use any of the following commands to produce a duplexed backup set:

- `BACKUP COPIES`
- `SET BACKUP COPIES`
- `CONFIGURE ... BACKUP COPIES`

RMAN does not produce multiple backup sets, but produces identical copies of each backup piece in the set. You cannot use this option with the `BACKUP AS COPY` command to create multiple image copies.

If you specify `REUSE`, you enable RMAN to overwrite an already existing backup set or image copy with the same file name as the file that `BACKUP` is currently creating.

The `PROXY` copy functionality backs up the specified files by giving the media management software control over the data transfer between storage devices and the data files on disk. The media manager—not RMAN—decides how and when to move data. When you run `BACKUP` with the `PROXY` option, RMAN performs these steps:

1. It searches for a channel of the specified device type that is proxy-capable. If no such channel is found, then RMAN issues a warning and attempts a conventional (that is, nonproxy) backup of the specified files.
2. If RMAN locates a proxy-capable channel, it calls the media manager to check whether it can proxy copy the files. If the media manager cannot proxy copy, then RMAN uses conventional backup sets to back up the files.

If you do not want RMAN to try a conventional copy when a proxy copy fails, use the `ONLY` option.

Because image copies are written only to disk, you cannot use the `PROXY` option with the `BACKUP AS COPY` command.

Note: If you specify `PROXY`, then the `%p` variable must be included in the `FORMAT` string either explicitly or implicitly within `%U`.

Backing Up Archived Redo Logs

- Online redo log file switch is automatic.
- Archived log failover is performed.
- You can specify a range of archived redo logs to back up.
- Backup sets of archived redo log files cannot contain any other type of file.

```
RMAN> BACKUP
   2>   FORMAT '/disk1/backup/ar_%t_%s_%p'
   3>   ARCHIVELOG FROM SEQUENCE=234
   4>   DELETE INPUT;
```

3-19

Backing Up Archived Redo Logs

A common problem experienced by DBAs is not knowing whether an archived log has been completely copied out to the archive log destination before attempting to back it up. RMAN has access to control file or recovery catalog information, so it knows which logs have been archived and can be restored during recovery.

You can back up archived redo log files with the `BACKUP ARCHIVELOG` command or back them up while backing up data files and control files with the `BACKUP … PLUS ARCHIVELOG` command. Archived logs always end up in a separate backup set even if `PLUS ARCHIVELOG` is used; in that case, a single backup command generates more than one backup set. If you want to back up only certain archived log files, you can specify the range of archived logs to back up. Archived logs are always put into a separate backup set from other files.

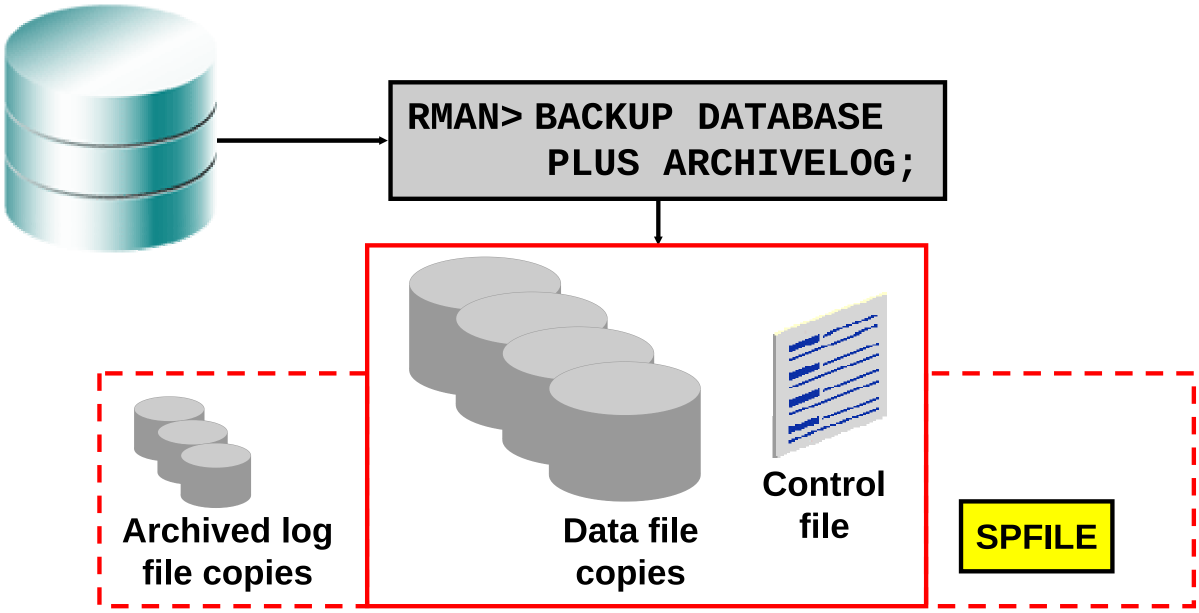
You can also use the `NOT BACKED UP` *`integer`* `TIMES` clause of the `BACKUP ARCHIVELOG` command to back up only those logs that have not been backed up at least the number of times specified. This is a convenient way to back up archived logs on specified media (for example, you want to keep at least three copies of each log on tape).

Backing Up Archived Redo Logs (continued)

RMAN automatically performs archived log failover. If any corrupt blocks are detected in an archived redo log file, RMAN searches other archiving destinations for a file without corrupt blocks.

The example shown in the slide backs up all archived redo logs with a sequence number of 234 or higher to a backup set. After the archived logs are copied, they are deleted from disk and marked as deleted in the `V$ARCHIVED_LOG` view.

Whole Database Backup



Whole Database Backup

A whole database backup is a copy of all data files and the control file. You can optionally include the SPFILE and archived log files. Using Recovery Manager to make an image copy of all the database files is as easy as mounting the database, starting RMAN, and entering the `BACKUP` command shown in the slide.

This is possible if you have already issued the following `CONFIGURE` commands:

- `CONFIGURE DEFAULT DEVICE TYPE TO disk;`
- `CONFIGURE DEVICE TYPE DISK BACKUP TYPE TO COPY;`
- `CONFIGURE CONTROLFILE AUTOBACKUP ON;`

You can also create a backup (either a backupset or image copies) of previous image copies of all data files and control files in the database by using the following command:

```
RMAN> BACKUP COPY OF DATABASE;
```

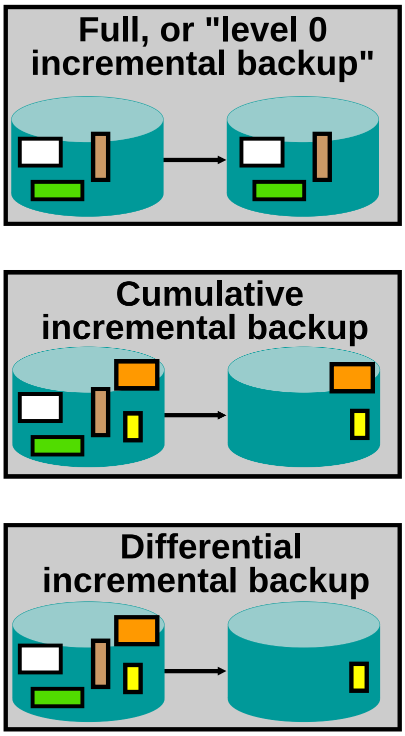
By default, RMAN executes each `BACKUP` command serially. However, you can parallelize the copy operation by:

- Using the `CONFIGURE DEVICE TYPE DISK PARALLELISM` *n*, where *n* is the desired degree of parallelism
- Allocating multiple channels
- Specifying one `BACKUP AS COPY` command and listing multiple files

Note: A high degree of parallelism requires more machine resources, but can save time.

RMAN Backup Types

- A *full backup* contains all used data file blocks.
- A *level 0 incremental backup* is equivalent to a full backup that has been marked as level 0.
- A *cumulative level 1 incremental backup* contains only blocks modified since the last level 0 incremental backup.
- A *differential level 1 incremental backup* contains only blocks modified since the last incremental backup.



RMAN Backup Types

Full Backups

A full backup is different from a whole database backup. A full data file backup is a backup that includes every used data block in the file. RMAN copies all blocks into the backup set or image copy, skipping only data file blocks that have never been used. For a full image copy, the entire file contents are reproduced exactly. A full backup cannot be part of an incremental backup strategy; it cannot be the parent for a subsequent incremental backup.

Incremental Backups

An incremental backup is either a level 0 backup, which includes every block in the data files except blocks that have never been used, or a level 1 backup, which includes only those blocks that have been changed since a previous backup was taken. A level 0 incremental backup is physically identical to a full backup. The only difference is that the level 0 backup can be used as the base for a level 1 backup, but a full backup can never be used as the base for a level 1 backup.

Incremental backups are specified through the `INCREMENTAL` keyword of the `BACKUP` command. You specify `INCREMENTAL LEVEL = [0 | 1]`.

RMAN Backup Types (continued)

Incremental Backups (continued)

RMAN can create multilevel incremental backups as follows:

- **Differential:** The default type of incremental backup that backs up all blocks changed after the most recent incremental backup at either level 1 or level 0
- **Cumulative:** Backs up all blocks changed after the most recent backup at level 0

Examples

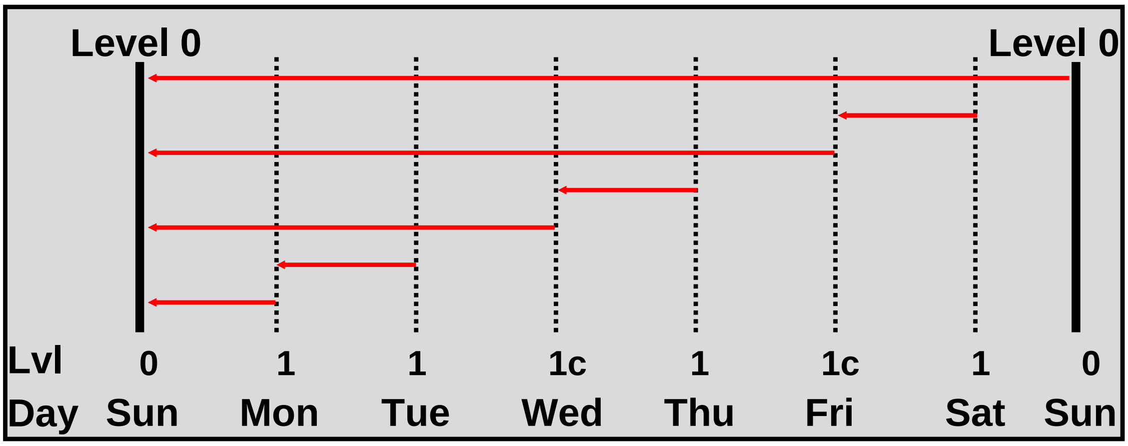
- To perform an incremental backup at level 0, use the following command:
```
RMAN> BACKUP INCREMENTAL LEVEL 0 DATABASE;
```
- To perform a differential incremental backup, use the following command:
```
RMAN> BACKUP INCREMENTAL LEVEL 1 DATABASE;
```
- To perform a cumulative incremental backup, use the following command:
```
RMAN> BACKUP INCREMENTAL LEVEL 1 CUMULATIVE DATABASE;
```

RMAN makes full backups by default if neither `FULL` nor `INCREMENTAL` is specified. Unused block compression causes never-written blocks to be skipped when backing up data files to backup sets, even for full backups.

A full backup has no effect on subsequent incremental backups, and is not considered part of any incremental backup strategy, although a full image copy backup can be incrementally updated by applying incremental backups with the `RECOVER` command. This is covered later in this lesson.

Differential Versus Cumulative

- A differential incremental backup contains all blocks changed since the last incremental backup.
- A cumulative incremental backup contains all blocks changed since the last level 0 incremental backup.



Differential Versus Cumulative

Cumulative incremental backups duplicate changes already copied by the previous noncumulative incremental backups at the same level. Therefore, if an incremental level 1 backup is taken, then the following cumulative level 1 backs up all newly modified blocks plus those already backed up by the incremental level 1. This means that only one incremental backup of the same level is needed to completely recover.

Comparison of incremental and cumulative backups:

- Differential incremental backups are faster, write out fewer blocks, and produce smaller backup files. This results in a faster backup process, but during recovery, RMAN has to retrieve each incremental backup and apply it.
- Cumulative incremental backups may take longer, write out more blocks, and produce larger backup files. Cumulative backups are provided for recovery speed because fewer backups must be applied when recovering.

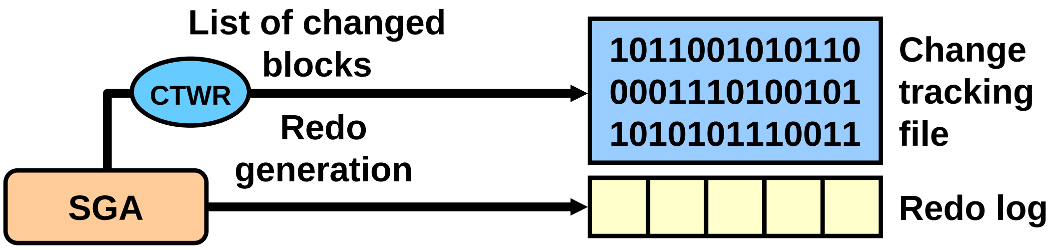
In the graphic shown in the slide, a company has decided on a backup strategy that uses both incremental and cumulative backups. Every Sunday, a level 0 incremental backup is taken. Twice a week, on Wednesday and Friday, a cumulative backup is taken to reduce the recovery time of the database. On other days, a differential backup is taken to reduce the backup time and storage requirements.

Block Change Tracking

Commands
BACKUP
> **Block C.T.**
Inc. Update
`LIST`
`REPORT`
`DELETE`

The backup process can be streamlined by enabling block change tracking, which:

- **Records changed blocks in a change tracking file**
- **Is used automatically by RMAN, if enabled**
- **Optimizes incremental backups by avoiding full data file scans during backup**



3-25

Block Change Tracking

The goal of an incremental backup is to back up only those data blocks that have changed since a previous backup. The entire data file is read during each incremental backup, even if just a very small part of that file has changed since the last incremental backup.

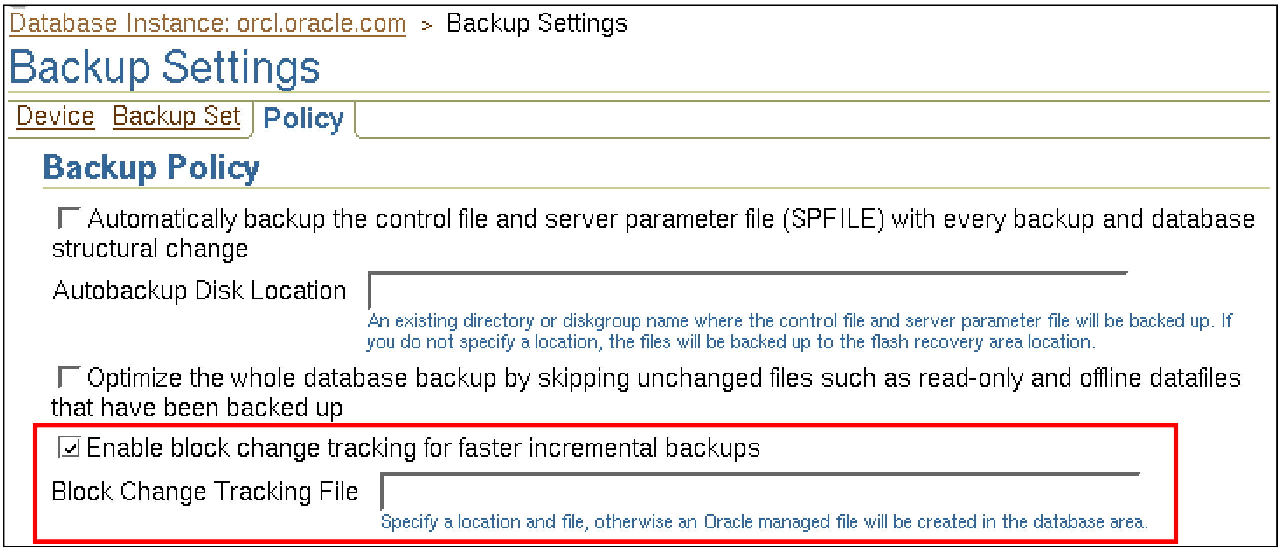
The block change tracking feature uses the change tracking writer (`CTWR`) background process to record the physical location of all database changes in a new type of file called the *change tracking file*. After enabling change tracking, the first level 0 incremental backup still has to scan the entire data file because the change tracking file does not yet reflect the status of the blocks. For subsequent incremental backups, RMAN uses the change tracking data to determine which blocks to read during an incremental backup, improving performance by eliminating the need to read the entire data file.

You use the same commands to perform incremental backups if block change tracking is enabled, and the change tracking files themselves generally require little maintenance after initial configuration. The size of the block change tracking file is proportional to:

- Database size, in bytes, and the number of enabled threads in a RAC environment
- The number of old backups maintained by the block change tracking file

Enabling Block Change Tracking

```
SQL> ALTER DATABASE ENABLE
  2> BLOCK CHANGE TRACKING
  3> USING FILE '/mydir/rman_change_track.f'
  4> REUSE;
```



3-26

Enabling Block Change Tracking

You enable block change tracking using the Maintenance page of Enterprise Manager (EM). Click the Backup Settings link and then click the Policy tab. You must supply the operating system login credentials to save this backup setting.

The minimum size for the block change tracking file is 10 MB, and new space is allocated in 10 MB increments. You do not have to specify a name for the block change tracking file if the `db_create_file_dest` parameter is set, in which case an Oracle-managed file is created.

You can use the following commands to configure fast incremental backup manually:

```
SQL> ALTER DATABASE ENABLE BLOCK CHANGE TRACKING;
SQL> ALTER DATABASE DISABLE BLOCK CHANGE TRACKING;
```

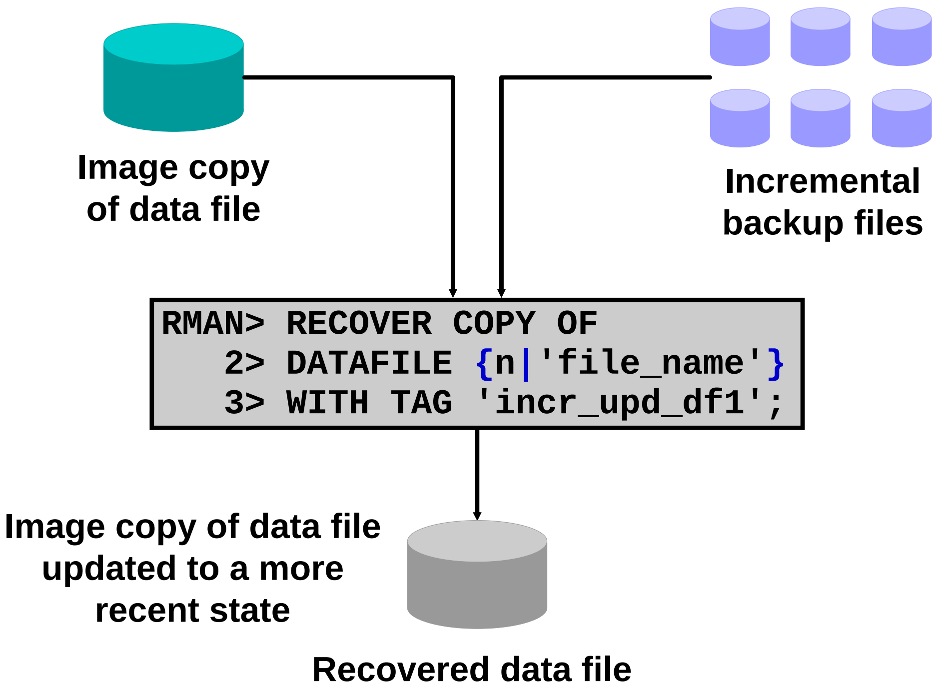
If the `db_create_file_dest` parameter is not configured, use the `USING FILE` clause to specify a user-defined directory location and file name for the tracking file.

You can view details for the current block change tracking configuration by querying the `V$BLOCK_CHANGE_TRACKING` view.

Change tracking is disabled by default because it does introduce some minimal performance overhead on your database during normal operations.

Incrementally Updating Backups

Commands
BACKUP
Block C.T.
> **Inc. Update**
LIST
REPORT
DELETE




```
RMAN> RECOVER COPY OF
   2> DATAFILE {n|'file_name'}
   3> WITH TAG 'incr_upd_df1';
```


Incrementally Updating Backups

With the Incrementally Updated Backups feature, you can use RMAN to apply incremental backups to data file image copies. With this recovery method, RMAN can recover a copy of a data file, or roll forward the image copy, to the specified point in time by applying the incremental backups. The image copy is updated with all changes up through the SCN at which the incremental backup was taken.

RMAN can use the resulting updated image copy in media recovery just as it would use a full image copy taken at that SCN, without the overhead of performing a full image copy of the database or data file every day.

Incrementally updating backups requires two different commands:

- Use the `BACKUP INCREMENTAL LEVEL 1...FOR RECOVER OF COPY WITH TAG ...` form of the `BACKUP` command to create incremental backups that can be incrementally updated. If an incremental level 0 backup does not already exist, then executing this command creates a level 0 backup with the specified tag.
- Apply any incremental backups to a set of data file copies with the same tag using the `RECOVER COPY ...WITH TAG ...` form of the `BACKUP` command. If there is no incremental backup or no data file copy, the command generates a message but does not generate an error.

Tags must be used to identify the incremental backups and data file copies created for use in this strategy, so that they do not interfere with other backup strategies that you implement.

LIST Command

Commands
BACKUP
Block C.T.
Inc. Update
> LIST
REPORT
DELETE

- List backup sets and copies of data files:

```
RMAN> LIST BACKUP OF DATABASE;
```

```
RMAN> LIST BACKUP OF DATAFILE
   2>   "/db01/ORADATA/u03/users01.dbf";
```

- List backup sets and copies of any data file for a specified tablespace:

```
RMAN> LIST COPY OF TABLESPACE "SYSTEM";
```

- List backup sets and copies containing archive logs for a specified range:

```
RMAN> LIST COPY OF DATABASE ARCHIVELOG
   2> FROM TIME='SYSDATE-7';
```

3-28

LIST Command

Use the RMAN LIST command to display information about backup sets, proxy copies, and image copies recorded in the repository. Use this command to list:

- Backups and copies that do not have the AVAILABLE status in the RMAN repository
- Backups and copies of data files that are available and can possibly be used in a restore operation
- Backup sets and copies that contain a backup of a specified list of data files or specified tablespaces
- Backup sets and copies that contain a backup of any archived logs with a specified name or range
- Backup sets and copies restricted by tag, completion time, recoverability, or device
- Incarnations of a specified database or of all databases known to the repository
- Stored scripts in the recovery catalog

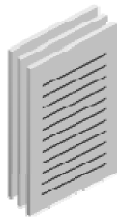
To use the LIST command, you must be connected to the target database. If you are connected in NOCATALOG mode, then the target database must be mounted. If you connect using a recovery catalog, then the target instance must be started, but does not need to be mounted.

You can control how the output is organized (BY BACKUP or BY FILE) as well as the level of detail in the output (VERBOSE or SUMMARY).

REPORT Command

Commands
BACKUP
Block C.T.
Inc. Update
LIST
\> REPORT
DELETE

- Produces a detailed analysis of the repository
- Produces reports to answer:
  – What are the data files in the database?
  – Which files need a backup?
  – Which backups can be deleted?
  – Which files are unrecoverable?



3-29

REPORT Command

With this command, you can analyze information in the RMAN repository in more detail.

Reports can be produced for a variety of questions, such as:

- What is the structure of the database?
```
RMAN> REPORT SCHEMA;
```
- Which files need to be backed up?
```
RMAN> REPORT NEED BACKUP ...;
```
- Which backups can be deleted (that is, are obsolete)?
```
RMAN> REPORT OBSOLETE;
```
- Which files are not recoverable because of unrecoverable operations?
```
RMAN> REPORT UNRECOVERABLE ...;
```

REPORT NEED BACKUP Command

- Lists all data files that require a backup
- Assumes that the most recent backup is used during a restore
- Provides four options:
  - Incremental
  - Days
  - Redundancy
  - Recovery window
- Uses the current retention policy configuration if no options are specified

REPORT NEED BACKUP Command

The REPORT NEED BACKUP command is used to identify all data files that need a backup. The report assumes that the most recent backup would be used in the event of a restore.

There are four options:

- **Incremental:** An integer that specifies the maximum number of incremental backups that should be restored during recovery. If complete recovery of a data file requires more than the specified number of incremental backups, then the data file requires a new full backup. For example, to report files that need three or more incremental backups for recovery:
  ```
  RMAN > REPORT NEED BACKUP incremental 3 database;
  ```
- **Days:** An integer that specifies the maximum number of days since the last full or incremental backup of a file. The file needs a backup if the most recent backup is equal to or greater than this number.
  For example, to report what system files have not been backed up for three days:
  ```
  RMAN > REPORT NEED BACKUP days 3 tablespace system;
  ```
- **Redundancy:** An integer that specifies the minimum level of redundancy considered necessary. For example, redundancy level two requires a backup if there are not two or more backups.
- **Recovery window:** A time window in which RMAN should be able to recover the database

REPORT NEED BACKUP: Examples

- Files that need more than three incremental backups for recovery:

```
RMAN> REPORT NEED BACKUP incremental 3;
```

- Files that have not been backed up for three days:

```
RMAN> REPORT NEED BACKUP days 3;
```

- Backup needed if there are not two or more backups already:

```
RMAN> REPORT NEED BACKUP redundancy 2;
```

- Backup needed to recover to three days ago:

```
RMAN> REPORT NEED BACKUP
2>    recovery window of 3 days;
```


REPORT NEED BACKUP: Examples

You can evaluate recovery time by reporting on the number of backups that need to be processed in order to recover files. If you do not want to ever have to process more than three incremental backups during a recovery, you can use this command that reports which files violate that requirement:

```
RMAN> REPORT NEED BACKUP incremental 3;
```

If you have recently performed some significant changes in the database, you need to consider which files have not been backed up since that activity. If the changes happened three days ago, the following command reports which files have not been backed up while those changes were implemented:

```
RMAN> REPORT NEED BACKUP days 3;
```

You may want to see which files do not have a certain number of backups already in existence, as a what-if scenario that is different from your retention policy. To do that for redundancy of two, you can enter this command:

```
RMAN> REPORT NEED BACKUP redundancy 2;
```

You can report on which files need to be backed up in order to be able to recover to as recently as three days ago by entering this command:

```
RMAN> REPORT NEED BACKUP recovery window of 3 days;
```

REPORT OBSOLETE and DELETE OBSOLETE

Commands
BACKUP
Block C.T.
Inc. Update
LIST
REPORT
> DELETE

- Find all recovery files that are deemed obsolete according to the current retention policy settings:

```
RMAN> REPORT OBSOLETE;
```

- List the obsolete recovery files, if no more than two backup copies are needed:

```
RMAN> REPORT OBSOLETE REDUNDANCY 2;
```

- Delete the backup set with a backup set key of 4:

```
RMAN> DELETE BACKUPSET 4;
```

- Delete the recovery files considered obsolete, because they have more than two backups:

```
RMAN> DELETE OBSOLETE REDUNDANCY 2;
```


REPORT OBSOLETE and DELETE OBSOLETE

An obsolete backup is not the same as an expired backup. An obsolete backup is no longer needed according to the user's retention policy. An expired backup is a backup that the CROSSCHECK command fails to find on the specified media device; the repository indicates it is there, but the backup files have been deleted or moved.

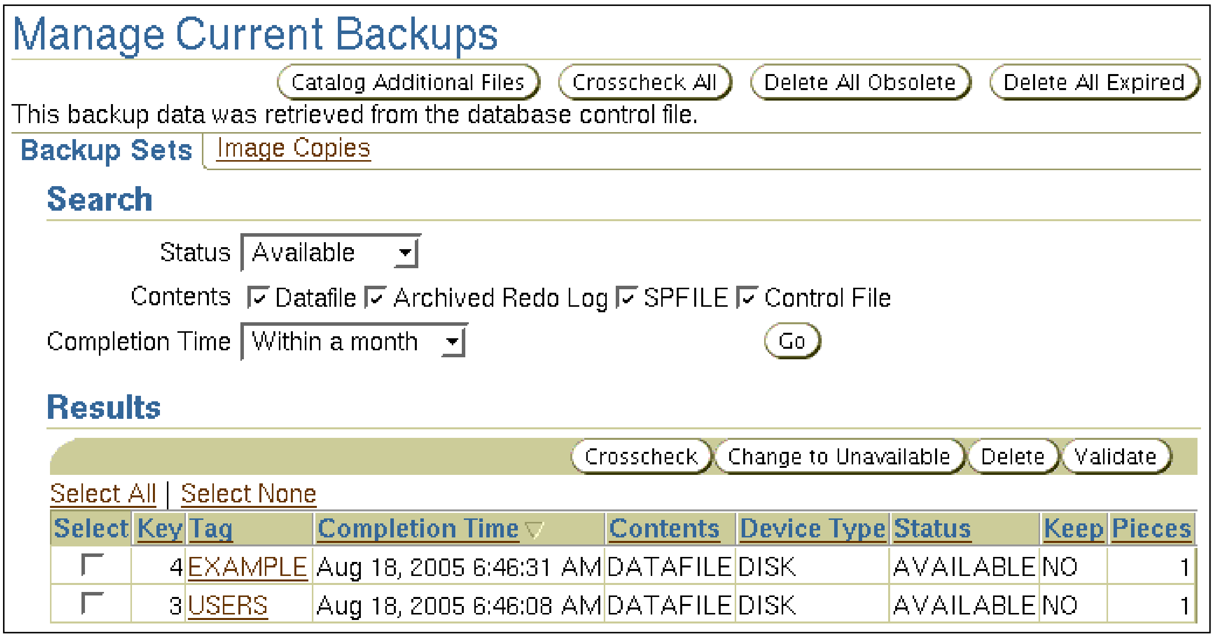
Using the REPORT OBSOLETE command, you can identify files that are no longer needed to satisfy backup retention policies. By default, the REPORT OBSOLETE command reports which files are obsolete under the currently configured retention policy. You can generate reports of files that are obsolete according to different retention policies by using REDUNDANCY or RECOVERY WINDOW retention policy options with the REPORT OBSOLETE command.

If you run REPORT OBSOLETE with no options and no retention policy is configured, then RMAN issues an error message.

The DELETE command can remove any file that the LIST and CROSSCHECK commands can operate on. For example, you can delete backup sets, archived redo logs, and data file copies. The DELETE command removes both the physical file and the catalog record for the file. The DELETE OBSOLETE command deletes backups that are no longer needed. It uses the same REDUNDANCY and RECOVERY WINDOW options as REPORT OBSOLETE.

If you delete backups without using RMAN, you can use the CROSSCHECK or UNCATALOG commands to remove the files from the recovery catalog.

Managing Backups with EM



Navigation aid:
Database home page > Maintenance > Manage Current Backups

Managing Backups with EM

You can manage your backup records through Enterprise Manager. Backup maintenance functions provided in Enterprise Manager include the following:

- Viewing lists of backups (backup sets and image copies) recorded in the RMAN repository
- Cross-checking your repository:
  - Verifying that the backups listed in the repository exist and are accessible
  - Marking as expired any backups not accessible at the time of the cross-check
- Deleting the record of expired backups from your RMAN repository
- Deleting obsolete backups from the repository and from disk

You can access the Manage Current Backups page in Enterprise Manager by clicking Manage Current Backups in the Backup/Recovery region of the Maintenance page. The Manage Current Backups page has two property pages: Backup Set (the initial view) and Image Copy. Each serves a similar purpose, listing the backups as recorded in the Recovery Manager repository.

Note: If you use a flash recovery area for your backup storage, many maintenance activities are reduced or eliminated because of the flash recovery area's automatic management of disk space and file retention based on the retention policy.

RMAN Dynamic Views

- V$ARCHIVED_LOG
- V$BACKUP_CORRUPTION
- V$BACKUP_DEVICE
- V$BACKUP_FILES
- V$BACKUP_PIECE
- V$BACKUP_REDOLOG
- V$BACKUP_SET
- V$BACKUP_SPFILE
- V$COPY_CORRUPTION
- V$RMAN_CONFIGURATION

RMAN Dynamic Views

You can use the following views to obtain RMAN information stored in the control file:

- V$ARCHIVED_LOG shows which archives have been created, backed up, and cleared in the database.
- V$BACKUP_CORRUPTION shows which blocks have been found to be corrupt during a backup of a backup set.
- V$BACKUP_DATAFILE is useful for creating equal-sized backup sets by determining the number of blocks in each data file. It can also help you find the number of corrupt blocks in the data file.
- V$BACKUP_DEVICE displays information about supported backup devices. The special device type DISK is not returned by this view because it is always available.
- V$BACKUP_FILES displays information about all RMAN backups (both image copies and backup sets) and archived logs. This view simulates the LIST BACKUP and LIST COPY RMAN commands.
- V$BACKUP_PIECE shows backup pieces created for backup sets.
- V$BACKUP_REDOLOG shows archived logs stored in backup sets.
- V$BACKUP_SET shows backup sets that have been created.
- V$BACKUP_SPFILE displays information about server parameter files in backup sets.
- V$COPY_CORRUPTION shows which blocks have been found to be corrupt during an image copy.

RMAN Dynamic Views (continued)

- `V$DATABASE_BLOCK_CORRUPTION` lists database blocks marked as corrupt during the most recent RMAN backup.
- `V$RMAN_CONFIGURATION` lists information about RMAN persistent configuration settings.

If you use proxy settings for RMAN, you can query:

- `V$PROXY_ARCHIVEDLOG`
- `V$PROXY_DATAFILE`

For backup performance statistics, you can query:

- `V$BACKUP_ASYNC_IO`
- `V$BACKUP_SYNC_IO`

Monitoring RMAN Backups

- Correlate server sessions with channels by using the `SET COMMAND ID` command.
- Query `V$PROCESS` and `V$SESSION` to determine which sessions correspond to which RMAN channels.
- Query `V$SESSION_LONGOPS` to monitor the progress of backups and copies.
- Use an operating system utility to monitor the process or threads.

Monitoring RMAN Backups

To correlate a process with a channel during a backup, perform the following steps:

1. Start Recovery Manager and connect to the target database and, optionally, the recovery catalog.
2. Set the `COMMAND ID` parameter after allocating the channels and then copy the desired object. The string specified by the `SET COMMAND ID` command is entered into the `V$SESSION.CLIENT_INFO` column of all allocated channels.

```
run {
     allocate channel t1 type disk;
     set command id to 'rman';
     backup datafile 1;
     release channel t1;}
```

3. Query the `V$PROCESS` and `V$SESSION` views to get the session identifier (`SID`) and the operating system process identifier (`SPID`) for the channels using the previously specified `COMMAND ID` string.

```
SELECT sid, spid, client_info
FROM v$process p, v$session s
WHERE p.addr = s.paddr
AND client_info LIKE '%id=rman%';
```

Monitoring RMAN Backups (continued)

4. Query the V$SESSION_LONGOPS view to get the status of the copy.

```
SELECT sid, serial#, context, sofar, totalwork,
            round(sofar/totalwork*100,2) "% Complete"
FROM V$SESSION_LONGOPS
WHERE opname LIKE 'RMAN:%'
AND opname NOT LIKE 'RMAN: aggregate%'
AND totalwork != 0;
```

5. If you use a channel of type `sbt` and the copy process appears to hang, query `V$SESSION_WAIT` by using the `SID` obtained in step 3 to determine whether RMAN is waiting for a media manager function call to complete.

```
SELECT * FROM V$SESSION_WAIT WHERE event LIKE '%sbt%';
```

Summary

In this lesson, you should have learned how to:

- **Use the RMAN `BACKUP` command to create backup sets and image copies**
- **List backups and image copies taken with RMAN**
- **Report and delete obsolete RMAN backups**

Practice Overview: Backing Up Your Database

This practice covers the following topics:

- Enabling archival of redo logs for a database
- Using RMAN to display the database structure
- Using Recovery Manager to back up data files and the control file
- Using Recovery Manager to make image copies of data files
- Creating a compressed backup of a database
- Scheduling a backup job

4

Recovering from Noncritical Losses

Objectives

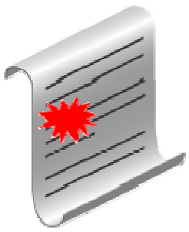
After completing this lesson, you should be able to:

- Recover temporary tablespaces
- Recover a redo log group member
- Recover from a lost index
- Re-create the password file

Causes of File Loss

File loss can be caused by:

- User error
- Application error
- Media failure



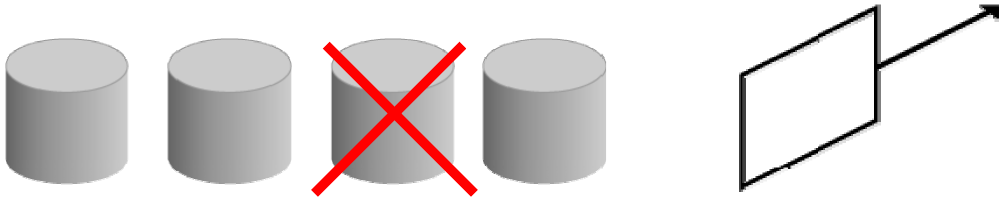
Causes of File Loss

Files can be lost or damaged due to:

- **User error:** An administrator may inadvertently delete or copy over a necessary operating system file.
- **Application error:** An application or script can also have a logic error in it, as it processes database files, resulting in a lost or damaged file.
- **Media failure:** A disk drive or controller may fail fully or partially, and introduce corruption into files, or even cause a total loss of files.

Critical Versus Noncritical

A noncritical file loss is one where the database can continue to function.



You fix the problem by taking one of these actions:

- **Create a new file.**
- **Rebuild the file.**
- **Recover the lost or damaged file.**

4-4

Critical Versus Noncritical

A noncritical file is one that the database and most applications can operate without. For example, if the database loses one multiplexed control file, there are still other control files that can be used to keep the database operating.

Although the loss of a noncritical file does not cause the database to crash, it can impair the functioning of the database. For example:

- The loss of an index tablespace can cause applications and queries to run much slower, or even make the application unusable, if the indexes were used to enforce constraints.
- The loss of an online redo log group, as long as it is not the current online log group, can cause database operations to be suspended until new log files are generated.
- The loss of a temporary tablespace can prevent users from running queries or creating indexes until they have been assigned to a new temporary tablespace.

Losing a TEMPFILE

SQL statements that require TEMP space to execute fail if one of the tempfiles is missing.

```
SQL> select * from big_table order by
1,2,3,4,5,6,7,8,9,10,11,12,13;
select * from big_table order by
1,2,3,4,5,6,7,8,9,10,11,12,13
              *
ERROR at line 1:
ORA-01565: error in identifying file
'/u01/app/oracle/oradata/orcl/temp01.dbf'
ORA-27037: unable to obtain file status
Linux Error: 2: No such file or directory
```


Losing a TEMPFILE

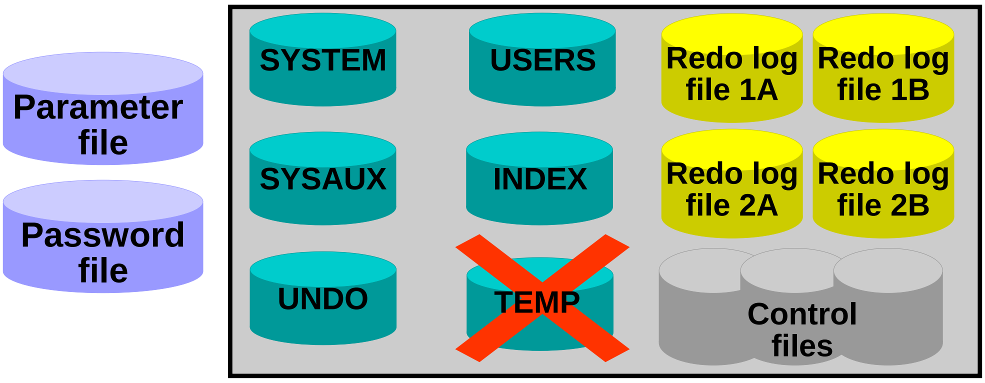
If a tempfile belonging to the TEMP tablespace is lost or damaged, the TEMP tablespace will not be available. This problem manifests itself as errors during the execution of SQL statements that require TEMP space for sorting.

The SQL statement shown in the slide has a long list of columns to order by, which results in the need for TEMP space. This is when the missing file error is encountered.

The Oracle database can start up with a missing temporary file. If any of the temporary files do not exist when the database is started, they are created automatically, and the database opens normally. When this happens, a message like the following appears in the alert log during startup:

```
Recreating tempfile /u01/app/oracle/oradata/orcl/temp01.dbf
```

Recovering from a TEMPFILE Loss



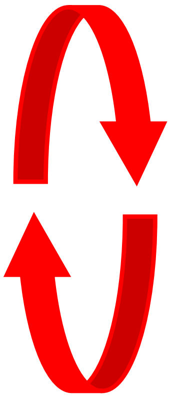
Recovering from a TEMPFILE Loss

You can recover from a lost TEMPFILE without restarting the database.

For example, to recover the database when the temp01.dbf data file belonging to the default temporary tablespace TEMP has been deleted at the OS level, add a new data file, and then drop the one that was deleted:

```
SQL> ALTER TABLESPACE temp ADD DATAFILE
'/u01/app/oracle/oradata/orcl/temp02.dbf' SIZE 20M;

Tablespace altered.

SQL> ALTER TABLESPACE temp DROP TEMPFILE
'/u01/app/oracle/oradata/orcl/temp01.dbf';

Tablespace altered.
```

Log Group Status: Review



A redo log group has a status of one of the following values at any given time:

- **`CURRENT`: The LGWR process is currently writing redo data to it.**
- **`ACTIVE`: It is no longer being written to, but it is still required for instance recovery.**
- **`INACTIVE`: It is no longer being written to, and it is no longer required for instance recovery.**

4-7

Log Group Status: Review

To deal with the loss of a redo log file, it is important to understand the possible states of redo log groups. Redo log groups cycle through three different states as part of the normal running of the Oracle database. They are, in order of the cycle:

- **`CURRENT`:** This state means that the redo log group is being written to by LGWR to record redo data for any transactions going on in the database. The log group remains in this state until there is a switch to another log group.
- **`ACTIVE`:** The redo log group still contains redo data that is required for instance recovery. This is the status during the time when a checkpoint has not yet executed that would write out to the data files all data changes that are represented in the redo log group.
- **`INACTIVE`:** The checkpoint discussed above has indeed executed, meaning that the redo log group is no longer needed for instance recovery, and is free to become the next `CURRENT` log group.

Losing a Redo Log Group Member

The alert log and the archiver process (ARC*n*) trace file record an error when a redo member file is missing.

```
Errors in file
/u01/app/oracle/admin/orcl/bdump/orcl_arc1_25739.trc:
ORA-00313: open failed for members of log group 2 of
thread 1
ORA-00312: online log 2 thread 1:
'/u01/app/oracle/oradata/orcl/redo02b.log'
ORA-27037: unable to obtain file status
Linux Error: 2: No such file or directory
```


Losing a Redo Log Group Member

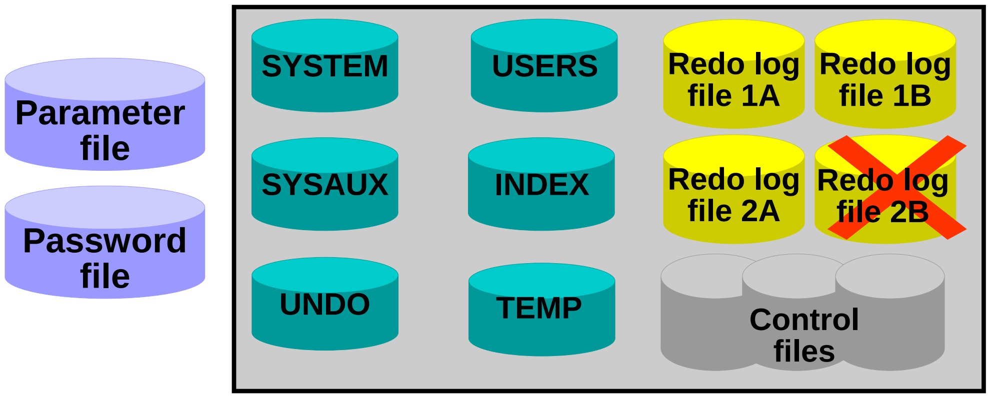
Redo data is crucial for recovery because it contains the record of all modifications to the database, allowing you to roll forward after restoring from a backup.

A redo log group can contain multiple members, and each one is identical to the other within the group. This is for redundancy purposes. At least two redo log groups must be available for the database to continue running, and at least one member must be available in each group.

If a member of a redo log group is inaccessible, there is an error written to the alert log and to the trace file of the archiver process.

If you lose a noncurrent redo log group, then you can use the `ALTER DATABASE CLEAR LOGFILE` statement to re-create all members in the group. No transactions are lost. If the lost redo log group was archived before it was lost, then nothing further is required. Otherwise, you should immediately take a new full backup of your database. Backups from before the log was lost are not recoverable because of the lost log.

Re-creating Redo Log Files




```
SQL> ALTER DATABASE DROP LOGFILE MEMBER
   > '/u01/app/oracle/oradata/orcl/redo02b.log';
SQL> !rm /u01/app/oracle/oradata/orcl/redo02b.log
SQL> ALTER DATABASE ADD LOGFILE MEMBER
   > '/u01/app/oracle/oradata/orcl/redo02b.log'
   > TO GROUP 2;
```

ORACLE

Re-creating Redo Log Files

In some cases, you may want to drop an entire group of redo log members, or you may want to drop one or more specific redo log members. For example, if a disk failure occurs, you may need to drop all the redo log files on the failed disk so that the database does not try to write to the inaccessible files.

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

- An instance requires at least two groups of redo log files, regardless of the number of members in the groups.
- You can drop a redo log group or group member only if it is inactive.
- A redo log group should be 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
```

Re-creating Redo Log Files (continued)

Drop a redo log group by using the `ALTER DATABASE` SQL statement with the `DROP LOGFILE` clause. The following statement drops redo log group number 3:

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

To drop a redo log member, you must have the `ALTER DATABASE` system privilege.

Consider these restrictions and precautions before dropping individual redo log members:

- You can drop redo log files so that a multiplexed redo log becomes temporarily asymmetric. For example, if you use duplexed groups of redo log files, you can drop one member of one group, even though all other groups have two members each. However, you should rectify this situation immediately so that all groups have at least two members, thus eliminating the single point of failure possible for the redo log.
- An instance always requires at least two valid groups of redo log files, regardless of the number of members in the groups.
- Make sure that the group to which a redo log member belongs is archived (if archiving is enabled) before dropping the member. To see whether this has happened, query the `V$LOG` view.
- You can drop a redo log member only if it is not part of an active or current group. If the group you want to drop is active, then force a log switch to occur. The group is then either active or inactive. If it is inactive, you can proceed to drop it. If it is active, then you first need to force a checkpoint in order to make it inactive. The following example shows the progression of log group #1 from `CURRENT` to `ACTIVE` to `INACTIVE`:

```
SQL> SELECT GROUP#, ARCHIVED, STATUS FROM V$LOG;
    GROUP# ARC STATUS
---------- --- ----------------
         1 NO  CURRENT
         2 YES INACTIVE
         3 YES INACTIVE
SQL> alter system switch logfile;
SQL> SELECT GROUP#, ARCHIVED, STATUS FROM V$LOG;
    GROUP# ARC STATUS
---------- --- ----------------
         1 YES ACTIVE
         2 NO  CURRENT
         3 YES INACTIVE
SQL> alter system checkpoint;
System altered.
SQL> SELECT GROUP#, ARCHIVED, STATUS FROM V$LOG;
    GROUP# ARC STATUS
---------- --- ----------------
         1 YES INACTIVE
         2 NO  CURRENT
         3 YES INACTIVE
```

Re-creating Redo Log Files (continued)

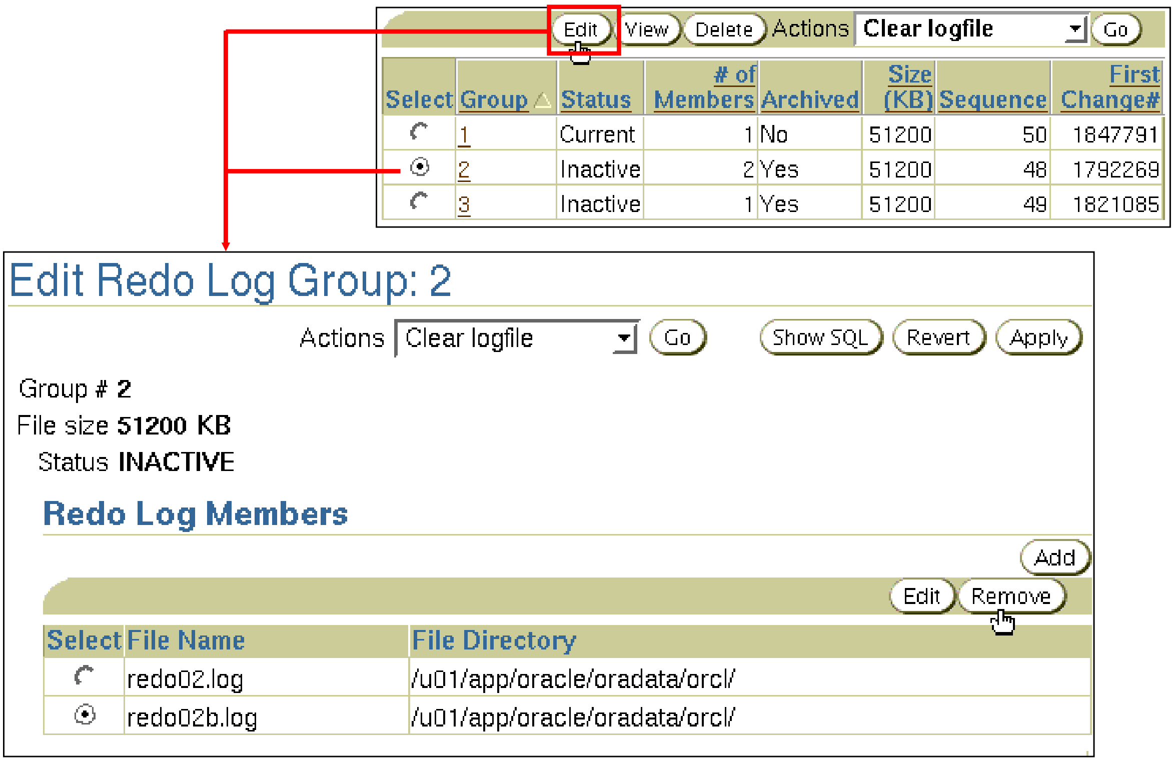
To drop specific inactive redo log members, use the `ALTER DATABASE` statement with the `DROP LOGFILE MEMBER` clause. The following statement drops the redo log file `/u01/app/oracle/oradata/orcl/redo02b.log`:

```
ALTER DATABASE DROP LOGFILE MEMBER
'/u01/app/oracle/oradata/orcl/redo02b.log';
```

When a redo log group or redo log member is dropped from the database, and you are not using the Oracle Managed Files (OMF) feature, the operating system files are not deleted from disk; only the control file is updated. After dropping a redo log group or redo log member, make sure that the drop completed successfully, and then use the appropriate operating system–command to delete the dropped redo log files, if they are not already gone.

When using Oracle Managed Files, the cleanup of operating systems files is done automatically for you.

Re-creating Redo Log Files



ORACLE

4-12

Re-creating Redo Log Files (continued)

With Enterprise Manager, you can create or edit information about the redo log groups associated with the current database. From the Administration page, select Redo Log Groups in the Storage region.

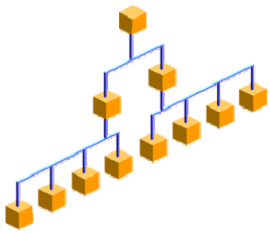
The Redo Log Groups page displays information about each redo log group, enabling you to view or edit a group. Select an individual redo log group and click View. The Redo Log Members table lists the files and directories that comprise the members of the redo log group. You can add or delete members from the group by clicking Edit.

Re-creating Indexes

Use options to reduce the time it takes to create the index:

- **`PARALLEL`**
- **`NOLOGGING`**

```
SQL> CREATE INDEX rname_idx
  2  ON hr.regions (region_name)
  3  PARALLEL 4;
```



Re-creating Indexes

When creating or re-creating an index, you can use the following keywords to reduce the creation time:

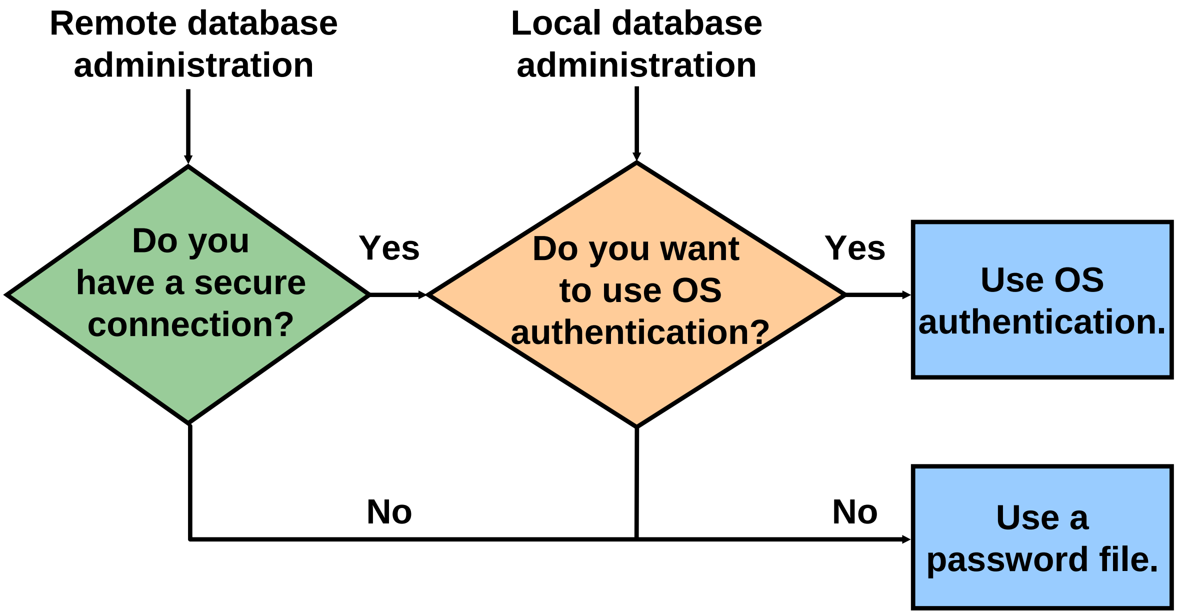
- **`PARALLEL` (`NOPARALLEL` is the default):** Multiple processes can work together simultaneously to create an index. By dividing the work necessary to create an index among multiple server processes, the Oracle server can create the index more quickly than if a single server process created the index sequentially. The table is randomly sampled and a set of index keys is found that equally divides the index into the same number of pieces as the specified degree of parallelism. A first set of query processes scans the table, extracts key, row ID pairs, and sends each pair to a process in a second set of query processes based on key. Each process in the second set sorts the keys and builds an index in the usual fashion. After all index pieces are built, the parallel coordinator concatenates the pieces (which are ordered) to form the final index.

Re-creating Indexes (continued)

- **`NOLOGGING`:** Using this keyword makes index creation faster because it creates a very minimal amount of redo log entries as a result of the creation process. This greatly minimized redo generation also applies to direct path inserts and Direct Loader (SQL*Loader) inserts. This is a permanent attribute and thus appears in the data dictionary. It can be updated with the `ALTER INDEX NOLOGGING/LOGGING` command at any time.

When an index is lost, it may be faster and simpler just to re-create it rather than attempt to recover it. One way to determine the SQL for creating the index is by using the `impdp SQLFILE=<`*`filename`*`>` command on a previously generated `expdp` output file. This generates the SQL statements needed to create the objects in the dump file. The `expdp` and `impdp` utilities are covered in detail in the *Oracle Database 10g: Administration Workshop I* course.

Authentication Methods for Database Administrators



Authentication Methods for Database Administrators

Depending on whether you want to administer your database locally on the same machine on which the database resides or to administer many different database servers from a single remote client, you can choose either operating system or password file authentication to authenticate database administrators:

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

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

Re-creating a Password Authentication File

1. Log in to the database by using OS authentication.
2. Set the `REMOTE_LOGIN_PASSWORDFILE` parameter to `NONE` and restart the database.
3. Re-create the password file by using `orapwd`.

```
$ orapwd file=$ORACLE_HOME/dbs/orapwORCL
  password=admin entries=5
```

4. Set `REMOTE_LOGIN_PASSWORDFILE` to `EXCLUSIVE`.
5. Add users to the password file and assign appropriate privileges to each user.
6. Restart the instance.

ORACLE

Re-creating a Password Authentication File

The Oracle database provides a password utility, `orapwd`, to create a password file. When you connect using the `SYSDBA` privilege, you are connecting as `SYS` schema and not the schema associated with your username. For `SYSOPER`, you are connected to the `PUBLIC` schema. Access to the database using the password file is provided by special `GRANT` commands issued by privileged users.

Typically, the password file is not included in backups because, in almost all situations, the password file can be re-created as a last resort. If you lose the password file, to re-create it requires that you shut down and restart the database at least once. To avoid unnecessary down time, you should include the password file in your backups.

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.

Note: 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 time stamps and checksums will be wrong.

Re-creating a Password Authentication File (continued)

Using a Password File

1. Log in to the database by using OS authentication.
2. Set the REMOTE_LOGIN_PASSWORDFILE parameter to NONE and restart the database.
3. Create the password file by using the password utility orapwd.

```
orapwd file=filename password=password entries=max_users
```

   Here:
   - **filename** is the name of the password file (mandatory).
   - **password** is the password for SYSOPER and SYSDBA (mandatory).
   - **Entries** is the maximum number of distinct users allowed to connect as SYSDBA or SYSOPER. If you exceed this number, you must create a new password file. It is safer to have a larger number. There are no spaces around the equal-to (=) character.

   Example:
```
orapwd file=$ORACLE_HOME/dbs/orapwU15
    password=admin entries=5
```

4. Set the REMOTE_LOGIN_PASSWORDFILE parameter to EXCLUSIVE, where:
   - **EXCLUSIVE** indicates that only one instance can use the password file and that the password file contains names other than SYS. By using an EXCLUSIVE password file, you can grant SYSDBA or SYSOPER privileges to individual users.
5. Connect to the database by using the password file created in step 3.

```
CONNECT sys/admin AS SYSDBA
```

6. Restart the instance.

Password File Locations

UNIX: $ORACLE_HOME/dbs

Windows: %ORACLE_HOME%\database

Maintaining the Password File

Delete the existing password file by using operating system–commands, and create a new password file by using the password utility.

Summary

In this lesson, you should have learned how to:

- Recover temporary tablespaces
- Recover a redo log group member
- Recover from a lost index
- Re-create the password file

Practice Overview: Recovering from Lost `TEMPFILE` and Redo Log File

This practice covers the following topics:

- Starting the database with a missing tempfile
- Creating a new temporary tablespace
- Altering the default temporary tablespace for a database
- Recovering from a lost online redo log member

4-19

5

Database Recovery

Objectives

User man.
RMAN CLI
EM
Complete
Incomplete
Control file
RO TBS

After completing this lesson, you should be able to:

- Perform complete or incomplete user-managed recovery
- Identify situations where incomplete recovery is necessary
- Perform complete or incomplete recovery by using RMAN
- Perform incomplete recovery based on time, SCN, log sequence, restore points, or the cancel method
- Recover an automatically backed up control file
- Use Enterprise Manage to perform recovery
- Recover read-only tablespaces

Recovery Methods

There are two methods for performing recovery:

- **User-managed recovery**
  - **Files must be maintained and moved into place manually.**
  - **Use SQL*Plus commands.**
- **RMAN recovery**
  - **Files are managed automatically.**
  - **Use RMAN functionality including all repository maintenance and reporting capabilities.**
  - **This can be done by using Enterprise Manager.**
  - **Oracle Corporation recommends using this method.**

ORACLE

5-3

Recovery Methods

User-managed recovery requires more manual involvement than RMAN recovery, which is the recommended method and the one covered in more detail in this lesson.

User-Managed Recovery: RECOVER Command

- Restore all database files from a backup and then recover the database:

```
SQL> RECOVER DATABASE
```

- Restore the damaged data files from a backup and then recover the data files:

```
SQL> RECOVER TABLESPACE index_tbs
```

Or:

```
SQL> RECOVER DATAFILE
  2> '/oradata/indx01.dbf'
```


User-Managed Recovery: RECOVER Command

The first step in performing user-managed media recovery is to manually restore the data files by copying them from a backup. If you do not restore a data file to its original location, you must update the control file with the new location by using an `ALTER DATABASE RENAME FILE` command. You must also restore any archived logs files needed to recover the restored data files. For RMAN restorations, you would use the `SET NEWNAME` command to specify the new location for that file.

You can use one of the following commands to recover the database or data file:

- `RECOVER [AUTOMATIC] DATABASE`
  This command can be used only for a closed database recovery.
- `RECOVER [AUTOMATIC] TABLESPACE <NUMBER> | <NAME>`
  This command can be used only for an open database recovery.
- `RECOVER [AUTOMATIC] DATAFILE <'filename'> | <NAME>`
  This command can be used for both an open and a closed database recovery.

The `AUTOMATIC` keyword instructs the Oracle database to automatically generate the name of the next archived redo log file needed to continue the recovery operation. Otherwise, you are prompted for these names.

RMAN Recovery: RESTORE and RECOVER Commands

User man.
> RMAN CLI
EM
Complete
Incomplete
Control file
RO TBS

```
run{
sql "ALTER TABLESPACE inv_tbs OFFLINE IMMEDIATE";
    RESTORE TABLESPACE inv_tbs;
    RECOVER TABLESPACE inv_tbs DELETE ARCHIVELOG;
    sql "ALTER TABLESPACE inv_tbs ONLINE";
   }
```

ORACLE

RMAN Recovery: RESTORE and RECOVER Commands

If you use RMAN to perform media recovery, it restores from backup any archived redo logs required during the recovery operation. If backups are stored on a media manager, channels must be configured or allocated for use in accessing backups stored there.

Reconstructing the contents of all or part of a database from a backup typically involves two phases: retrieving a copy of the data file from a backup, and reapplying changes to the file since the backup from the archived and online redo logs, to bring the database to the desired SCN (usually the most recent one). The `RESTORE` command retrieves the data file onto disk from a backup location on tape, disk, or other media, and makes it available to the database server. The `RECOVER` command takes the restored copy of the data file and applies to it the changes recorded in the database's redo logs.

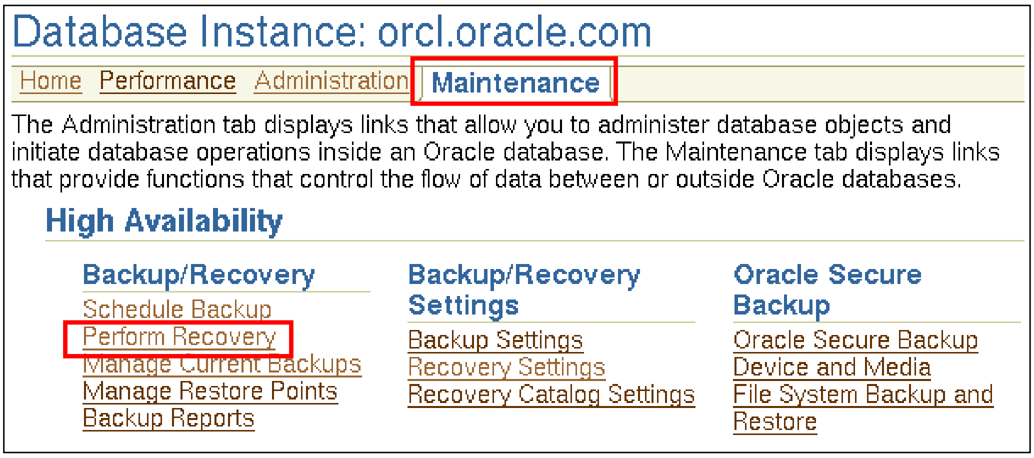
A very useful option in managing disk space associated with these restored files is the `DELETE ARCHIVELOG` option, which causes the deletion of restored archived redo logs from disk when they are no longer needed for the `RECOVER` operation.

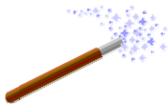
For restores to the flash recovery area, the `DELETE ARCHIVELOG` option is automatically in effect.

Recovery Using Enterprise Manager

User man.
RMAN CLI
> EM
Complete
Incomplete
Control file
RO TBS

With the Enterprise Manager Recovery Wizard, you can create and run an RMAN script to perform the recovery.





```
RMAN> RECOVER DATABASE …
```

5-6

Recovery Using Enterprise Manager

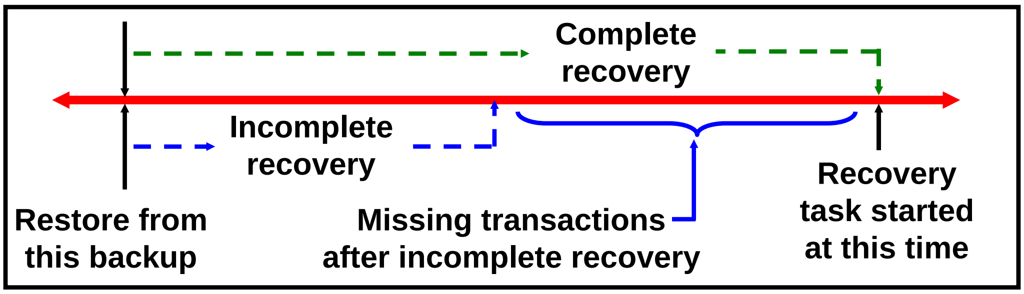
You can also perform complete or incomplete recovery by using the Recovery Wizard available through Enterprise Manager. On the Login page, log in as a user with the SYSDBA privilege. After clicking Login, you see the Database Summary page.

On the Database Summary page, click the Maintenance tab. The Maintenance page provides the user with various backup, restore, and recovery options. On the Maintenance page, click Perform Recovery.

Complete Versus Incomplete Recovery

There are two types of recovery:

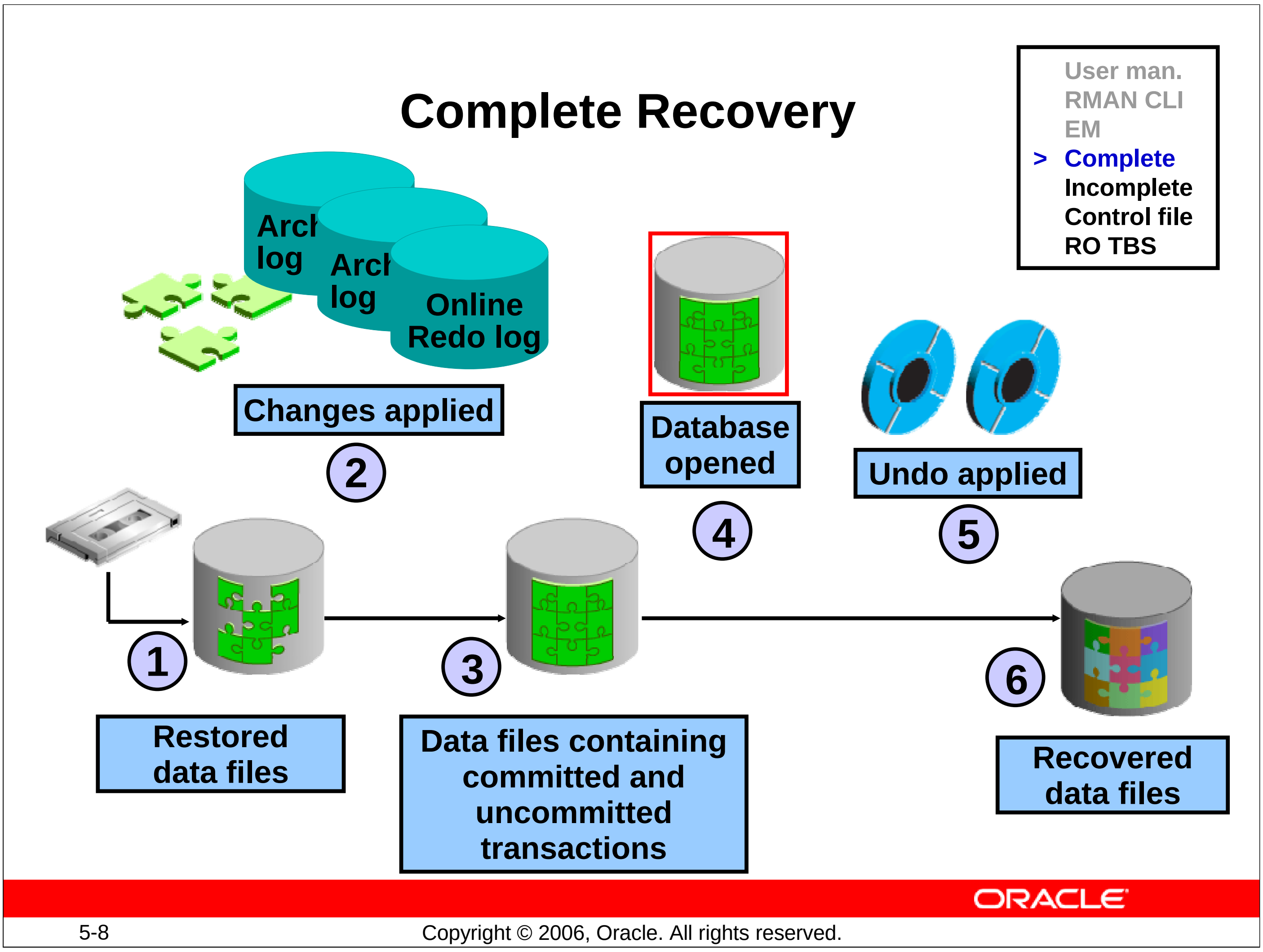
- Complete recovery brings the database up to the present, including all data changes made to the point in time when the recovery was requested.



- Incomplete recovery brings the database up to a specified point in time in the past, before the recovery operation was requested.

Complete Versus Incomplete Recovery

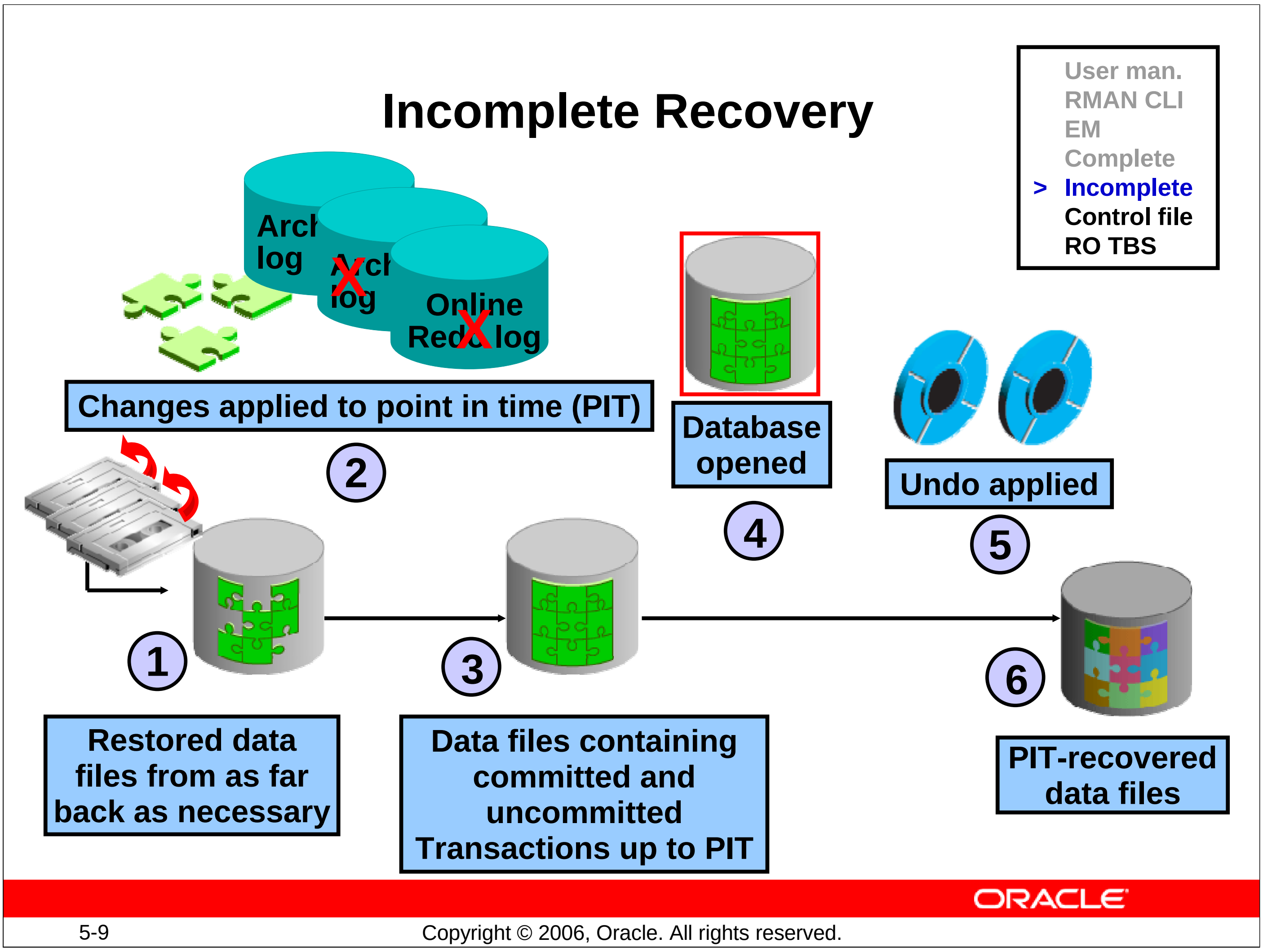
When you perform complete recovery, you bring the database to the state where it is fully up-to-date, including all data modifications done to the present time. Incomplete recovery, however, brings the database to some point in the past. This means there are missing transactions; any data modifications done between the recovery destination time and the present are lost. In many cases, this is the desirable goal because there may have been some things done to the database that should be undone. Recovering to a point in the past is a way to remove those unwanted transactions.



Complete Recovery

These are the steps that take place during complete recovery:

1. Damaged or missing files are restored from a backup.
2. Changes from incremental backups, archived redo log files, and online redo log files are applied as necessary. The redo log changes are applied to the data files until the current online log is reached and the most recent transactions have been reentered. Undo blocks are generated during this entire process. This is referred to as rolling forward or cache recovery.
3. The restored data files may now contain committed and uncommitted changes.
4. The database is opened before undo is applied. This is to provide higher availability.
5. The undo blocks are used to roll back any uncommitted changes. This is sometimes referred to as transaction recovery.
6. The data files are now in a recovered state and are consistent with the other data files in the database.



Incomplete Recovery

Incomplete recovery, or database point-in-time recovery, uses a backup to produce a noncurrent version of the database. That is, you do not apply all of the redo records generated after the most recent backup. Perform this type of recovery only when absolutely necessary.

To perform incomplete recovery, you need:

- A valid offline or online backup of all the data files made before the recovery point
- All archived logs from the time of the backup until the specified time of recovery

The progression taken to perform an incomplete recovery is listed below:

1. Restore data files from backup. The backup that is used may not be the most recent one, if your restore point destination is to be not very recent.
2. Apply redo from the archived redo log files, including as many as necessary to reach the restore point destination.
3. Now the data files contain some committed and some uncommitted transactions because the redo can contain uncommitted data.
4. The database is opened before undo is applied. This is to provide higher availability.
5. While the redo was being applied, redo supporting the undo data files was also applied. So, the undo is available to be applied to the data files in order to undo any uncommitted transactions. That is done next.
6. The data files are now recovered to the point in time that you chose.

Incomplete Recovery (continued)

Point-in-time recovery is the only option if you must perform a recovery and discover that you are missing an archived log containing transactions that occurred sometime between the time of the backup you are restoring from and the target recovery SCN. Without the missing log, you have no record of the updates to your data files during that period. Your only choice is to recover the database from the point in time of the restored backup, as far as the unbroken series of archived logs permits, and then open the database with the RESETLOGS option. All changes in or after the missing redo log file are lost.

Situations Requiring Incomplete Recovery

- Complete recovery fails because of a missing archived log file.
- One or more unarchived redo log files and a data file are lost.
- A backup of the control file is used to open or recover the database.

Situations Requiring Incomplete Recovery

You usually perform incomplete recovery of the whole database in the following situations:

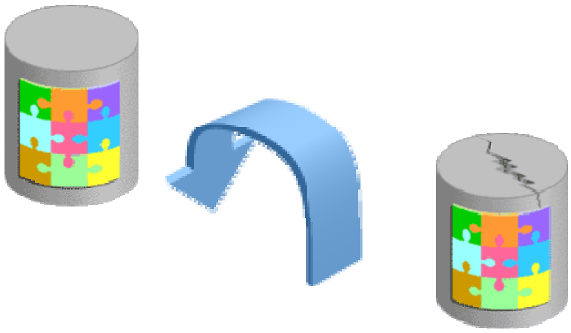
- **Loss of redo logs:** Redo logs were not mirrored and you lost a redo log before it was archived, along with a data file. Recovery cannot continue past the lost redo log.
- **Missing archive:** A complete recovery operation fails because of a bad or missing archived log. Recovery can only be completed to a time in the past, before applying the archived log.
- **Backup control file:** A backup of the control file is used to open the database instead of the current copy. You may need to use a control file backup if:
  - All control files are lost, the control file cannot be re-created, and a binary backup of the control file exists. Mirroring the control file (onto different disks) and keeping a current text version of the `CREATE CONTROLFILE` statement reduces the chances of having to use this method.
  - You are recovering a database to a previous point in time, and the restored database has a different structure than the current database.

You must specify the `USING BACKUP CONTROLFILE` clause in the `RECOVER DATABASE` command when using an old copy of the control file for recovery or to open the database.

Types of Incomplete Recovery

There are four types of incomplete recovery:

- Time-based recovery
- Cancel-based recovery
- Change-based recovery
- Log sequence recovery



Types of Incomplete Recovery

Time-Based Recovery

Using the `UNTIL TIME` clause, you specify the previous point in time to which the database should be recovered. Recovery terminates after all changes up to the specified time are committed. Use this approach when a user makes unwanted changes to data or drops important tables, and the approximate time of the error is known. Recovery time and data loss are minimized if you are notified immediately. Well-tested programs, security, and procedures should prevent the need for this type of recovery.

Cancel-Based Recovery

During the recovery process, you enter `CANCEL` at the recovery prompt (instead of a log file name) to terminate recovery. Use this approach when:

- A current redo log file or group is damaged and is not available for recovery. Mirroring should prevent the need for this type of recovery.
- An archived redo log file needed for recovery is lost. Frequent backups and multiple archive destinations should prevent the need for this type of recovery.

Types of Incomplete Recovery (continued)

Change-Based Recovery

Using the `UNTIL CHANGE` clause for user-managed backups and the `UNTIL SCN` clause for RMAN-managed backups, you specify the system change number (SCN) of the last committed change to be recovered. Recovery terminates after all changes up to the specified SCN are committed. Use this approach when recovering databases in a distributed environment. You can optionally use the `UNTIL RESTORE POINT` syntax and specify an alias for the SCN, called a restore point. Restore points are covered later in this lesson.

Log Sequence Recovery

With RMAN-managed backups, you can specify the last log sequence number to be used for database recovery with the `UNTIL SEQUENCE` clause. After all log files up to but not including the specified log file have been applied, recovery terminates.

Performing User-Managed Incomplete Recovery

- Recover a database until time:

```
SQL> RECOVER DATABASE UNTIL
  2  TIME '2005-12-14:12:10:03';
```

- Recover a database until cancel:

```
SQL> RECOVER DATABASE UNTIL CANCEL;
```

- Recover using the backup control file:

```
SQL> RECOVER DATABASE
  2  UNTIL TIME '2005-12-14:12:10:03'
  3  USING BACKUP CONTROLFILE;
```

5-14

Performing User-Managed Incomplete Recovery

The following command is used to perform incomplete recovery:

```
RECOVER [AUTOMATIC] DATABASE option
```

Here:

- **AUTOMATIC:** Automatically applies archived and redo log files
- ***option*:** `UNTIL TIME 'YYYY-MM-DD:HH24:MI:SS'`

```
UNTIL CANCEL
UNTIL CHANGE <integer>
USING BACKUP CONTROLFILE
```

Note: To apply redo log files automatically during recovery, you can use the SQL*Plus `SET AUTORECOVERY ON` command, enter `AUTO` at the recovery prompt, or use the `RECOVER AUTOMATIC` command.

Performing User-Managed Incomplete Recovery

To perform user-managed incomplete recovery, follow these steps:

1. **Shut down the database.**
2. **Restore data files.**
3. **Mount the database.**
4. **Recover the database.**
5. **Open the database with the `RESETLOGS` option.**

5-15

Performing User-Managed Incomplete Recovery (continued)

1. If the database is open, shut it down by using the `NORMAL`, `IMMEDIATE`, or `TRANSACTIONAL` option.
2. Restore all data files from backup (the most recent, if possible). You may also need to restore archived logs. If there is enough space available, restore to the `LOG_ARCHIVE_DEST` location or use the `ALTER SYSTEM ARCHIVE LOG START TO` <*`LOCATION`*> command or the `SET LOGSOURCE` <*`LOCATION`*> command to change the location.
3. Mount the database.
4. Recover the database by using the `RECOVER DATABASE` command.
5. To synchronize data files with control files and redo logs, open the database by using the `RESETLOGS` option.

User-Managed Time-Based Recovery: Example

This is the scenario:

- **A job ran in error, and its effects have to be undone.**
- **This happened 15 minutes ago, and there has been little database activity since then.**
- **You decide to perform incomplete recovery to restore the database back to its state as of 15 minutes ago.**

```
SQL> SHUTDOWN IMMEDIATE
$ cp /BACKUP/* /u01/db01/ORADATA
SQL> STARTUP MOUNT
SQL> RECOVER DATABASE UNTIL TIME '2005-11-28:11:44:00';
SQL> ALTER DATABASE OPEN RESETLOGS;
```

ORACLE

5-16

User-Managed Time-Based Recovery: Example

The following is a typical scenario employing `UNTIL TIME` recovery. Assume the following facts:

- The current time is 12:00 p.m. on November 28, 2005.
- A job was run incorrectly, and many tables in several schemas were affected.
- This happened at approximately 11:45 a.m.
- Database activity is minimal because most staff are currently in a meeting. The state of the database before the job ran must be restored.

Because the approximate time of the error is known and the database structure has not changed since 11:44 a.m., you can use the `UNTIL TIME` method:

1. If the database is open, shut it down by using the `NORMAL`, `IMMEDIATE`, or `TRANSACTIONAL` option.
2. Restore all data files from backup (the most recent if possible). You may also need to restore archived logs. If there is enough space available, restore to the `LOG_ARCHIVE_DEST` location or use the `ALTER SYSTEM ARCHIVE LOG START TO` <*`LOCATION`*> command or the `SET LOGSOURCE` <*`LOCATION`*> command to change the location.
3. Mount the database.

User-Managed Time-Based Recovery: Example (continued)

4. Recover the database:

```
SQL> recover database until time '2005-11-28:11:44:00'
ORA-00279: change 148448 … 11/27/05 17:04:20 needed for
thread ...
Media recovery complete.
```

5. To synchronize data files with control files and redo logs, open the database by using the `RESETLOGS` option:

```
SQL> alter database open resetlogs;
SQL> archive log list
...
Oldest online log sequence 0
Next log sequence to archive 1
Current log sequence 1
```

When recovery is successful, notify users that the database is available for use, and any data entered after the recovery time (11:44 a.m.) will need to be reentered.

User-Managed Cancel-Based Recovery: Example

The scenario is the same as the one for the time-based example, except for these findings:

- **Redo logs are not multiplexed.**
- **One of the online redo logs is missing.**
- **The missing redo log is not archived.**
- **The redo log contained information from 11:34 a.m.**
- **Twenty-six minutes of data are lost.**
- **Users can reenter their data manually.**

User-Managed Cancel-Based Recovery: Example

After searching through the directory for the redo log files, you notice that redo log `log2a.rdo` cannot be located and has not been archived. Therefore, you cannot recover past this point.

Querying `V$LOG_HISTORY` confirms the absence of archived log sequence 48 (`log2a.rdo`):

```
SQL> SELECT * FROM v$log_history;
RECID    STAMP       ...  FIRST_CHANGE     FIRST_TIME
-----    ---------   ...  ------------     ----------
    1    318531466   ...  88330            05-11-15:12:43
   47    319512880   ...  309067           05-11-28:11:26
```

User-Managed Cancel-Based Recovery: Example

Recover the database as follows:

1. Shut down the database.
2. Restore all data files from the most recent backup.
3. You already have a valid backup, so mount the database.
4. Execute `RECOVER DATABASE UNTIL CANCEL`.
5. Execute `ALTER DATABASE OPEN RESETLOGS` to open the database.

5-19

User-Managed Cancel-Based Recovery: Example (continued)

The steps for cancel-based recovery are the same as for time-based recovery, except for the `RECOVER DATABASE` step. When the `RECOVER DATABASE UNTIL CANCEL` command is executed, it recovers the database until it cannot find a log file. When you are prompted for the file name, enter `CANCEL`, and the recovery stops at that point in time.

Performing Incomplete Recovery by Using RMAN

1. Mount the database.
2. Allocate multiple channels for parallelization.
3. Restore all data files.
4. Recover the database by using `UNTIL TIME`, `UNTIL SEQUENCE`, or `UNTIL SCN`.
5. Open the database by using `RESETLOGS`.

Performing Incomplete Recovery by Using RMAN

RMAN can perform recovery of the database to a past time, SCN, or log sequence number.

Incomplete recovery of the database requires you to open the database with the `RESETLOGS` option. This option gives the online redo logs a new time stamp and SCN, thus eliminating the possibility of corrupting data files by the application of obsolete archived redo logs. You cannot recover some data files to a time before the `RESETLOGS` and others to a time after the `RESETLOGS`. You must recover all data files to the same SCN. The only exception is if the data file is offline normal or read-only. You can bring files in read-only or offline normal tablespaces online after the `RESETLOGS` because there are no transactional changes for these files stored in the redo logs.

Note: You can use RMAN to restore the data files only if the backups were taken or registered with RMAN.

Time-Based Recovery Using RMAN: Example

```
RMAN> RUN {
   2> SET UNTIL TIME = '2005-11-28:11:44:00';
   3> RESTORE DATABASE;
   4> RECOVER DATABASE;
   5> ALTER DATABASE OPEN RESETLOGS; }
```


Time-Based Recovery Using RMAN: Example

At 12:00 p.m. on Tuesday, November 28, 2005, you determine that the `OE.ORDERS` table was dropped in error. The approximate time of failure is known and the database structure has not changed since 11:44 a.m. You can use the `UNTIL TIME` method:

1. If the target database is open, perform a clean shutdown.
2. Mount the target database. Do not back up the database during the recovery.
3. Ensure that `NLS_LANG` and `NLS_DATE_FORMAT` environment variables are set appropriately:
   ```
   $ NLS_LANG=american_america.we8iso8859p15
   $ NLS_DATE_FORMAT='YYYY-MM-DD:HH24:MI:SS'
   ```
4. Start Recovery Manager and connect to the target database.
   ```
   $ rman target rman/rman@ORCL
   ```
5. You can allocate multiple channels to improve the performance:
   ```
   RMAN> run {allocate channel c1 type DISK;
      2>      allocate channel c2 type DISK;
   ```

Time-Based Recovery Using RMAN: Example (continued)

6. Specify the time for recovery and restore all data files from a backup with RMAN commands. RMAN chooses the correct files based on the `SET UNTIL` command:
   ```
   RMAN> ... set until time = '2005-11-28:11:44:00';
   RMAN> ... restore database;
   ```
   Note: If you need to restore archived redo log files to a new location, use the RMAN `SET ARCHIVELOG DESTINATION TO` <*location*> command.
7. Recover the database to the time specified in the `SET UNTIL` command:
   ```
   RMAN> ... recover database;
   ```
8. Open the database by using the `RESETLOGS` option:
   ```
   RMAN> ... alter database open resetlogs; }
   ```
9. Check whether the table exists.
10. Notify users that the database is available for use, and that they should reenter any data that was not committed before the system failure occurred.

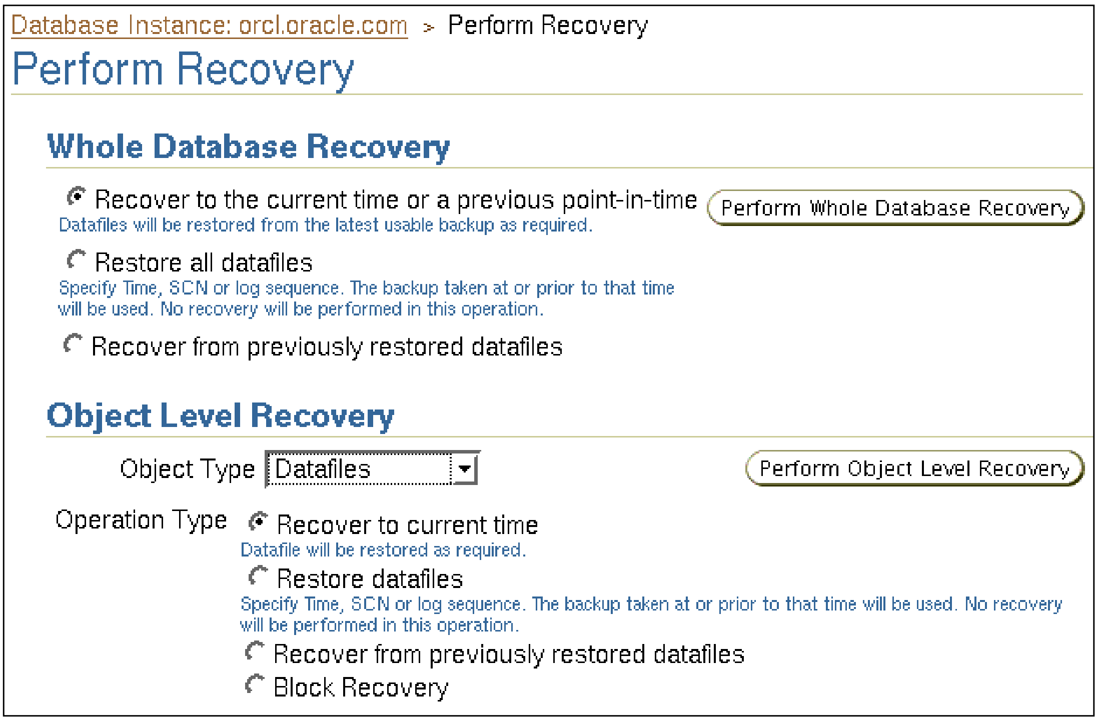
Log Sequence Recovery Using RMAN: Example

```
RMAN> RUN {
   2> SET UNTIL SEQUENCE 120 THREAD 1;
   3> ALTER DATABASE MOUNT;
   4> RESTORE DATABASE;
   5> RECOVER DATABASE; # recovers through log 119
   6> ALTER DATABASE OPEN RESETLOGS;
   7> }
```


Log Sequence Recovery Using RMAN: Example

The `UNTIL SEQUENCE` clause specifies a redo log sequence number and thread as an upper limit. RMAN selects only files that can be used to recover up to but not including the specified log sequence number. The example in the slide assumes that log sequence 120 was lost due to a disk crash and the database needs to be recovered using the available archived redo logs.

Incomplete Recovery Using Enterprise Manager



5-24

Incomplete Recovery Using Enterprise Manager

To recover the entire database to a point in time, on the Perform Recovery page, select the “Recover to the current time or a previous point-in-time” option. Then, click Perform Whole Database Recovery.

Choose “Restore all datafiles” to restore all the data files in the database to a previous backup state. You can also recover from previously restored data files. This uses redo data to roll the database forward to some point.

Incomplete Recovery and the Alert Log

The following are some best practices regarding the alert log in incomplete recovery scenarios:

- **Check the alert log before and after recovery.**
- **Look for error information, hints, and SCNs.**
- **Confirm that steps in the recovery process were successful.**

Incomplete Recovery and the Alert Log

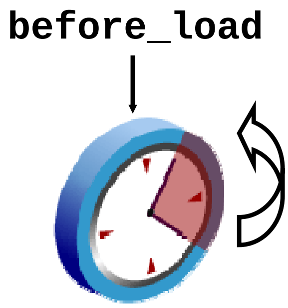
During recovery, progress information is stored in the alert log. This file should always be checked before and after recovery. The following is a sample entry in the `alert.log` file:

```
$ vi $ORACLE_BASE/admin/orcl/bdump/alert_orcl.log
...
ALTER DATABASE RECOVER  database until cancel
Media Recovery Start
ORA-279 signalled during: ALTER DATABASE RECOVER  database
until cancel  ...
Fri Aug 26 15:22:46 2005
ALTER DATABASE RECOVER    CONTINUE DEFAULT
...
Fri Aug 26 15:28:27 2005
ALTER DATABASE RECOVER CANCEL
Fri Aug 26 15:28:27 2005
Media Recovery Canceled
Completed: ALTER DATABASE RECOVER CANCEL
```

Restore Points

A restore point:

- Serves as an alias for an SCN or a specific point in time
- Is stored in the control file
- Can be used with:
  - `RECOVER DATABASE`
  - `FLASHBACK DATABASE`
  - `FLASHBACK TABLE`



1

```
SQL> CREATE RESTORE POINT before_load;
```

2

```
RMAN> RECOVER DATABASE UNTIL RESTORE POINT before_load;
```

ORACLE

5-26

Restore Points

Creating a normal restore point assigns the restore point name to a specific point in time or SCN. This name functions as a kind of bookmark or alias that you can use with commands that recognize a `RESTORE POINT` clause as shorthand for specifying a point in time.

Before performing any operation that you may have to reverse, you can create a normal restore point. The name of the restore point and the SCN are recorded in the control file. Then, if you later need to refer to that point in time in a `RECOVER DATABASE` command, you can do so without figuring out a time stamp or SCN value. Using Flashback Database, Flashback Table, or point-in-time recovery, you can refer to the target time using the name of the restore point instead of a time expression or SCN. Defining a normal restore point before an operation to be reversed later eliminates the need to manually record an SCN in advance, or to investigate the correct SCN after the fact by using features such as Flashback Query.

Normal restore points are very lightweight. The control file can maintain a record of thousands of normal restore points with no significant impact upon database performance. Normal restore points eventually age out of the control file if not manually deleted, so they require no ongoing maintenance.

Note: The use of restore points with `FLASHBACK` commands is covered in the lesson titled “Flashback.”

Incomplete Recovery: Best Practices

- Plan for and practice scenarios ahead of time.
- Investigate and verify that incomplete recovery is necessary.
- Follow all steps carefully.
- Take whole database backups before and after recovery.
- Always verify that the recovery was successful.
- Take advantage of restore points.

Incomplete Recovery: Best Practices

- It is important to follow all recovery steps carefully because most incomplete recovery problems are caused by a DBA error during the recovery process.
- During database recovery, transaction activity can be only rolled forward to the desired time, not back to the desired time. This is the reason why all data files must be restored for the database to be taken back in time. Failure to restore all data files prevents the (unsynchronized) database from opening.
- Before starting incomplete recovery, perform a whole closed database backup (including control files and redo logs). This is helpful in the following ways:
  - It allows you to recover from error. If your recovery fails (for example, you recover past the desired point of recovery), redo logs and control files cannot be used for the next recovery unless there is a backup of these files.
  - It saves time if the recovery fails. In this situation, you can restore the data files from the new backup, rather than from a previous backup, which needs archives applied.

Note: If a whole backup is not performed, at least archive the current redo log:

```
SQL> ALTER SYSTEM ARCHIVE LOG CURRENT
```

and back up the control file:

```
SQL> ALTER DATABASE BACKUP CONTROLFILE TO
'/u01/data/backup.ctl';
```

Incomplete Recovery: Best Practices (continued)

- Perform a whole closed backup after a successful recovery. This can save many hours if another recovery is required before completion of the next scheduled backup. If you are using Oracle Database 10*g*, this step is now optional.
- Always verify that the problem has been corrected before allowing users to access the system, in case the recovery failed and needs to be performed again.

Consider the following example:

- A database at log sequence 14 has archived logs from sequence 2 (`arch_2.rdo)` to sequence 13 (`arch_13.rdo`).
- After performing incomplete recovery, a new database incarnation is created, setting the database log sequence to 0.
- Archived logs `arch_2.rdo` to `arch_13.rdo` are now part of the old database incarnation.
- After a few log switches, the archived log `arch_2.rdo` is overwritten and is backed up with all other archives (including the old archived logs `arch_3.rdo` to `arch_13.rdo`).
- At a later stage, if recovery requires `arch_6.rdo`, you need to make sure that the archived log restored from the backup is for the correct database incarnation; otherwise, an error will result.

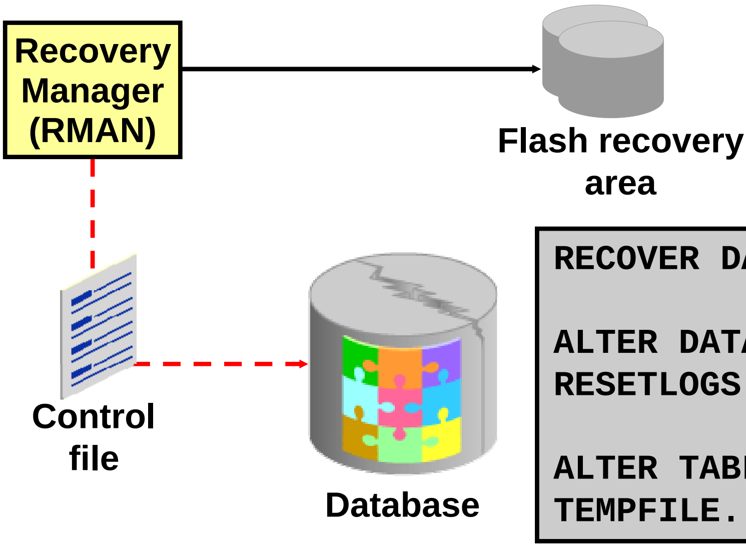
To prevent confusion, you can use the `%r` format option of the `log_archive_format` database initialization parameter to:

- Automatically incorporate the database resetlogs ID into the archived log file names
- Ensure that unique names are constructed for the archived log files across multiple incarnations of the database

Recovering a Control File Autobackup

User man.
RMAN CLI
EM
Complete
Incomplete
\> Control file
RO TBS

```
RMAN> RESTORE CONTROLFILE TO
2> '/oradata/ctlfile.bak' FROM AUTOBACKUP;
```




```
RECOVER DATABASE;

ALTER DATABASE OPEN
RESETLOGS;

ALTER TABLESPACE temp ADD
TEMPFILE...;
```

ORACLE

5-29

Recovering a Control File Autobackup

If you are not using a recovery catalog, you should have autobackup of the control file configured, so that you are able to quickly restore the control file if needed. The commands used for restoring your control file are the same, whether or not you are using a flash recovery area. However, if you are using a flash recovery area, RMAN implicitly cross-checks backups and image copies listed in the control file, and catalogs any files in the flash recovery area not recorded in the restored control file, improving the usefulness of the restored control file in the restoration of the rest of your database.

Note: Tape backups are not automatically cross-checked after the restoration of a control file. If you are using tape backups, then after restoring the control file and mounting the database, you must cross-check the backups on tape.

Recovering a Control File Autobackup (continued)

To restore the control file from an autobackup, the database must be in a `NOMOUNT` state. Then, you use the `RESTORE CONTROLFILE FROM AUTOBACKUP` command:

```
RMAN> SHUTDOWN IMMEDIATE;
RMAN> STARTUP NOMOUNT;
RMAN> RESTORE CONTROLFILE FROM AUTOBACKUP;
```

RMAN searches for a control file autobackup. If one is found, RMAN restores the control file from that backup to all the control file locations listed in the `CONTROL_FILES` initialization parameter.

If you have a recovery catalog, you do not have to set the DBID or use the control file autobackup to restore the control file. You can use the `RESTORE CONTROLFILE` command with no arguments:

```
RMAN> RESTORE CONTROLFILE;
```

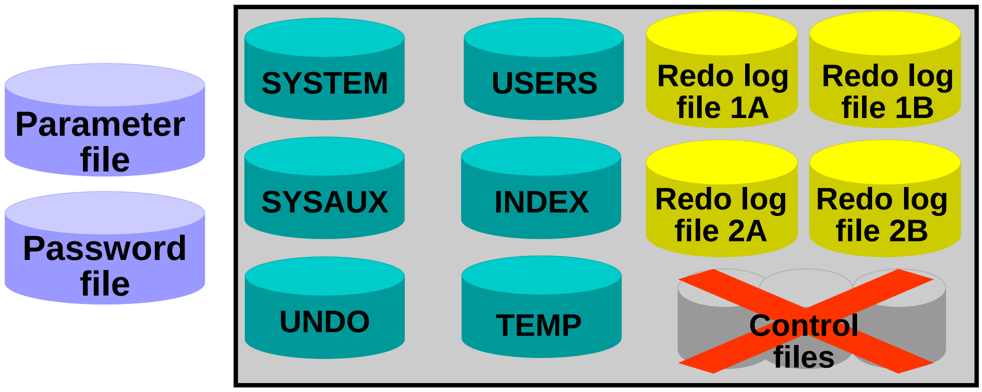
The instance must be in the `NOMOUNT` state when you perform this operation, and RMAN must be connected to the recovery catalog. The restored control file is written to all locations listed in the `CONTROL_FILES` initialization parameter.

If you have also lost the SPFILE for the database and need to restore it from the autobackup, the procedure is similar to restoring the control file from autobackup. You must first set the DBID for your database, and then use the `RESTORE SPFILE FROM AUTOBACKUP` command.

After you have started the instance with the restored server parameter file, RMAN can restore the control file from the autobackup. After you restore and mount the control file, you have the backup information necessary to restore and recover the database.

After restoring the control files of your database from backup, you must perform complete media recovery and then open your database with the `RESETLOGS` option.

Creating a New Control File




```
SQL> ALTER DATABASE BACKUP CONTROLFILE
     TO TRACE;
```

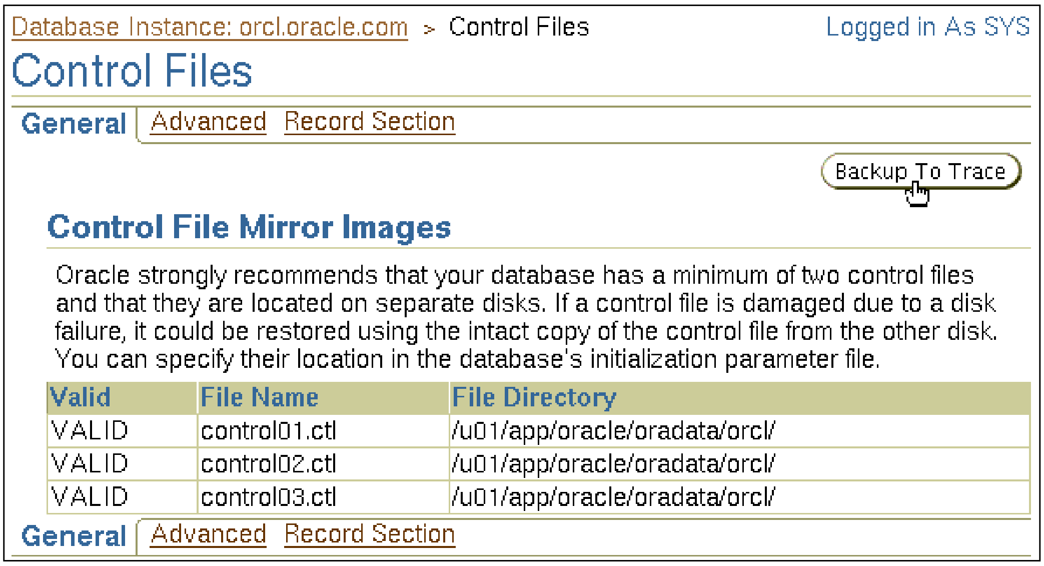

Creating a New Control File

If you have autobackup of the control file configured, you should rarely, if ever, need to re-create your control file. But, if needed, you can generate and save a script that does the re-creation.

The `ALTER DATABASE BACKUP CONTROLFILE TO TRACE` command generates a user trace file that contains the SQL command to re-create the control file. Copy the trace file to a script file, such as `new_control.sql`; delete the trace header information before the words `STARTUP NOMOUNT`; and make any other desired changes, such as increasing `MAXDATAFILES`, `MAXLOGFILES`, and so on. Run the script to create a new control file.

You must use this command while the database is mounted or open and while you are connected as a user with DBA privileges.

Creating a New Control File



ORACLE

5-32

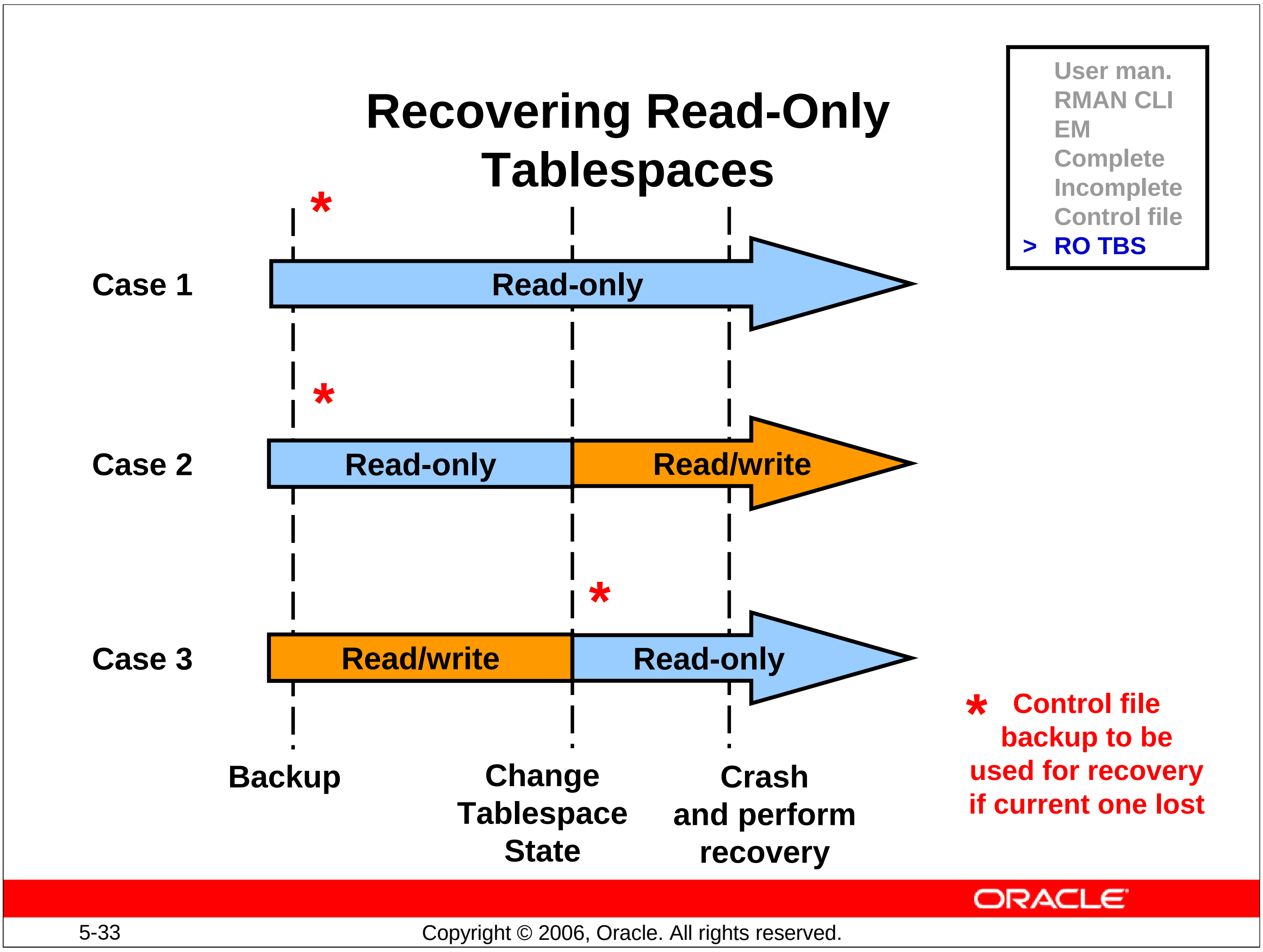
Creating a New Control File (continued)

The Database Control Console allows you to manage the control files used by your database. On the Administration page, select Control Files in the Storage section.

You can use the Control Files General page to view the control file mirror images and their locations. Click Backup To Trace in order to create a trace file for the control file.

You can also write your own `CREATE CONTROLFILE` command, but you need to supply the full path names and sizes for:

- The redo log files
- All the data files associated with the database, including the data files for `SYSTEM` and `SYSAUX`



Recovering Read-Only Tablespaces

Making a tablespace read-only prevents write operations on the data files in the tablespace, regardless of a user's update privilege level. The primary purpose of read-only tablespaces is to eliminate the need to perform backup and recovery of large, static portions of a database. Read-only tablespaces also provide a way to protecting historical data so that users cannot modify it. Because read-only tablespaces can never be updated, they can reside on CD-ROM or WORM (write once, read many) devices.

The method of recovering a read-only tablespace depends on the backups that are available and whether the tablespace was altered to read/write or read-only within the recovery period.

Case 1: The tablespace being recovered is read-only, and was read-only when the last backup occurred. In this case, you can simply restore the tablespace from the backup. There is no need to apply any redo information.

Case 2: The tablespace being recovered is read/write, but was read-only when the last backup occurred. In this case, you need to restore the tablespace from the backup and apply the redo information from the point when the tablespace was made read/write.

Case 3: The tablespace being recovered is read-only, but was read/write when the last backup occurred. You should always back up a tablespace after making it read-only to avoid this situation. However, if this does occur, you must restore the tablespace from the backup and recover up to the time that the tablespace was made read-only.

Recovering Read-Only Tablespaces (continued)

In all three cases, if the current control file is not available, the asterisk denotes which control file backup should be used for recovery. This is necessary because when a backup control file is used, the recovery process will require you to perform an `OPEN RESETLOGS`. This updates the datafile headers, and datafiles cannot be written to if they are read-only.

Read-Only Tablespace Recovery Issues

Special considerations must be taken for read-only tablespaces when:

- **Re-creating a control file**
- **Renaming data files**
- **Using a backup control file**

Read-Only Tablespace Recovery Issues

Re-creating a Control File

If you need to re-create a control file with the `CREATE CONTROL FILE` command and your database has read-only tablespaces, you must follow special procedures. The steps are listed in the trace file that is generated by the `ALTER DATABASE BACKUP CONTROLFILE TO TRACE` command. Because the tablespace is read-only, there are no changes being made to it, and thus it is assumed that no recovery is needed. The tablespace data files are not included in the control file; therefore, as the database is started up with the new control file, the control file contents are cross-checked against the files in the data dictionary. Any files found in the data dictionary that are not in the control file are added to the control file with a name like `MISSINGnnnnn`. After the database is open, you must rename the files in the control file by using the `ALTER DATABASE RENAME FILE` command.

```
ALTER DATABASE RENAME FILE 'MISSING00005'
  TO '/u01/app/oracle/oradata/orcl/example01.dbf';
ALTER TABLESPACE "EXAMPLE" ONLINE;
```

Oracle Corporation recommends enabling control file autobackup in RMAN so that you do not have to depend on this workaround that is required for a control file that has been backed up using the `BACKUP CONTROLFILE TO TRACE` command.

Read-Only Tablespace Recovery Issues (continued)

Changing Data File Location

If you cannot restore a copy of the data files in a read-only tablespace to the correct destination, you can use the `ALTER DATABASE RENAME` command to place the files in a new location.

Backup Control File

If you have a read-only tablespace on read-only media, then you may encounter errors or poor performance when recovering with the `USING BACKUP CONTROLFILE` option. This situation occurs when the backup control file indicates that a tablespace was read/write when the control file was backed up. In this case, media recovery may attempt to write to the files. For read-only media, the database issues an error saying that it cannot write to the files.

Following are alternatives that you can use to recover read-only media when using a backup control file:

- Take data files from read-only tablespaces offline before performing recovery with a backup control file, and then bring the files online at the end of media recovery.
- Use the correct version of the control file for the recovery. If the tablespace will be read-only when recovery completes, then the control file backup must be from a time when the tablespace was read-only. Similarly, if the tablespace will be read/write at the end of recovery, then the control file must be from a time when the tablespace was read/write.

Recovering the Database

If a datafile is read-only at the point in time to which the database is being recovered, then RMAN does not recover it. To change this behavior and have RMAN verify the datafile headers are current for the point in time, specify the `CHECK READONLY` option with the `RECOVER DATABASE` command.

Summary

In this lesson, you should have learned how to:

- Perform complete or incomplete user-managed recovery
- Perform complete or incomplete recovery by using RMAN
- Identify situations where incomplete recovery is necessary
- Perform incomplete recovery based on time, SCN, log sequence, restore points, or the cancel method
- Recover a control file autobackup
- Use Enterprise Manage to perform recovery
- Recover read-only tablespaces

Practice Overview: Performing Incomplete Recovery

This practice covers the following topics:

- Point-in-time recovery using RMAN
- Recovery from the loss of control files

5-38

6

Flashback

Objectives

Recycle bin
Flashback DB
Config. FB DB
Monitor FB DB
Guar. Res. Pt.

After completing this lesson, you should be able to:

- Query the recycle bin
- Configure Flashback Database
- Perform Flashback Database to a point in time
- Monitor flashback log statistics
- Enable and disable the Flashback Database feature
- Use the Enterprise Manager Recovery Wizard to perform Flashback Database
- Use guaranteed restore points with Flashback Database

Flashback Technology: Review

Object Level	Scenario Examples	Flashback Technology	Uses	Affects Data
Database	Truncate table; Undesired multitable changes made	Database	Flashback logs	TRUE
Table	Drop table	Drop	Recycle bin	TRUE
	Update with the wrong `WHERE` clause	Table	Undo data	TRUE
	Compare current data with data from the past	Query	Undo data	FALSE
	Compare versions of a row	Version	Undo data	FALSE
Tx	Investigate several historical states of data	Transaction	Undo data	FALSE

6-3

Flashback Technology: Review

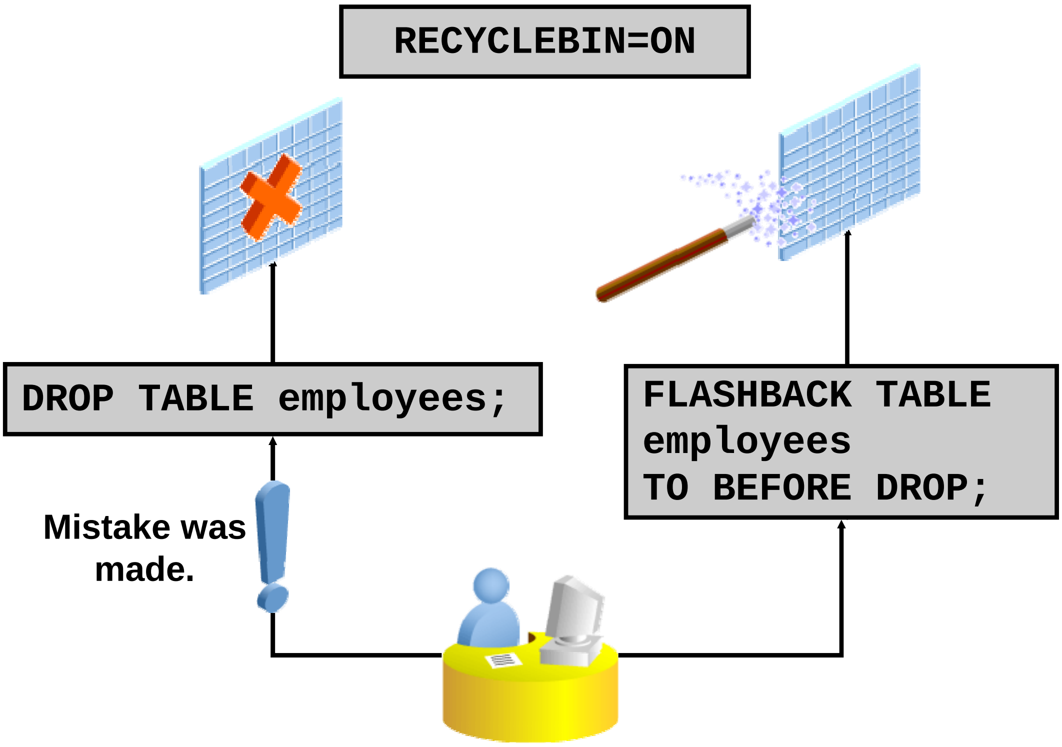
Flashback technology must be used when a logical corruption occurs in the Oracle database, and you need to recover data quickly and easily. As with human errors, it is difficult to identify the objects and rows that are affected by an erroneous transaction. With flashback technology, you can diagnose how errors are introduced into the database, and then you can repair the damage. You can view the transactions that have contributed to specific row modifications, view the entire set of versions of a given row during some time period, or just view data as it appeared at a specific time in the past. The table in the slide shows typical uses of flashback technology.

Flashback Database uses the flashback logs to perform flashback. Flashback Drop uses the recycle bin. All other techniques use undo data.

Not all flashback features modify the database. Some are simply methods to query other versions of data. Those are tools for you to use to investigate a problem and aid in recovery. The results of those flashback queries can help you do one of these two things:

- Determine which type of database-modifying flashback operation to perform to fix the problem.
- Feed the result set of these queries into an `INSERT`, `UPDATE`, or `DELETE` statement that enables you to easily repair the erroneous data.

Flashback Drop and the Recycle Bin



6-4

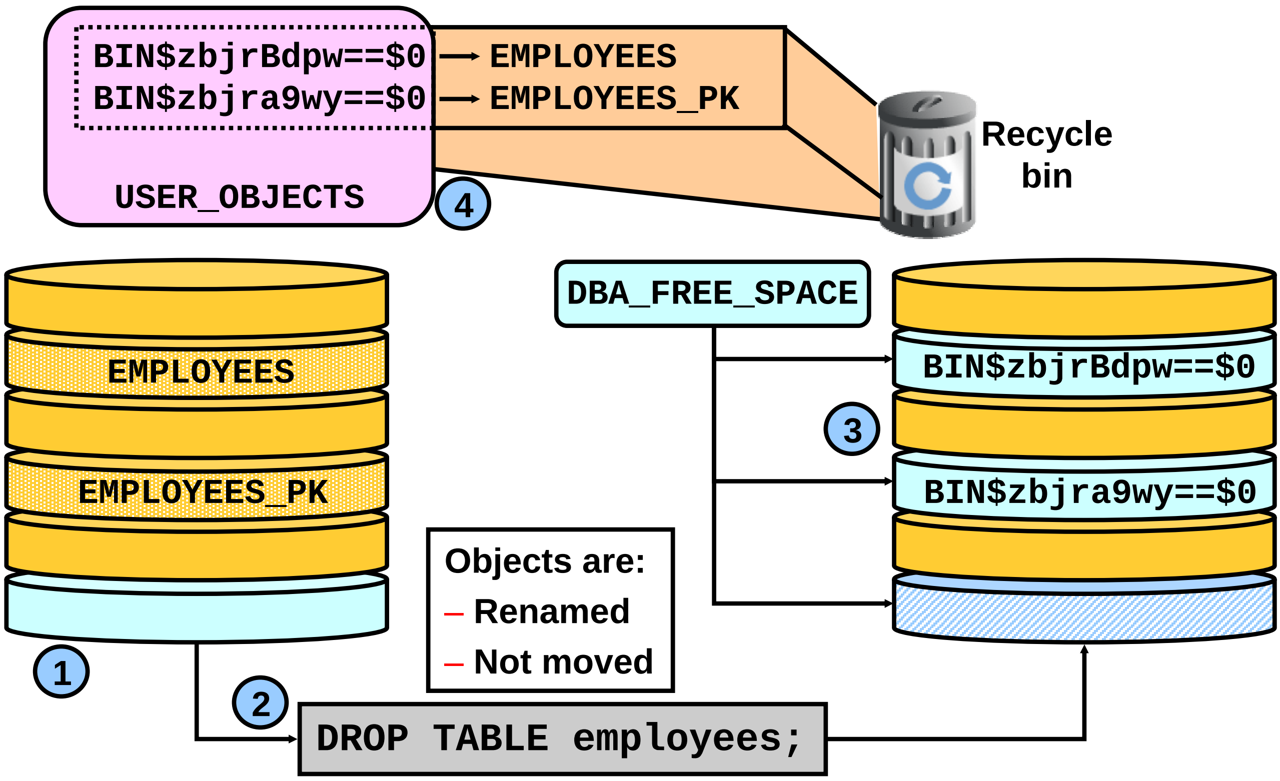
Flashback Drop and the Recycle Bin

In previous releases of the Oracle database, if you dropped a table by mistake, you had to recover the database to a prior time to recover the dropped table. This procedure was often time consuming and resulted in loss of work of other transactions.

Oracle Database 10*g* introduces the Flashback Drop feature, which you can use to undo the effects of a `DROP TABLE` statement without having to use point-in-time recovery.

Note: The `RECYCLEBIN` initialization parameter is used to control whether the Flashback Drop capability is turned `ON` or `OFF`. If the parameter is set to `OFF`, then dropped tables do not go into the recycle bin. If this parameter is set to `ON`, the dropped tables go into the recycle bin and can be recovered. By default, `RECYCLEBIN` is set to `ON`.

Recycle Bin



Recycle Bin

Without the recycle bin enabled, when you drop a table, the space associated with the table and its dependent objects is immediately reclaimable (that is, it can be used for other objects).

If the recycle bin is enabled, when you drop a table, then the space associated with the table and its dependent objects is not immediately reclaimable, even though it does appear in `DBA_FREE_SPACE`. Instead, the dropped objects are temporarily placed in the recycle bin and still belong to their owner. The space used by recycle bin objects is never automatically reclaimed unless there is space pressure. This enables you to recover recycle bin objects for the maximum possible duration.

When a dropped table is moved to the recycle bin, the table and its associated objects and constraints are renamed using system-generated names. This is necessary to avoid name conflicts that may arise if you later create a new object with the same name.

The recycle bin itself is a data dictionary table that maintains the relationships between the original names of dropped objects and their system-generated names. You can query the content of the recycle bin by using the `DBA_RECYCLEBIN` view.

Recycle Bin (continued)

The diagram in the slide illustrates this new behavior:

1. You have created a table called `EMPLOYEES` in your tablespace.
2. You drop the `EMPLOYEES` table.
3. The extents occupied by `EMPLOYEES` are now considered as free space.
4. `EMPLOYEES` is renamed and inserted into the recycle bin.

Restoring Tables from the Recycle Bin

- Restore dropped tables and dependent objects.
- If multiple recycle bin entries have the same original name:
  - Use unique, system-generated names to restore a particular version
  - When using original names, the restored table is last in, first out (LIFO)
- Rename the original name if that name is currently used.

```
FLASHBACK TABLE <table_name>
TO BEFORE DROP [RENAME TO <new_name>];
```


Restoring Tables from the Recycle Bin

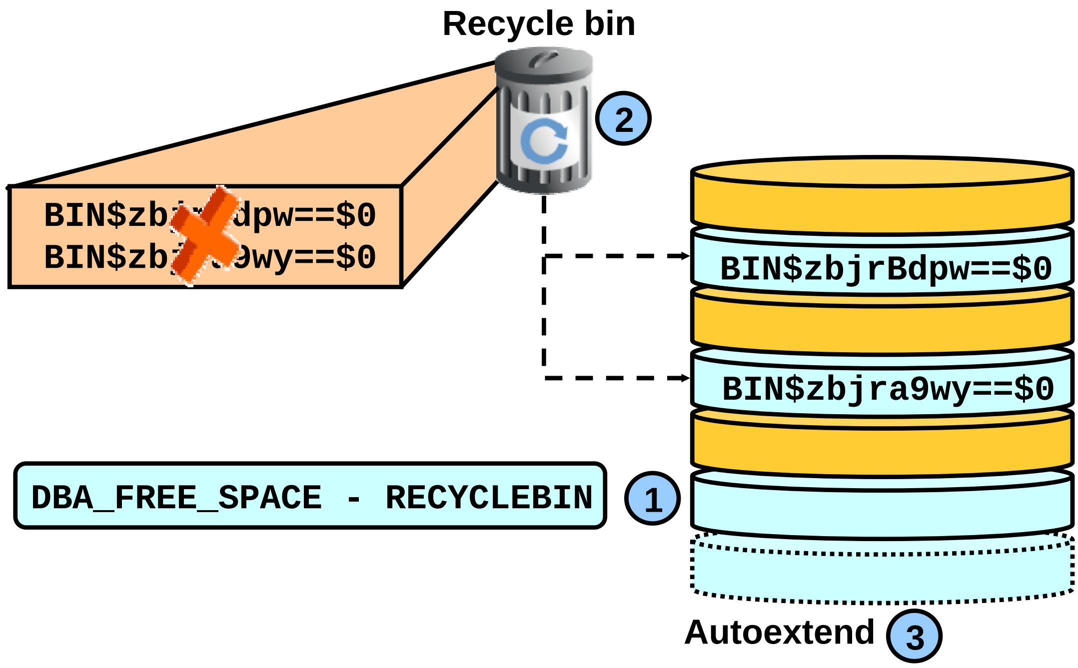
Use the `FLASHBACK TABLE ... TO BEFORE DROP` command to recover a table and all of its possible dependent objects from the recycle bin. You can specify either the original name of the table or the system-generated name assigned to the object when it was dropped.

If you specify the original name, and if the recycle bin contains more than one object of that name, then the object that was moved to the recycle bin most recently is recovered first (LIFO: last in, first out). If you want to retrieve an older version of the table, you can specify the system-generated name of the table that you want to retrieve, or issue additional `FLASHBACK TABLE ... TO BEFORE DROP` statements until you retrieve the table you want.

If a new table of the same name has been created in the same schema since the original table was dropped, then an error is returned unless you also specify the `RENAME TO` clause.

Note: When you flash back a dropped table, the recovered indexes, triggers, and constraints keep their recycle bin names. Therefore, it is advisable to query the recycle bin and `DBA_CONSTRAINTS` before flashing back a dropped table. In this way, you can rename the recovered indexes, triggers, and constraints to more usable names.

Recycle Bin: Automatic Space Reclamation



Recycle Bin: Automatic Space Reclamation

As long as the space used by recycle bin objects is not reclaimed, you can recover those objects by using Flashback Drop. The following are the recycle bin object reclamation policies:

- Manual cleanup when you explicitly issue a PURGE command
- Automatic cleanup under space pressure: While objects are in the recycle bin, their corresponding space is also reported in DBA_FREE_SPACE because their space is automatically reclaimable. The free space in a particular tablespace is then consumed in the following order:
  1. Free space not corresponding to recycle bin objects
  2. Free space corresponding to recycle bin objects. In this case, recycle bin objects are automatically purged from the recycle bin using a first in, first out (FIFO) algorithm.
  3. Free space automatically allocated if the tablespace is autoextensible

Recycle Bin: Automatic Space Reclamation (continued)

Suppose you create a new table inside the `TBS1` tablespace. If there is free space allocated to this tablespace that does not correspond to a recycle bin object, then this free space is used as a first step. If this is not enough, free space is used that corresponds to recycle bin objects that reside inside `TBS1`. If the free space of some recycle bin objects is used, then these objects get purged automatically from the recycle bin. At this time, you can no longer recover those objects by using the Flashback Drop feature. As a last resort, if space requirement is not yet satisfied, the `TBS1` tablespace is extended if possible.

Recycle Bin: Manual Space Reclamation

```
PURGE {TABLE <table_name>|INDEX <index_name>}
```

```
PURGE TABLESPACE <ts_name> [USER <user_name>]
```

```
PURGE [USER_|DBA_]RECYCLEBIN
```

Database Instance: orcl.oracle.com > Tables > Recycle Bin

Recycle Bin

Results

Purge | Flashback Drop

Select All | Select None | Expand All | Collapse All

Select	Object Name	Schema	Object Type	Tablespace	Drop Time	Create Time	Size	Operation
☐	▼Recycle Bin							View Content
☐	▶EMPLOYEES	HR2	TABLE	USERS	2005-08-31:17:44:17	2005-08-31:17:40:45	8	View Content
☑	JOBS	HR2	TABLE	USERS	2005-08-31:17:44:30	2005-08-31:17:41:29	8	View Content

ORACLE

6-10

Recycle Bin: Manual Space Reclamation

Use the PURGE command to permanently remove objects from the recycle bin. When an object is purged from the recycle bin, the object and its dependent objects are permanently removed from the database. As a consequence, objects purged from the recycle bin are no longer recoverable by using the Flashback Drop feature. The following are the possible uses of PURGE:

- PURGE TABLE purges the specified table.
- PURGE INDEX purges the specified index.
- PURGE TABLESPACE purges all the objects residing in the specified tablespace. In addition, objects residing in other tablespaces may get purged if they are dependent. Optionally, you can also specify the USER clause to purge only those objects that belong to the specified user running low on disk quota for the specified tablespace.
- PURGE RECYCLEBIN purges all the objects that belong to the current user. RECYCLEBIN and USER_RECYCLEBIN are synonymous.
- PURGE DBA_RECYCLEBIN purges all the objects. You must have enough system privileges or the SYSDBA system privilege to issue this command.

Note: For PURGE TABLE and PURGE INDEX commands, if you specify an original name and
if the recycle bin contains more than one object of that name, then the object that has been in the recycle bin the longest is purged first (FIFO).

Bypassing the Recycle Bin

```
DROP TABLE <table_name> [PURGE] ;
```

```
DROP TABLESPACE <ts_name>
[INCLUDING CONTENTS] ;
```

```
DROP USER <user_name> [CASCADE] ;
```


Bypassing the Recycle Bin

You can use the DROP TABLE PURGE command to permanently drop a table and its dependent objects from the database. When you use this command, the corresponding objects are not moved to the recycle bin. This command provides the same functionality that the DROP TABLE command provided in previous releases.

When you issue the DROP TABLESPACE ... INCLUDING CONTENTS command, the objects in the tablespace are not placed in the recycle bin. Moreover, objects in the recycle bin belonging to the tablespace are purged. When you issue the same command without the INCLUDING CONTENTS clause, the tablespace must be empty for the command to succeed. However, there can be objects belonging to the tablespace in the recycle bin. In this case, these objects are purged.

When you issue the DROP USER ... CASCADE command, the user and all the objects owned by the user are permanently dropped from the database. Any objects in the recycle bin belonging to the dropped user are purged.

Querying the Recycle Bin

```
SELECT owner, original_name, object_name,
       type, ts_name, droptime, related, space
FROM dba_recyclebin
WHERE can_undrop = 'YES';
```

```
SELECT original_name, object_name,
       type, ts_name, droptime, related, space
FROM user_recyclebin
WHERE can_undrop = 'YES';
```

```
SQL> SHOW RECYCLEBIN
```


Querying the Recycle Bin

You can view all the objects that you have dropped by querying `user_recyclebin` or `RECYCLEBIN`.

`dba_recyclebin` shows you all the objects that have been dropped by all users and that are still in the recycle bin.

You can also use the SQL*Plus `SHOW RECYCLEBIN` command. This command shows you only those objects that can be "undropped."

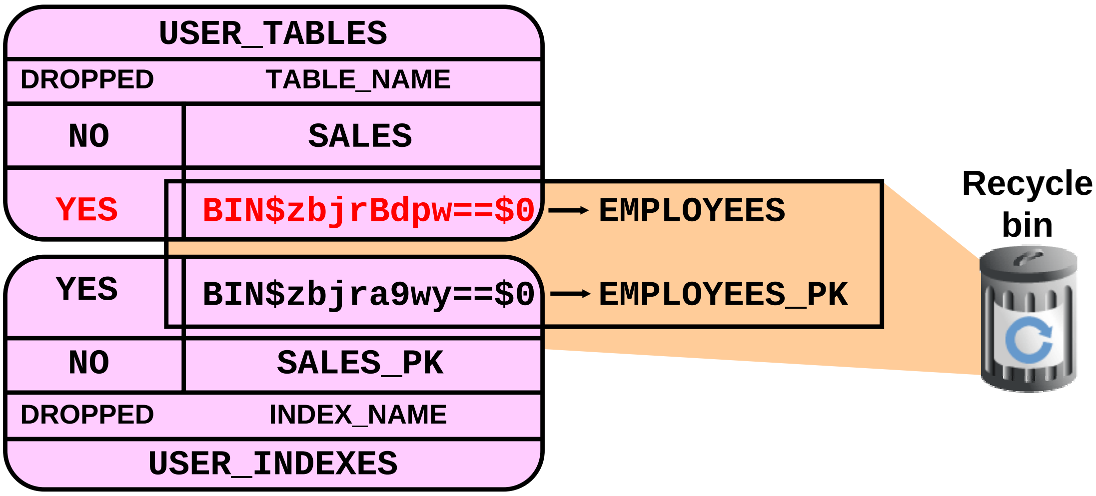
The examples show how to extract important information from the recycle bin:

- `original_name` is the name of the object before it is dropped.
- `object_name` is the system-generated name of the object after it is dropped.
- `type` is the object's type.
- `ts_name` is the name of the tablespace to which the object belongs.
- `droptime` is the date at which the object was dropped.
- `related` is the object identifier of the dropped object.
- `space` is the number of blocks currently used by the object.

You can also see the content of the recycle bin by using Database Control.

Note: For detailed information about the `DBA_RECYCLEBIN` view, see the *Oracle Database Reference* guide.

Querying Data from Dropped Tables




```
SELECT ...
FROM "BIN$zbjrBdpw==$0" [AS OF ...]
WHERE  ...
```


Querying Data from Dropped Tables

When you drop a table, the table is moved to the recycle bin, and its original name is changed to a unique, system-generated name. Because you still own the dropped table, you can still see its characteristics from various dictionary views such as `DBA_TABLES`, `DBA_OBJECTS`, `DBA_SEGMENTS`, and so on. To make a distinction between tables that are in the recycle bin and tables that are not, the `DBA_TABLES` view has a new column called `DROPPED` that is set to `YES` for tables that were dropped but are still in the recycle bin.

So, as long as a system-generated table name is in the recycle bin, you can use it in a `SELECT` statement and also in flashback queries.

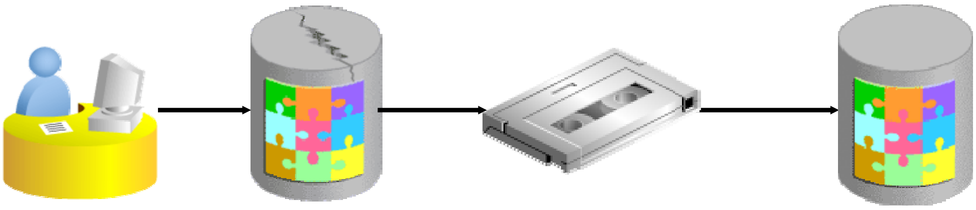
However, you cannot issue any sort of DML or DDL statements on objects that reside in the recycle bin.

Flashback Database: Review

Recycle bin
> Flashback DB
Config. FB DB
Monitor FB DB
Guar. Res. Pt.

The Flashback Database operation:

- Works like a rewind button for the database
- Can be used in cases of logical data corruptions made by users

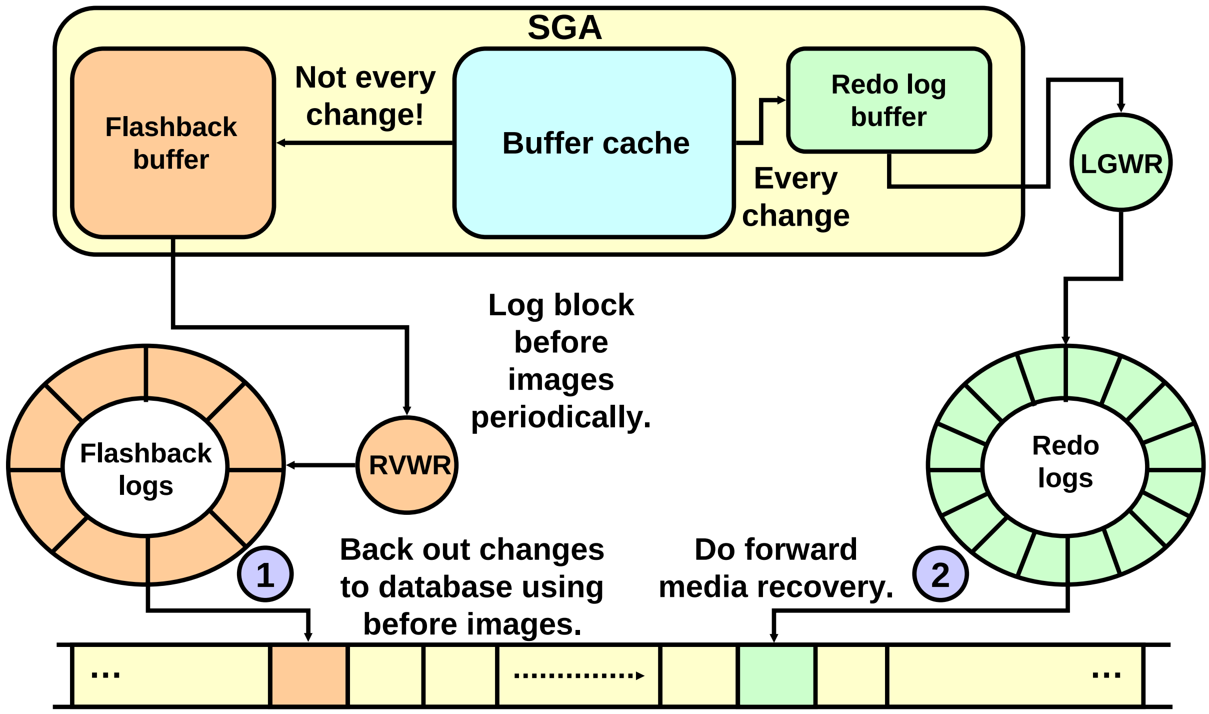


Flashback Database: Review

With Flashback Database, you can quickly bring your database to an earlier point in time by undoing all the changes that have taken place since that time. This operation is fast because you do not need to restore backups. You can use this feature to undo changes that have resulted in logical data corruptions.

If you have experienced a loss of media or physical corruption in your database, then you must use traditional recovery methods.

Flashback Database Architecture



Flashback Database Architecture

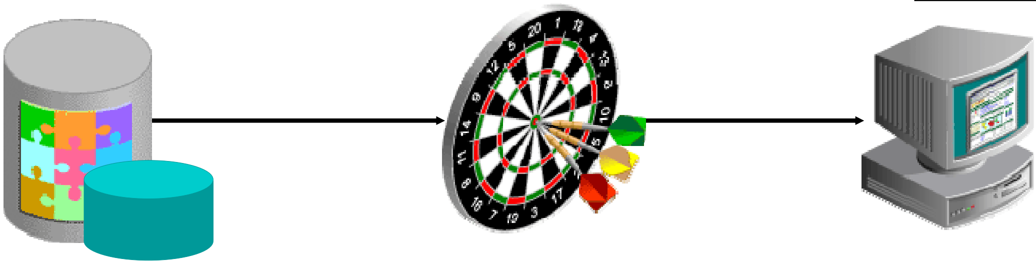
When you enable Flashback Database, the new RVWR background process is started. This background process sequentially writes Flashback Database data from the flashback buffer to the Flashback Database logs, which are circularly reused. Subsequently, when a FLASHBACK DATABASE command is issued, the flashback logs are used to restore to the blocks' before images, and then redo data is used to roll forward to the desired flashback time.

The overhead of enabling Flashback Database depends on the read-write mix of the database workload. Because queries do not need to log any flashback data, the more write-intensive the workload, the higher the overhead of turning on Flashback Database.

Note: Flashback Database logs are not archived.

Configuring Flashback Database

Recycle bin
Flashback DB
> Config. FB DB
Monitor FB DB
Guar. Res. Pt.



1. Configure the flash recovery area.
2. Set the retention target.
3. Enable Flashback Database.

```
SQL> SHUTDOWN IMMEDIATE;
SQL> STARTUP MOUNT EXCLUSIVE;
SQL> ALTER SYSTEM SET
  2  DB_FLASHBACK_RETENTION_TARGET=2880 SCOPE=BOTH;
SQL> ALTER DATABASE FLASHBACK ON;
SQL> ALTER DATABASE OPEN;
```

6-16

Configuring Flashback Database

You can configure Flashback Database as follows:

1. Configure the flash recovery area.
2. Set the retention target with the `DB_FLASHBACK_RETENTION_TARGET` initialization parameter. You can specify an upper limit, in minutes, on how far back you want to be able to flash back the database. The example uses 2880 minutes, which is equivalent to two days. This parameter is only a target and does not provide any guarantee. Your flashback time interval depends on how much flashback data has been kept in the flash recovery area.
3. Enable Flashback Database with the following command:

   ```
   ALTER DATABASE FLASHBACK ON;
   ```

   Before you can issue the command to enable Flashback Database, the database must be configured for archiving and started in `MOUNT EXCLUSIVE` mode.

You can determine whether Flashback Database is enabled with the following query:

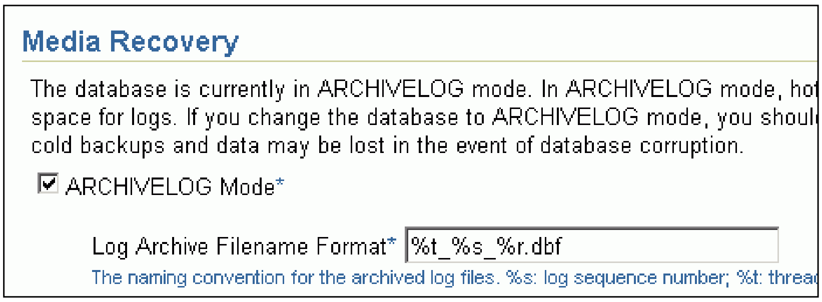
```
SELECT flashback_on FROM v$database;
```

You can disable Flashback Database with the `ALTER DATABASE FLASHBACK OFF` command. As a result, all existing Flashback Database logs are deleted automatically.

Note: You can enable Flashback Database only when the database is mounted in exclusive mode, not open.

Configuring Flashback Database Using EM

Make sure that the database is in `ARCHIVELOG` mode.



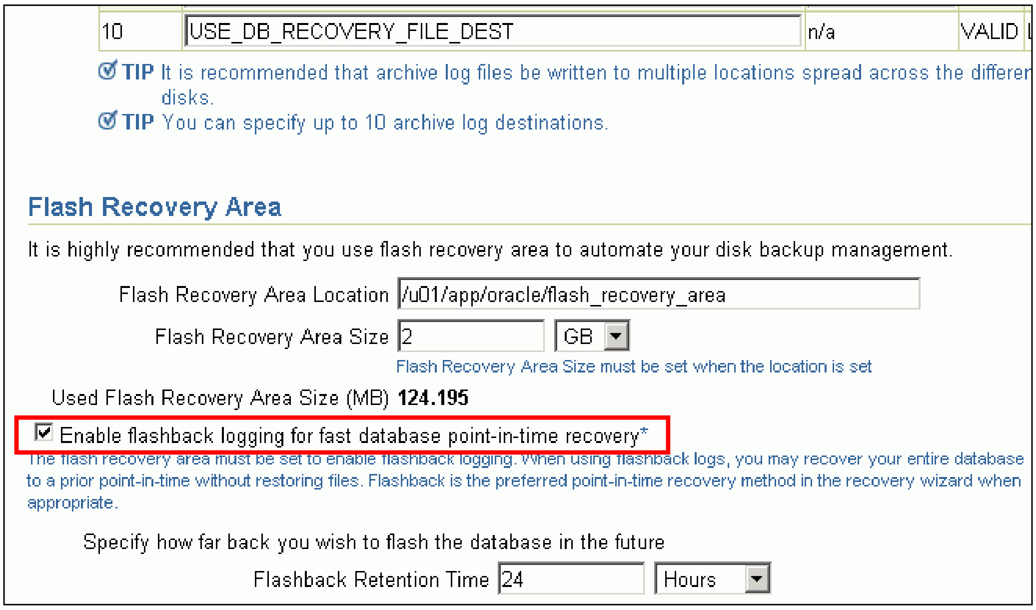
6-17

Configuring Flashback Database Using EM

Log in to Enterprise Manager Database Console. On the Maintenance page, select Backup/Recovery Settings, and then choose Recovery Settings. Make sure that your database is in `ARCHIVELOG` mode. If not, select ARCHIVELOG Mode and then click Continue. You will need to shut down and restart the instance for your changes to take effect.

Configuring Flashback Database Using EM

Enable flashback logging and specify the flash recovery area.



ORACLE

Configuring Flashback Database Using EM (continued)

When you are certain that the database is in `ARCHIVELOG` mode, return to the Recovery Settings page and scroll down to the Media Recovery and Flash Recovery Area regions to observe the new settings. When the flash recovery area and archiving are configured, `USE_DB_RECOVERY_FILE_DEST` is configured for archive log destination 10. Enable flashback logging by selecting Enable Flashback Logging. You also have the ability to set the flashback retention time, and you can view important information regarding your flashback database window.

Review the flash recovery area location. The flash recovery area is a unified storage location for all recovery-related files and activities in an Oracle database. All files that are needed to completely recover a database from a media failure are part of the flash recovery area. The recovery-related files that can be created in the flash recovery area include: archived redo log files, control files, backups created by Recovery Manager (RMAN), flashback logs, and the change tracking file. By allocating a storage location and unifying recovery-related files within a specific area, the Oracle database server relieves the database administrator from having to manage the disk files created by these components. The default location for the flash recovery area is `$ORACLE_BASE`. If you would like it in a different location, change it now. Scroll down to the bottom of the Recovery Settings page and click **Apply**.

Flashback Database: Examples

```
RMAN> FLASHBACK DATABASE TO TIME =
   2> "TO_DATE('2004-05-27 16:00:00',
   3> 'YYYY-MM-DD HH24:MI:SS')";

RMAN> FLASHBACK DATABASE TO SCN=23565;

RMAN> FLASHBACK DATABASE
   2> TO SEQUENCE=223 THREAD=1;
```

```
SQL> FLASHBACK DATABASE
  2  TO TIMESTAMP(SYSDATE-1/24);

SQL> FLASHBACK DATABASE TO SCN 53943;

SQL> FLASHBACK DATABASE TO RESTORE POINT b4_load;
```

6-19

Flashback Database: Examples

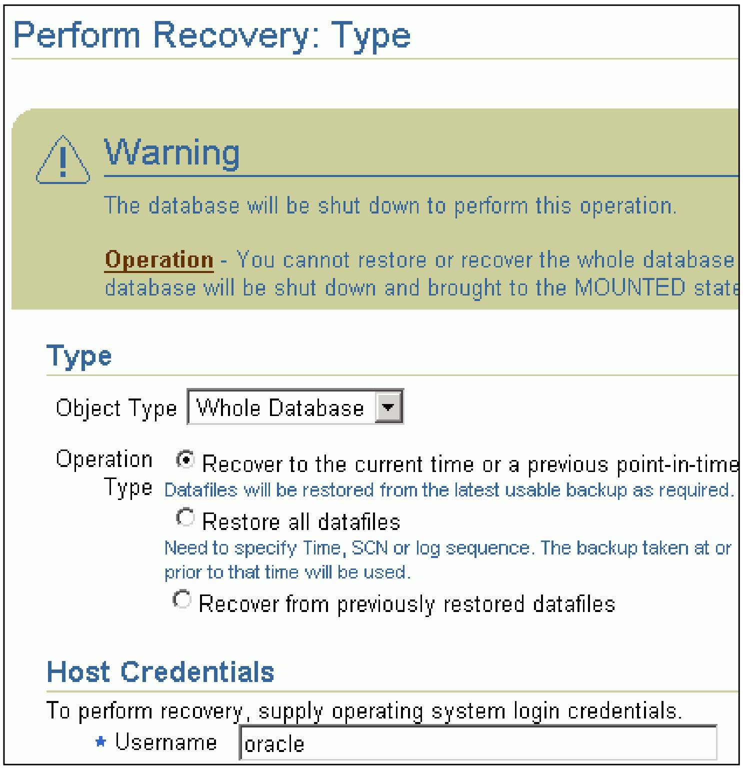
You can use the RMAN `FLASHBACK DATABASE` command to execute the Flashback Database operation. You can use `SEQUENCE` and `THREAD` to specify a redo log sequence number and thread as a lower limit. RMAN selects only files that can be used to flash back to, but not including, the specified sequence number.

Alternatively, you can use the `FLASHBACK DATABASE` SQL command to return the database to a past time or SCN. If you use the `TO SCN` clause, you must provide a number. If you specify `TO TIMESTAMP`, you must provide a time stamp value. You can also specify a restore point name.

Note: The database must be mounted in exclusive mode to issue the `FLASHBACK DATABASE` command and must be opened with the `RESETLOGS` option when finished.

Performing Flashback Database Using EM

Select object and operation type.

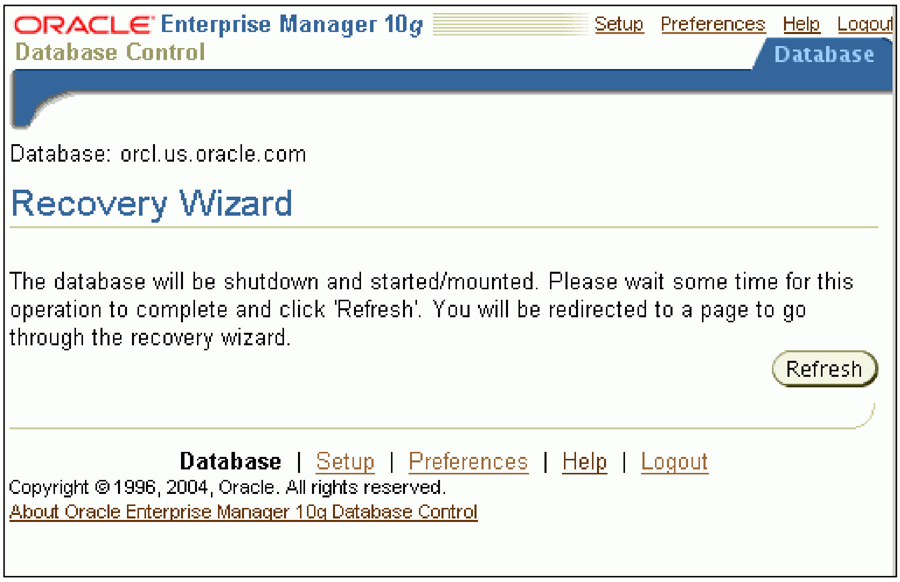


Performing Flashback Database Using EM

On the Maintenance page, choose Perform Recovery. From the Object Type drop-down list, select Whole Database. Next, select “Recover to the current time or a previous point-in-time” as Operation Type. Finally, provide the operating system credentials for a database user (that is, one who belongs to the `dba` group). When these steps are completed, click Continue to proceed to the next step in the Flashback Database operation.

Performing Flashback Database Using EM

Launching the Recovery Wizard:

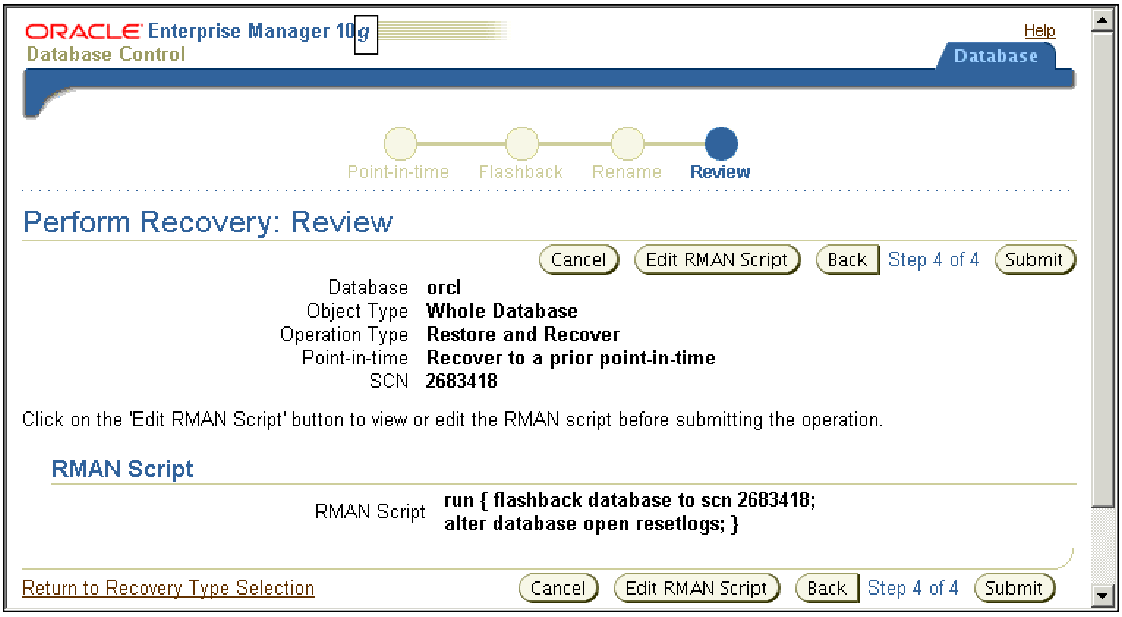


ORACLE

Performing Flashback Database Using EM (continued)

After the recovery operation type has been chosen, the Recovery Wizard is launched. You are informed that the database will be shut down and restarted in `MOUNT` mode. This operation takes several minutes and you will be informed of the delay. After waiting an appropriate amount of time, you are then prompted to click Refresh to continue with the operation.

Performing Flashback Database Using EM



ORACLE

6-22

Performing Flashback Database Using EM (continued)

The Recovery Wizard is now started. At this stage, the database is shut down and started in `MOUNT` mode. Click Refresh.

This displays the Perform Recovery: Point-in-time page. On this page, select the “Recover to a prior point-in-time” option, and then specify either a date or an SCN. Then, click Next.

The Perform Recovery: Flashback page appears next, and you can choose to perform either recovery using flashback or regular recovery. Choose the corresponding option, and then click Next.

This brings you directly to the Perform Recovery: Review page that is shown in the slide. Click Submit to flash back the database.

Excluding Tablespaces from Flashback Database

```
ALTER TABLESPACE <ts_name> FLASHBACK {ON|OFF}
```

```
SQL> SELECT name, flashback_on
  2  FROM   v$tablespace;
```

- Take the tablespace offline before you perform the Flashback Database recovery.
- Drop the tablespace or recover the offline files with traditional point-in-time recovery.

Excluding Tablespaces from Flashback Database

You may have a tablespace for which you do not want to log Flashback Database data. You can use the ALTER TABLESPACE command to exclude a tablespace from participating in flashback of the database. This attribute can also be specified when a tablespace is created. The default value is ON.

You must take this tablespace offline before flashing back the database. You can then drop the tablespace or recover the offline data files by using traditional point-in-time recovery methods. You can query the V$TABLESPACE view to determine the flashback status for a tablespace.

Note: If you re-create the control file, all tablespaces are placed in FLASHBACK ON mode. You must repeat the ALTER TABLESPACE commands to ensure that the tablespaces are excluded from Flashback Database operations.

Flashback Database Considerations

- When the Flashback Database operation completes, open the database:
  - In read-only mode to verify that the correct target time or SCN was used
  - With a `RESETLOGS` operation to allow for DML
- The opposite of "flash back" is "recover."
- You cannot use Flashback Database in the following situations:
  - The control file has been restored or re-created.
  - A tablespace has been dropped.
  - A data file has been shrunk.
- Use the `TO BEFORE RESETLOGS` to flash back to before the last `RESETLOGS` operation.

6-24

Flashback Database Considerations

In situations where you cannot use the Flashback Database feature, you should use an incomplete recovery operation to return the database to a specific time. After the Flashback Database operation is complete, you can open the database in read-only mode to verify that the correct target time or SCN was used. If not, you can flash back the database again, or perform a recovery to roll forward the database. So, to undo a Flashback Database operation, you should recover the database forward.

You cannot use Flashback Database to recover a data file that was dropped during the span of time you are flashing back. The dropped data file is added to the control file and marked offline, but it is not flashed back. Flashback Database cannot flash back a data file to a time after its creation and before the resize operation. If a file was resized during the span of time to which you are going to flash back the database, then you should take the file offline before beginning the Flashback Database operation. This is applicable for files that are shrunk rather than expanded. You can use Flashback Database with data files that you have configured for automatic extension.

Flashback Database Considerations (continued)

You can flash back to just before the last `RESETLOGS` operation by supplying the `TO BEFORE RESETLOGS` clause in the `FLASHBACK DATABASE` command.

Note: The flashback retention target is not an absolute guarantee that flashback will be available. If space is needed for required files in the flash recovery area, flashback logs may be deleted automatically.

Monitoring Flashback Database

Recycle bin
Flashback DB
Config. FB DB
> Monitor FB DB
Guar. Res. Pt.

To monitor the ability to meet your retention target:

- View the flash recovery area disk quota:

```
SQL> SELECT estimated_flashback_size,
  2         flashback_size
  3  FROM   V$FLASHBACK_DATABASE_LOG;
```

- Determine the current flashback window:

```
SQL> SELECT oldest_flashback_scn,
  2  oldest_flashback_time
  3  FROM   V$FLASHBACK_DATABASE_LOG;
```

- Monitor logging in the Flashback Database logs:

```
SQL> SELECT *
  2  FROM   V$FLASHBACK_DATABASE_STAT;
```


Monitoring Flashback Database

It is important for you to monitor space usage of the flash recovery area so that you know how well you are meeting your retention target. Use the V$FLASHBACK_DATABASE_LOG view to monitor the Flashback Database retention target:

- ESTIMATED_FLASHBACK_SIZE uses previously logged flashback data to provide an estimate of how much disk space is needed in the flash recovery area for flashback logs to meet the current flashback retention target. The estimate is based on the workload since the instance was started, or during the most recent time interval equal to the flashback retention target, whichever is shorter.
- FLASHBACK_SIZE gives you the current size in bytes of the flashback data.
- OLDEST_FLASHBACK_SCN and OLDEST_FLASHBACK_TIME display the approximate lowest SCN and time to which you can flash back your database. CURRENT_SCN in V$DATABASE gives you the current database SCN.

Use the V$FLASHBACK_DATABASE_STAT view to monitor the overhead of logging flashback data in the Flashback Database logs. This view contains 24 hours of information, with each row representing a one-hour time interval. You can use this view to determine rate changes in the flashback data generation.

```
SQL> SELECT begin_time, end_time, flashback_data, db_data,
  2   redo_data, estimated_flashback_size AS EST_FB_SZE
  3   FROM V$FLASHBACK_DATABASE_STAT;
```

Monitoring Flashback Database (continued)

```
BEGIN_TIM END_TIME  FLASHBACK_DATA    DB_DATA  REDO_DATA EST_FB_SZE
--------- --------- -------------- ---------- ---------- ----------
12-FEB-04 12-FEB-04          16384          0      24576          0
12-FEB-04 12-FEB-04        6594560    7471104    1533440  815923200
12-FEB-04 12-FEB-04       17235968   12361728    5150720  839467008
12-FEB-04 12-FEB-04      311648256   37249024   10272768  855195648
```

Based on this information, you may need to adjust the retention time or the flash recovery area size.

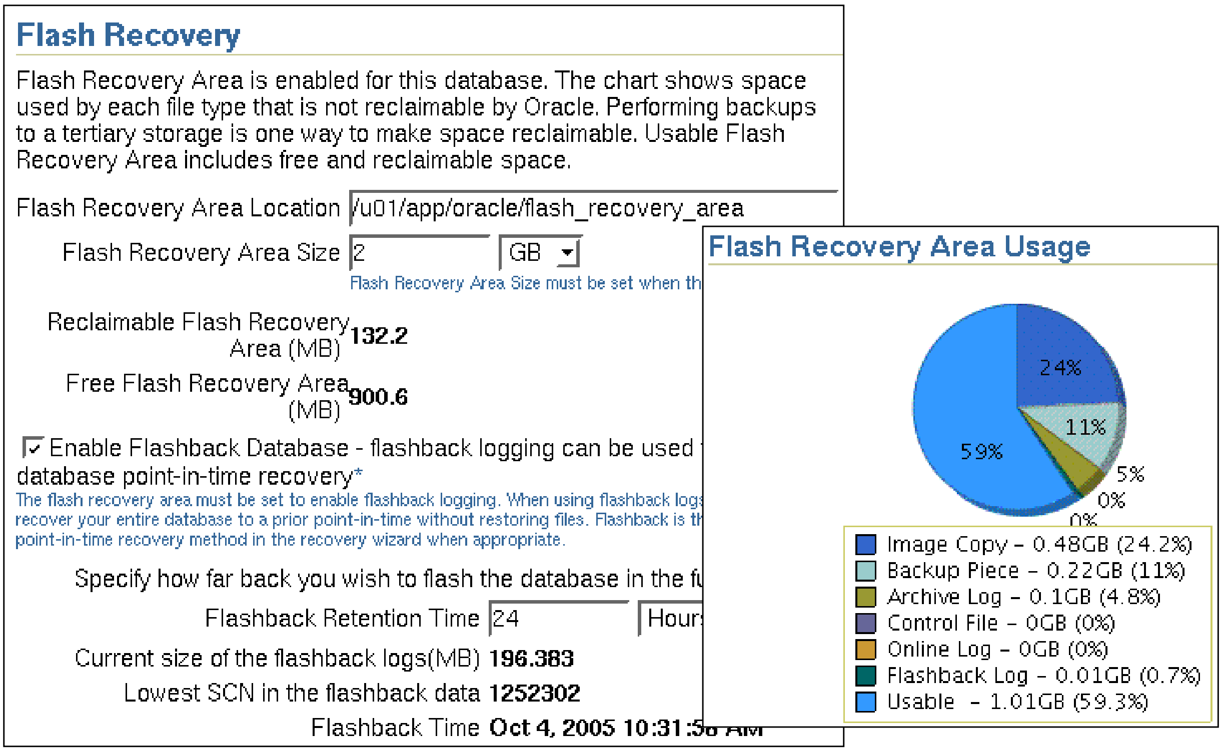
`FLASHBACK_DATA` and `REDO_DATA` represent the number of bytes of flashback data and redo data written, respectively, during the time interval, and `DB_DATA` gives the number of bytes of data blocks read and written. This view also contains the estimated flashback space needed for the interval.

You can query `V$RECOVERY_FILE_DEST` to view information regarding the flash recovery area. The column descriptions are:

- **`NAME`:** Flash recovery area name, indicating location string
- **`SPACE_LIMIT`:** Disk limit specified in the `DB_RECOVERY_FILE_DEST_SIZE` parameter
- **`SPACE_USED`:** Space used by flash recovery area files (in bytes)
- **`SPACE_RECLAIMABLE`:** Amount of space that can be reclaimed by deleting obsolete, redundant, and other low-priority files through the space management algorithm
- **`NUMBER_OF_FILES`:** Number of files

```
SQL> SELECT name, space_limit AS quota,
  2         space_used        AS used,
  3         space_reclaimable AS reclaimable,
  4         number_of_files   AS files
  5  FROM  v$recovery_file_dest ;

NAME                           QUOTA       USED  RECLAIMABLE  FILES
------------------------ ---------- ----------  -----------  -----
/u01/flash_recovery_area 5368709120 2509807104    203386880    226
```

Monitoring Flashback Database with EM



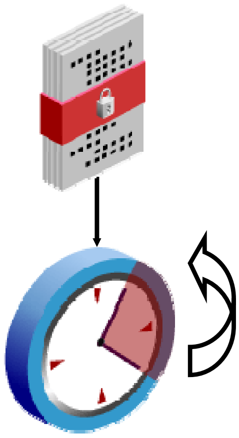
Monitoring Flashback Database with EM

Most of the Flashback Database statistics mentioned on the preceding pages can be viewed from the Recovery Settings page. These metrics include the current space used by all flashback logs, the lowest SCN, and the time of the lowest SCN in the flashback data.

Guaranteed Restore Points

Recycle bin
Flashback DB
Config. FB DB
Monitor FB DB
> Guar. Res. Pt.

A guaranteed restore point ensures that you can perform a FLASHBACK DATABASE command to that SCN at any time.



```
SQL> CREATE RESTORE POINT before_load
  2  GUARANTEE FLASHBACK DATABASE;
```


Guaranteed Restore Points

Like normal restore points, which are covered in the lesson titled “Database Recovery,” guaranteed restore points can be used as aliases for SCNs in recovery operations. However, they also provide specific functionality related to the use of the Flashback Database feature.

Creating a guaranteed restore point at a particular SCN enforces the requirement that you can perform a Flashback Database operation to return your database to its state at that SCN, even if flashback logging is not enabled for your database. If flashback logging is enabled, creating a guaranteed restore point enforces the retention of flashback logs required for Flashback Database back to any point in time after the creation of the earliest guaranteed restore point.

A guaranteed restore point can be used to revert a whole database to a known good state days or weeks ago, as long as there is enough disk space in flash recovery area to store the needed logs. As with Flashback Database, even the effects of `NOLOGGING` operations such as direct load inserts can be reversed using guaranteed restore points.

Note: As with normal restore points, guaranteed restore points can be used to specify a point in time for `RECOVER DATABASE` operations. See the lesson titled “Database Recovery” for more information.

Summary

In this lesson, you should have learned how to:

- Query the recycle bin
- Configure Flashback Database
- Perform Flashback Database to a point in time using Enterprise Manager or RMAN
- Monitor flashback log statistics
- Enable and disable the Flashback Database feature
- Use guaranteed restore points with Flashback Database

Practice Overview: Performing Flashback Database

This practice covers the following topics:

- Performing Flashback Database to undo unwanted transactions
- Monitoring the Flashback Database retention
- Determine the size of the flashback logs

7

Dealing with Database Corruption

ORACLE

Objectives

After completing this lesson, you should be able to:

- Identify the causes of database corruption:
  - Hardware
  - Software
- Detect database corruption by using:
  - `ANALYZE`
  - `DBVERIFY`
  - `DB_BLOCK_CHECKING`
  - `DBMS_REPAIR`
- Repair corruptions by using RMAN

ORACLE

What Is Block Corruption?

- Whenever a block is read or written, a consistency check is performed.
  – Block version
  – DBA (data block address) value in cache as compared to the DBA value in the block buffer
  – Block-checksum, if enabled
- A corrupt block is identified as being one of the following:
  – Media corrupt
  – Logically (or software) corrupt

What Is Block Corruption?

A corrupted data block is a block that is not in a recognized Oracle format, or whose contents are not internally consistent. Typically, corruptions are caused by faulty hardware or operating system problems. The Oracle database identifies corrupt blocks as either "logically corrupt" or "media corrupt." If it is logically corrupt, then there is an Oracle internal error. Logically corrupt blocks are marked corrupt by the Oracle database after it detects the inconsistency. If it is media corrupt, then the block format is not correct; the information in the block does not make any sense after being read from disk.

You can repair a media corrupt block by recovering the block or dropping the database object that contains the corrupt block, or both. If media corruption is due to faulty hardware, the problem will not be completely resolved until the hardware fault is corrected.

Block Corruption Symptoms: ORA-01578

The error `ORA-01578: "ORACLE data block corrupted (file # %s, block # %s)"`:

- Is generated when a corrupted data block is found
- Always returns the absolute file number and block number
- Is returned to the session that issued the query being performed when the corruption was discovered
- Appears in the `alert.log` file

7-4

Block Corruption Symptoms: ORA-01578

Usually, the ORA-01578 error is the result of a hardware problem. If the ORA-01578 error is always returned with the same arguments, it is most likely a media corrupt block.

If the arguments change each time, there may be a hardware problem, and the customer should have the memory and page space checked, and the I/O subsystem checked for bad controllers.

How to Handle Corruption

- Check the alert log and operating system log file.
- Use available diagnostic tools to find out the type of corruption.
- Determine whether the error persists by running checks multiple times.
- Recover data from the corrupted object if necessary.

7-5

How to Handle Corruption

Always try to find out whether the error is permanent. Run the `ANALYZE` command multiple times or, if possible, perform a shutdown and a startup and try again to perform the operation that failed earlier.

Find out whether there are more corruptions. If you encounter one, there may be other corrupted blocks, as well. Use tools such as `DBVERIFY` to handle such a situation.

How to Handle Corruption

- Resolve any hardware issues:
  - Memory boards
  - Disk controllers
  - Disks
- Recover or restore data from the corrupt object if necessary.

7-6

How to Handle Corruption (continued)

There is no point in continuing to work if there are hardware failures. When you encounter hardware problems, the vendor should be contacted and the machine should be checked and fixed before continuing. A full hardware diagnostics session should be run.

Many types of hardware failures are possible:

- Faulty I/O hardware or firmware
- Operating system I/O or caching problem
- Memory or paging problems
- Disk repair utilities

Corruption-Related Features

Feature	Corruption Detected	Repairs Corruption
DBVERIFY	Physical	FALSE
ANALYZE	Logical	FALSE
DB_BLOCK_CHECKING	Logical	FALSE
DB_BLOCK_CHECKSUM	Physical	FALSE
exp	Physical	FALSE
Flashback	Logical	TRUE
DBMS_REPAIR	Logical	TRUE
Block media recovery	None	TRUE

ORACLE

7-7

Corruption-Related Features

There are many tools available for detecting, diagnosing, and repairing corruption in the Oracle database. The slide shows a summary of the ones covered in this lesson.

DBVERIFY Utility

- Works only on data files; redo log files cannot be checked
- Checks block consistency
- Can be used while the database is open
- Name of the utility program: dbv

```
$ dbv file=/u01/oradata/users01.dbf \
blocksize=8192
```

ORACLE

DBVERIFY Utility

DBVERIFY is an external command-line utility that performs a physical data structure integrity check on a database that is offline or online. It can be used against backup files and online files (or pieces of files). Use DBVERIFY primarily when you need to ensure that a backup of a database or data file is valid before it is restored or as a diagnostic aid when you have encountered data corruption problems. Because DBVERIFY can be run against an offline database, integrity checks are significantly faster.

Limitations of DBVERIFY include the following:

- DBVERIFY cannot detect problems such as `INDEX` versus `TABLE` mismatches, which can be detected by the `ANALYZE TABLE .. VALIDATE STRUCTURE CASCADE` command.
- DBVERIFY does *not* verify redo log files or control files.
- DBVERIFY only checks a block in isolation; it does not know whether the block is part of an existing object or not.
- For raw devices, you should use the `END` parameter to avoid scanning blocks past the end of the data file space:

```
dbv FILE=/dev/rdsk/r1.dbf END=last_data_block#
```

Interpreting DBVERIFY Output

- A “page” is a block.
- If the head and tail do not match, DBVERIFY rereads the block. If they match, an influx block is reported; otherwise, a corruption is signaled.

```
Total Pages Examined         : 12800
Total Pages Processed (Data) : 4408
Total Pages Failing   (Data) : 0
Total Pages Processed (Index): 1264
  .
  .
  .
Total Pages Marked Corrupt   : 4
Total Pages Influx           : 0
Highest block SCN            : 654836 (0.654836)
```


Interpreting DBVERIFY Output

Influx blocks are split blocks. If DBVERIFY reports influx blocks but does not report corruption, it means that when it read the block the first time, `DBWn` was writing a new version and it caught part of the old and part of the new version of this block. Also, DBVERIFY checks only for logical corruption. Therefore, it is possible for corruption to occur above the high-water mark. A sample DBVERIFY check is shown below:

```
$ dbv file=example01.dbf blocksize=8192
DBVERIFY: Release 10.2.0.1.0 - Production on Fri Sep 9
13:17:45 2005

Copyright (c) 1982, 2005, Oracle.  All rights reserved.

DBVERIFY - Verification starting : FILE = example01.dbf


DBVERIFY - Verification complete
```

Interpreting DBVERIFY Output (continued)

```
Total Pages Examined         : 12800
Total Pages Processed (Data) : 4409
Total Pages Failing   (Data) : 0
Total Pages Processed (Index): 1264
Total Pages Failing   (Index): 0
Total Pages Processed (Other): 1539
Total Pages Processed (Seg)  : 0
Total Pages Failing   (Seg)  : 0
Total Pages Empty            : 5588
Total Pages Marked Corrupt   : 0
Total Pages Influx           : 0
Highest block SCN            : 654836 (0.654836)
```

ANALYZE Command

- Performs a logical block check
- Does not mark blocks as soft corrupt; only reports them
- Validates index and table entries

```
SQL> ANALYZE TABLE table_name VALIDATE
  2 STRUCTURE CASCADE;

SQL> ANALYZE INDEX index_name VALIDATE
  2  STRUCTURE;
```


ANALYZE Command

Use the ANALYZE command to validate the structure of a table or table partitions, and index or index partitions. The object to be analyzed must be local and it must be in your own schema or you must have the ANALYZE ANY system privilege. The CASCADE option validates an object, including all related objects. You can run this in a SQL*Plus session on a specific object, to perform an integrity check and to determine whether an error is persistent, by running the same ANALYZE command several times.

For partitioned tables, ANALYZE also verifies that the row belongs to the correct partition. If the row does not collate correctly, the row ID is inserted in the INVALID_ROWS table.

```
SQL> ANALYZE TABLE partitioned_table PARTITION (p1)
  2  VALIDATE STRUCTURE INTO invalid_rows;
```

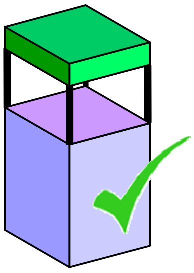
A simple select statement (`SELECT * FROM table`) performs a full table scan, which means that it reads all the data blocks up to the high-water mark of the table. You could use this to perform a quick check for corruptions in your current table data. You can also use Data Pump to export objects; this also fully scans each table.

Note: ANALYZE validates bitmap information for automatic segment space management (ASSM) segments but does not account for unformatted blocks under the high-water mark in ASSM segments.

Verifying Block Integrity in Real Time: DB_BLOCK_CHECKING

The DB_BLOCK_CHECKING initialization parameter:

- **Controls the degree of self-consistency checks performed on each block as it is processed**
- **Can prevent memory and data corruption**
- **Can be set by using the ALTER SESSION or ALTER SYSTEM DEFERRED command**



Verifying Block Integrity in Real Time: DB_BLOCK_CHECKING

When DB_BLOCK_CHECKING is set to TRUE, the Oracle database performs block checking for all data blocks. The Oracle database checks a block by reading the data on the block and making sure that it is self-consistent. Block checking can often prevent memory and data corruption. Block checking typically causes 1% to 10% overhead, depending on workload. The more updates or inserts being executed, the more expensive it is to turn on block checking. The four possible values for DB_BLOCK_CHECKING are:

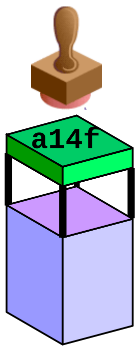
- **OFF:** No block checking is performed in any tablespaces except for SYSTEM.
- **LOW:** Basic block header checks are performed after block contents change in memory (for example, after UPDATE or INSERT statements, and on-disk reads).
- **MEDIUM:** All LOW checks, as well as block checking for all non-index-organized table blocks, are performed.
- **FULL:** All LOW and MEDIUM checks, as well as checks on index blocks, are performed.

You should set DB_BLOCK_CHECKING to FULL if the performance overhead is acceptable. The default value is FALSE, which, for backward compatibility, is equivalent to OFF. Even if this is turned off, block checking for the SYSTEM tablespace is always turned on.

Verifying Block Integrity in Real Time: DB_BLOCK_CHECKSUM

The DB_BLOCK_CHECKSUM initialization parameter:

- Determines whether a checksum is maintained and verified on each block
- Can prevent corruption caused by underlying I/O systems



Verifying Block Integrity in Real Time: DB_BLOCK_CHECKSUM

If DB_BLOCK_CHECKSUM is set to TRUE, the DBW*n* process and the direct loader calculate a checksum and store it in the cache header of every data block when writing it to disk. A checksum is a number calculated from all the bytes stored in the block. When the block is subsequently read, the checksum is recomputed and the stored value is checked with this computed value. Because checksums allow the database to detect corruption caused by underlying disks, storage systems, or I/O systems with only a 1% to 2% overhead, Oracle recommends that you set DB_BLOCK_CHECKSUM to TRUE, which is the default.

Using EXP to Detect Corruption

Conventional export can be used to detect corruption.

```
$ exp hr/hr tables=departments

About to export specified tables via Conventional Path
...
. . exporting table                    DEPARTMENTS
EXP-00056: ORACLE error 1578 encountered
ORA-01578: ORACLE data block corrupted (file # 5, block #
51)
ORA-01110: data file 5:
'/u01/app/oracle/oradata/orcl/example01.dbf'
```

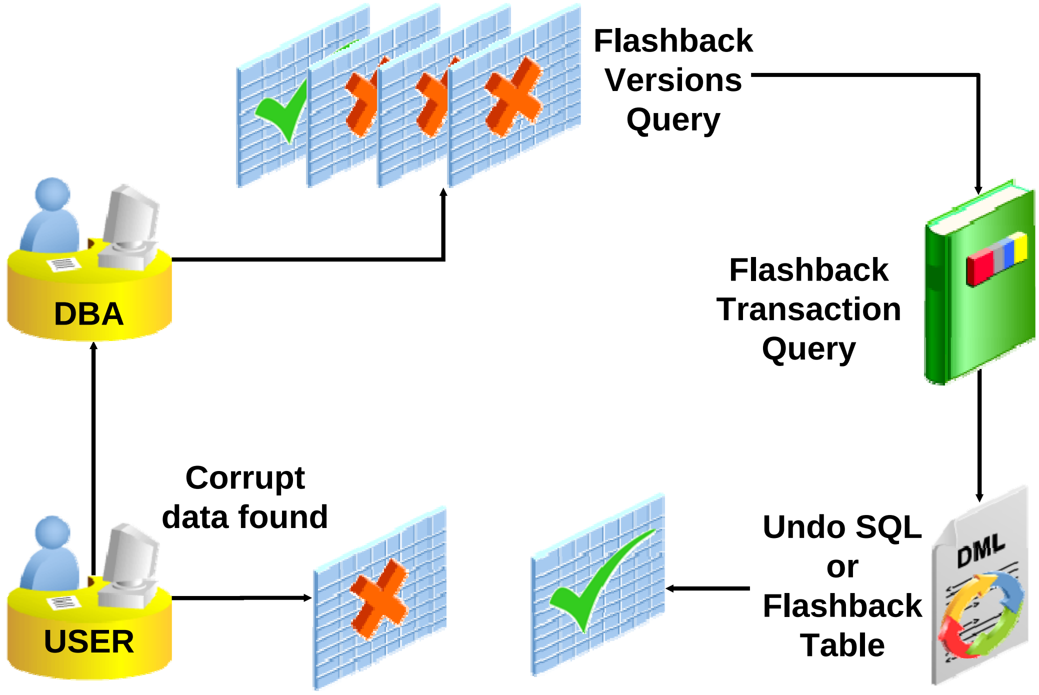
ORACLE

7-14

Using EXP to Detect Corruption

Another option for detecting block corruption is the export utility, or EXP. Because EXP fully scans every block of the object it is exporting, it reports an errors when it encounters corruption.

Using Flashback for Logical Corruption



Using Flashback for Logical Corruption

After a physical corruption has been ruled out, you can use a combination of the flashback features to determine when a logical corruption occurred. For example, you can first use Flashback Versions Query to view the values of a row over a period of time. Flashback Versions Query can also return the transaction ID. When you have the transaction ID, you can view all objects affected by the same transaction.

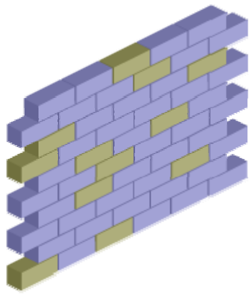
To undo the data corruption, you can use the information returned in the `UNDO_SQL` column to fix the error, or you can flash back the table to the time(SCN) before the transaction was issued.

Note: Details about performing a Flashback Versions Query are covered in the *Oracle Database 10g: Administration Workshop I* course.

DBMS_REPAIR Package

Available procedures

- CHECK_OBJECT
- FIX_CORRUPT_BLOCKS
- DUMP_ORPHAN_KEYS
- REBUILD_FREELISTS
- SEGMENT_FIX_STATUS
- SKIP_CORRUPT_BLOCKS
- ADMIN_TABLES



7-16

DBMS_REPAIR Package

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. The procedures contained in the package include:

- **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 (or logically) corrupt
- **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:** Ignores blocks marked corrupt during table and index scans. If not used, you get the ORA-01578 error when encountering blocks marked corrupt.
- **ADMIN_TABLES:** Provides administrative functions (create, drop, or purge) for repair of orphan key tables. These tables are always created in the SYS schema.

Note: Orphan keys are index entries that point to table rows that no longer exist.

Using DBMS_REPAIR

1. **Detect and report corruptions.**

```
SET SERVEROUTPUT ON
DECLARE num_corrupt INT;
BEGIN
 num_corrupt := 0;
 DBMS_REPAIR.CHECK_OBJECT (
   schema_name => 'HR',
   object_name => 'DEPARTMENTS',
   repair_table_name => 'REPAIR_TABLE',
   corrupt_count => num_corrupt);
END;
```

2. **Evaluate the costs and benefits of DBMS_REPAIR.**

Using DBMS_REPAIR

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. After using the options presented earlier in this lesson, you can consider using the DBMS_REPAIR package to correct the corruption. The CHECK_OBJECT procedure checks the specified objects, and populates a repair table with information about corruptions and repair directives. Before executing any of the DBMS_REPAIR procedures, you must build the repair table by using the ADMIN_TABLES procedure:

```
BEGIN
 DBMS_REPAIR.ADMIN_TABLES (
   table_name => 'REPAIR_TABLE',
   table_type => DBMS_REPAIR.REPAIR_TABLE,
   action => DBMS_REPAIR.CREATE_ACTION,
   tablespace => 'USERS');
END;
```

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.

Using DBMS_REPAIR (continued)

A first step is to answer the following questions:

- What is the extent of the corruption? To determine whether there are corruptions and repair actions, execute the CHECK_OBJECT procedure, and query the repair table.
- What are the other options that are available for addressing block corruptions?
- What logical corruptions or side effects are introduced when using DBMS_REPAIR to make an object usable? Can these be addressed satisfactorily?
- 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. The following 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;
```

Using DBMS_REPAIR

3. Make objects usable.

```
SET SERVEROUTPUT ON
DECLARE num_fix INT;
BEGIN
 num_fix := 0;
 DBMS_REPAIR.FIX_CORRUPT_BLOCKS (
   schema_name => 'HR',
   object_name => 'DEPARTMENTS',
   object_type => DBMS_REPAIR.TABLE_OBJECT,
   repair_table_name => 'REPAIR_TABLE',
   fix_count => num_fix);
END;
```


Using DBMS_REPAIR (continued)

DBMS_REPAIR makes the object usable by ignoring corruptions during table and index scans. By using the FIX_CORRUPT_BLOCKS and SKIP_CORRUPT_BLOCKS procedures, you can make a corrupt object usable by establishing an environment that skips corruptions that remain outside the scope of repair capabilities of DBMS_REPAIR.

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. You can see whether this is currently in effect for a table by viewing the SKIP_CORRUPT column of the DBA_TABLES data dictionary view.

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.

Using DBMS_REPAIR

4. Repair corruptions and rebuild lost data.

```
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;
```

7-20

Using DBMS_REPAIR (continued)

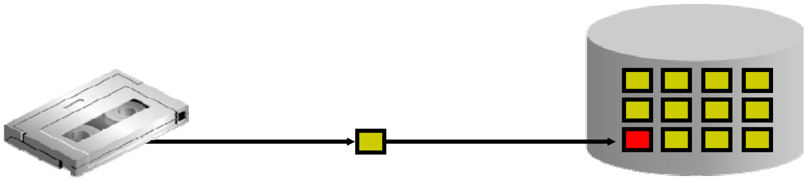
After making an object usable, you can recover data by using the DUMP_ORPHAN_KEYS procedure. This procedure reports on index entries that point to rows in corrupt data blocks. All such index entries are inserted into an orphan key table that stores the key and row ID of the corruption. The orphan key table must have been previously created.

After the index entry information has been retrieved, you can rebuild the index by using the ALTER INDEX ... REBUILD ONLINE statement.

Block Media Recovery (BMR)

Block media recovery:

- **Lowers the mean time to recover (MTTR)**
- **Increases availability during media recovery**
  - **The data file remains online during recovery.**
  - **Only blocks being recovered are inaccessible.**
- **Is invoked through RMAN via the `BLOCKRECOVER` command.**
  - **Restores individual blocks from available backups**
  - **Coordinates with the server to have them recovered**



ORACLE

7-21

Block Media Recovery (BMR)

BMR reduces the smallest recoverable unit of media recovery from a data file to a block. When a small number of blocks in the database are known to require media recovery, it is more efficient to selectively restore and recover just those blocks. Only blocks that are being recovered need to be unavailable, allowing continuous availability of the rest of the database during recovery.

BMR provides two main benefits over file-level recovery:

- Lowers the mean time to recover (MTTR)
- Allows increased availability of data during media recovery because the data file that is being recovered remains online

BMR uses existing recovery mechanisms to apply changes from the redo stream to versions of blocks that are restored from suitable backups. RMAN must be used to perform BMR. RMAN restores individual data blocks from available backups and coordinates with the Oracle server process to have them recovered. Without block-level recovery, if even a single block is corrupt, the entire file must be restored and all redo data must be applied to that file. The reduction in MTTR that is realized by using block-level recovery includes both restore and recovery time. Note that only complete recovery is possible. Incomplete recovery would render the database logically inconsistent.

BLOCKRECOVER Command

The RMAN BLOCKRECOVER command:

- Identifies the backups containing the blocks to recover
- Reads the backups and accumulates requested blocks into in-memory buffers
- Manages the block media recovery session by reading the archive logs from backup if necessary
- Cannot be used for incomplete recovery

```
RMAN> BLOCKRECOVER DATAFILE 6 BLOCK 3;
```

7-22

BLOCKRECOVER Command

RMAN supports BMR by means of the `BLOCKRECOVER` command. When the user encounters block corruption, the error message, alert log, and trace files indicate which block is causing problems. The DBA can then invoke this command to restore only the block in question, thus saving an enormous amount of down time and data unavailability.

The `BLOCKRECOVER` command does the following:

- Identifies the backups from which to obtain the blocks to recover
- Reads the backups and accumulates requested blocks into in-memory buffers. If any of the desired blocks are corrupt (either media or logical corruption), RMAN reads the next oldest backup of that file, looking for a good copy of the block. The `UNTIL` option limits selection to backup sets or file copies that are taken at or before the specified time, SCN, or log sequence; this forces `BLOCKRECOVER` to use an older backup instead of the most recent one.
- Starts and manages the block media recovery session, reading the archive logs from backup if necessary
- Always does a complete recovery. No point-in-time recovery is possible by using the `BLOCKRECOVER` command.

Examples of Using BLOCKRECOVER

- Recovering a group of corrupt blocks
- Limiting block media recovery by type of restore
- Limiting block media recovery by backup tag
- Limiting block media recovery by time, SCN, or log sequence

Examples of Using BLOCKRECOVER

- Recovering a group of corrupt blocks
```
BLOCKRECOVER DATAFILE 2 BLOCK 12, 13
DATAFILE 7 BLOCK 5, 98, 99 DATAFILE 9 BLOCK 19;
```
- This example recovers a series of blocks and restores only from data file copies:
```
{
  BLOCKRECOVER DATAFILE 3 BLOCK 1,2,3,4,5
  TABLESPACE sales DBA 4194405, 4194409, 4194412
  FROM DATAFILE COPY;
}
```
  Note: DBA is data block address.
- Limiting BMR by backup tag:
```
BLOCKRECOVER TABLESPACE SYSTEM DBA 4194404, 4194405
FROM TAG "weekly_backup";
```
- The following example recovers two blocks in the `SYSTEM` tablespace and forces the blocks to be restored from backups that were created at least two days ago:
```
BLOCKRECOVER TABLESPACE SYSTEM DBA 4194404, 4194405 RESTORE
UNTIL TIME 'SYSDATE-2';
```

Examples of Using `BLOCKRECOVER` (continued)

- The following example recovers two blocks and forces the blocks to be restored by using backups that were made before SCN 100:
```
BLOCKRECOVER DATAFILE 9 BLOCK 13 DATAFILE 2 BLOCK 19 RESTORE
UNTIL SCN 100;
```
- The following example recovers two blocks and forces the blocks to be restored by using backups that were made before log sequence 7024:
```
BLOCKRECOVER DATAFILE 9 BLOCK 13 DATAFILE 2 BLOCK 19 RESTORE
UNTIL SEQUENCE 7024;
```

The RMAN BMR Interface

Dynamic views show the current state of corruption.

- **The `V$DATABASE_BLOCK_CORRUPTION` view shows the list of currently corrupted database blocks.**

```
RMAN> BLOCKRECOVER CORRUPTION LIST
   2> RESTORE UNTIL TIME 'sysdate – 10';
```

- **The `V$BACKUP_CORRUPTION` view shows the list of corrupted blocks in data file backups.**
- **The `V$COPY_CORRUPTION` view shows the list of corrupted blocks in image file copies.**

The RMAN BMR Interface

By using the `CORRUPTION LIST` clause, you can recover blocks that are listed in `V$DATABASE_BLOCK_CORRUPTION`. This view is populated during a backup operation, as corrupt blocks are encountered. If the backup encounters more than the tolerated number of corrupt blocks, then the view is not populated at all. You should then run the `BACKUP…VALIDATE` command to fully populate this view with a record of all corrupt blocks.

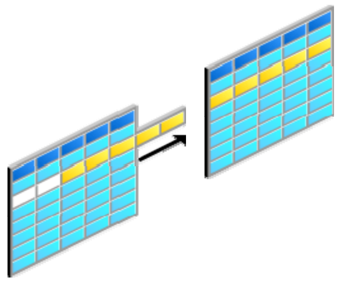
After a block has been repaired through block media recovery (or normal media recovery), `V$DATABASE_BLOCK_CORRUPTION` is not updated until you take a new backup. The `UNTIL` clause specifies that only backups and copies that are created before the specified time, SCN, or log sequence number should be restored and used for the recovery. RMAN will still recover fully to the present time.

Two types of corruption result in rows that are being added to `V$BACKUP_CORRUPTION` and `V$COPY_CORRUPTION` by the `BACKUP` and `COPY` commands, respectively:

- **Physical corruption (sometimes called media corruption):** The Oracle server does not recognize the block at all: the checksum is invalid, the block contains all zeros, or the header and footer of the block do not match. Physical corruption checking is `ON` by default, and can be turned off with the `NOCHECKSUM` option.
- **Logical corruption:** The block has a valid checksum, the header and footer match, and so forth, but the contents are logically inconsistent. Logical checking is `OFF` by default, and can be turned on with the `CHECK LOGICAL` option.

Alternative Actions to Take

- **Table: The data in the corrupted block is lost.**
  - **Drop the table and re-create it, and import data from an export dump.**
  - **Use SQL or PL/SQL to pull data out of the table into a newly created table.**
- **Index: Drop and re-create the index.**



ORACLE

Alternative Actions to Take

If you do not plan to restore data files and recover, use the following statement to determine which object has corrupted blocks.

The absolute file number (for example, 5) and block number (for example, 2) can be found in the error message; for example:

```
ORA-01578: ORACLE data block corrupted (file #5, block # 2)
```

Run the following command:

```
SQL> SELECT segment_name, segment_type, relative_fno
  2  FROM dba_extents
  3  WHERE  file_id = 5
  4  AND 2 BETWEEN block_id AND block_id + blocks - 1;
 SEGMENT_NAME     SEGMENT_TYPE     RELATIVE_FNO
 --------------   ---------------  ------------
 EXAMPLE          TABLE PARTITION             5
```

After you determine which object is corrupted, there are other options available to you for recovering from it. For a table, you can use an export dump file. You can also use SQL to generate a good table from the corrupted one. This may require knowledge of the business data. If you have a corrupted index, it may be most efficient to simply drop and re-create the index.

Summary

In this lesson, you should have learned how to:

- Identify the causes of database corruption:
  - Hardware
  - Software
- Detect database corruption by using:
  - `ANALYZE`
  - `dbverify`
  - `DB_BLOCK_CHECKING`
  - `DBMS_REPAIR`
- Repair corruptions by using RMAN

Practice Overview: Perform Block Media Recovery

This practice covers the following topics:

- Discovering corruption
- Identifying the location of the corruption
- Recovering from the corruption by using block media recovery

8

Monitoring and Managing Memory

Objectives

After completing this lesson, you should be able to:

- Describe the memory components in the SGA
- Implement Automatic Shared Memory Management
- Manually configure SGA parameters
- Configure automatic PGA memory management

Memory Management: Overview

DBAs must consider memory management to be a crucial part of their job because:

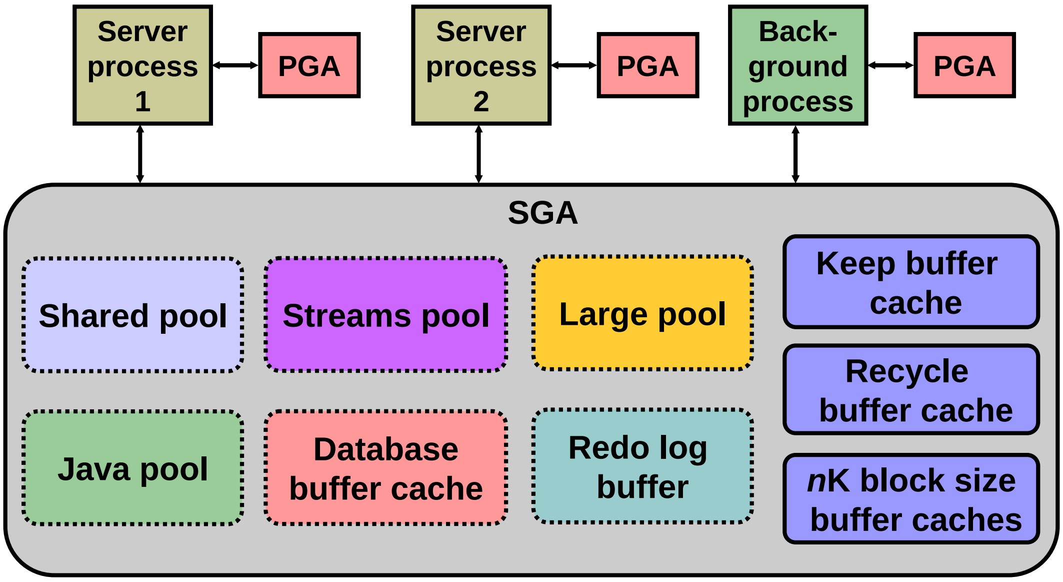
- **There is a finite amount of memory available**
- **Allocating more memory to serve certain types of functions can improve overall performance**
- **Automatically tuned memory allocation is often the appropriate configuration, but specific environments or even short-term conditions may require further attention**

Memory Management: Overview

Because there is a finite amount of memory available on a database server and thus, on an Oracle database instance, you must pay attention to how memory is allocated. If too much memory is allowed to be used by a particular area that does not need it, then there is the possibility that there are other functional areas unnecessarily doing without enough memory to perform optimally. With the ability to have memory allocation automatically determined and maintained for you, the task is simplified greatly. But even automatically tuned memory needs to be monitored for optimization and may need to be manually configured to some extent.

Beyond the introduction to memory tuning presented in the *Oracle Database 10g: Administration Workshop I* course, this lesson describes how automatic memory tuning works, when to do manual tuning, what the Program Global Area (PGA) is, and details of each of the memory structures in an Oracle instance.

Oracle Memory Structures



Oracle Memory Structures

The basic memory structures associated with an Oracle instance include:

- **System Global Area (SGA):** Shared by all server and background processes
- **Program Global Area (PGA):** Private to each server and background process; there is one PGA for each process

The System Global Area (SGA) is a shared memory area that contains data and control information for the instance, including the following:

- **Database buffer cache:** Caches blocks of data retrieved from disk
- **Redo log buffer:** Caches redo information until it can be written to disk
- **Shared pool:** Caches various constructs that can be shared among users
- **Large pool:** Optional area used for buffering large I/O requests in support of parallel query, shared server, Oracle XA, and certain types of backup operations
- **Java pool:** Holds session-specific Java code and data within the Java Virtual Machine (JVM)
- **Streams pool:** Used by Oracle Streams
- **Keep buffer cache:** Holds data that is kept in the buffer cache as long as possible
- **Recycle buffer cache:** Holds data that is quickly aged out of the buffer cache
- ***n*K block size buffer caches:** Caches data blocks that are of a different size than the default database block size; used to support transportable tablespaces

Oracle Memory Structures (continued)

The size of the database buffer cache, shared pool, large pool, streams pool, and Java pool can be adjusted automatically to meet present needs. Also, those memory buffers, along with the keep buffer cache, the recycle buffer cache, and the *n*K block size buffer caches, can be changed without shutting down the instance.

The preconfigured database has been pretuned with adequate settings for the memory parameters. However, as your database usage expands, you may find it necessary to alter the settings of the memory parameters.

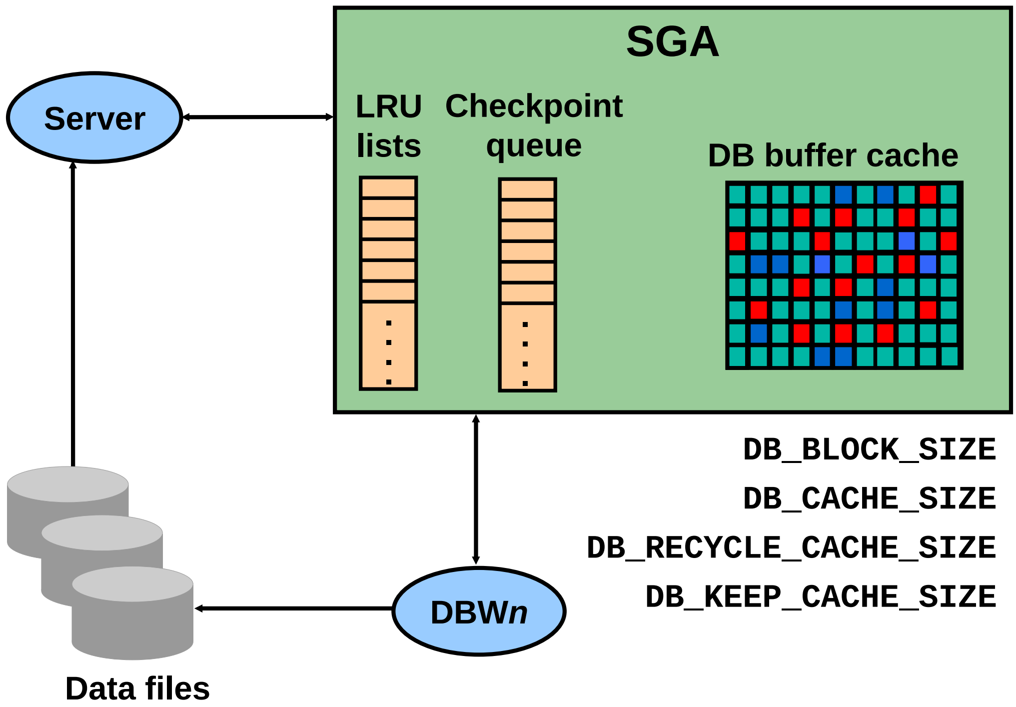
The Oracle database provides alerts and advisors to identify memory-sizing problems and to help you determine appropriate values for memory parameters.

A Program Global Area (PGA) is a memory region that contains data and control information for each server process. A server process is a process that services a client’s requests. Each server process has its own private PGA that is created when the server process is started. Access to it is exclusive to that server process.

The amount of PGA memory used and the contents of the PGA depend on whether the instance is configured in shared server mode. Generally, the PGA contains the following:

- **Private SQL area:** Contains data such as bind information and run-time memory structures. Each session that issues a SQL statement has a private SQL area.
- **Session memory:** Memory allocated to hold session variables and other information related to the session

Buffer Cache



Buffer Cache

You can configure the buffer cache by specifying a value for the `DB_CACHE_SIZE` parameter. The buffer cache holds copies of the data blocks from the data files having block size of `DB_BLOCK_SIZE`. The buffer cache is a part of the SGA; so all users can share these blocks. The server processes read data from the data files into the buffer cache. To improve performance, the server process sometimes reads multiple blocks in a single read operation. The `DBWn` process writes data from the buffer cache into the data files. To improve performance, `DBWn` writes multiple blocks in a single write operation.

At any given time, the buffer cache may hold multiple copies of a single database block. Only one current copy of the block exists, but to satisfy queries, server processes may need to construct read-consistent copies from past image information. This is called a consistent read (CR) block.

The least recently used (LRU) list monitors the usage of buffers. The buffers are sorted on the basis of a combination of how recently and how often they have been referenced. Thus, buffers that are most frequently and recently used are found at the most recently used end. Incoming blocks are copied to a buffer from the least recently used end, which is then assigned to the middle of the list, as a starting point. From here, the buffer works its way up or down the list, depending on usage.

Buffer Cache (continued)

Buffers in the buffer cache can be in one of four states:

- **Pinned:** The block is either currently being read into the cache or being written to. Other sessions wait to access the block.
- **Clean:** The buffer is now unpinned and is a candidate for immediate aging out if the current contents (data block) are not referenced again. Either the contents are in sync with disk or the buffer contains a CR snapshot of a block.
- **Free/unused:** The buffer is empty because the instance just started. This state is very similar to the clean state, except that the buffer has not been used.
- **Dirty:** The buffer is no longer pinned but the contents (data block) have changed and must be flushed to disk by `DBWn` before it can be aged out.

Server processes use the buffers in the buffer cache, but the `DBWn` process makes buffers in the cache available by writing changed buffers back to the data files. The checkpoint queue lists the buffers that are to be written out to disk.

Then Oracle database supports multiple block sizes in the same database. The standard block size is used for the `SYSTEM` tablespace. You specify the standard block size by setting the initialization parameter `DB_BLOCK_SIZE`. Legitimate values are from 2K to 32K, and the default is 8K. The cache sizes of nonstandard block size buffers are specified by the following parameters:

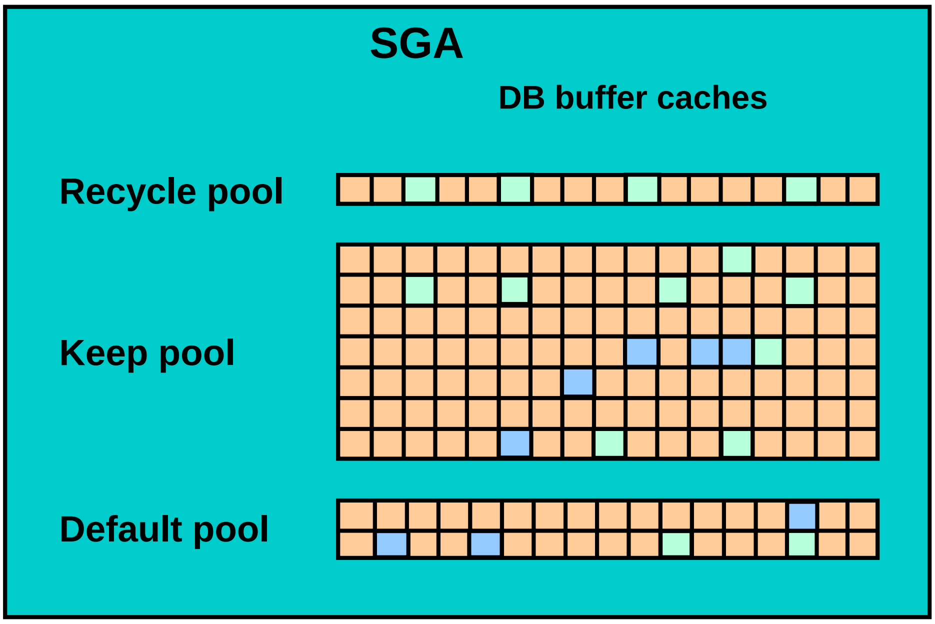
- `DB_2K_CACHE_SIZE`
- `DB_4K_CACHE_SIZE`
- `DB_8K_CACHE_SIZE`
- `DB_16K_CACHE_SIZE`
- `DB_32K_CACHE_SIZE`

The `DB_nK_CACHE_SIZE` parameters cannot be used to size the cache for the standard block size. If the value of `DB_BLOCK_SIZE` is `nK`, it is illegal to set `DB_nK_CACHE_SIZE`. The size of the cache for the standard block size is always determined from the value of `DB_CACHE_SIZE`.

Each buffer cache has a limited size, so typically not all the data on disk can fit in the cache. When the cache is full, subsequent cache misses cause the Oracle database to write dirty data already in the cache to disk to make room for the new data. (If a buffer is not dirty, it does not need to be written to disk before a new block can be read into the buffer.) Subsequent access to any data that was written to disk results in additional cache misses.

The size of the cache affects the likelihood that a request for data will result in a cache hit. If the cache is large, it is more likely to contain the data that is requested. Increasing the size of a cache increases the percentage of data requests that result in cache hits.

Using Multiple Buffer Pools



Using Multiple Buffer Pools

The database administrator (DBA) may be able to improve the performance of the database buffer cache by creating multiple buffer pools. You assign objects to a buffer pool depending on how the objects are accessed. There are three buffer pools:

- **Keep:** This pool is used to retain objects in memory that are likely to be reused. Keeping these objects in memory reduces I/O operations. Buffers are kept in this pool by ensuring that the pool is sized larger than the total size of the segments assigned to the pool. This means that buffers do not have to be aged out. The keep pool is configured by specifying a value for the `DB_KEEP_CACHE_SIZE` parameter.
- **Recycle:** This pool is used for blocks in memory that have little chance of being reused. The recycle pool is sized smaller than the total size of the segments assigned to the pool. This means that blocks read into the pool will often have to age out a buffer. The recycle pool is configured by specifying a value for the `DB_RECYCLE_CACHE_SIZE` parameter.
- **Default:** This pool always exists. It is equivalent to the buffer cache of an instance without a keep or a recycle pool and is configured with the `DB_CACHE_SIZE` parameter.

Note: The memory in the keep or recycle pool is not a subset of the default buffer pool.

Using Multiple Buffer Pools

```
CREATE INDEX cust_idx …
  STORAGE (BUFFER_POOL KEEP …);

ALTER TABLE oe.customers
  STORAGE (BUFFER_POOL RECYCLE);

ALTER INDEX oe.cust_lname_ix
  STORAGE (BUFFER_POOL KEEP);
```

8-9

Using Multiple Buffer Pools (continued)

The `BUFFER_POOL` clause is used to define the default buffer pool for an object. It is part of the `STORAGE` clause and is valid for `CREATE` and `ALTER` table, cluster, and index statements. The blocks from an object without an explicitly set buffer pool go into the default buffer pool.

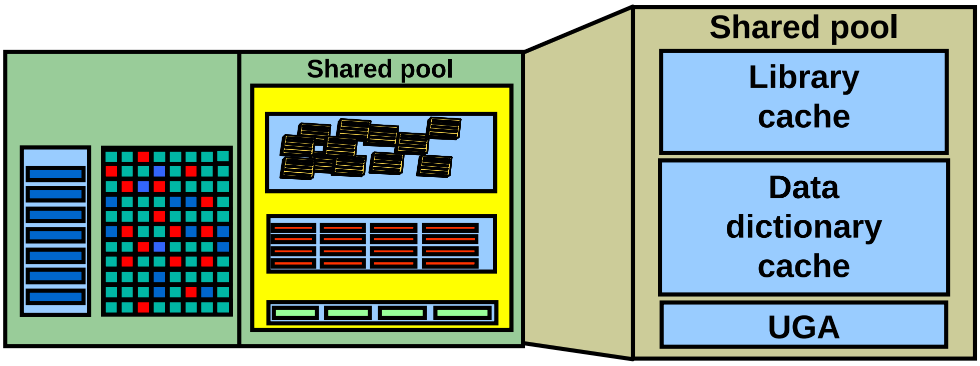
The syntax is `BUFFER_POOL [KEEP | RECYCLE | DEFAULT]`.

When the default buffer pool of an object is changed using the `ALTER` statement, blocks that are already cached remain in their current buffers until they are flushed out by the normal cache management activity. Blocks read from disk are placed into the newly specified buffer pool for the segment.

Because buffer pools are assigned to a segment, objects with multiple segments can have blocks in multiple buffer pools. For example, an index-organized table can have different pools defined on both the index and the overflow segment.

Shared Pool

- Size is specified by using `SHARED_POOL_SIZE`.
- Library cache contains statement text, parsed code, and execution plan.
- Data dictionary cache contains definitions for tables, columns, and privileges from the data dictionary tables.
- The User Global Area (UGA) contains session information if using Oracle shared server.



8-10

Shared Pool

You can specify the size of the shared pool with the `SHARED_POOL_SIZE` initialization parameter. The shared pool is a memory area that stores information shared by multiple sessions. It contains different types of data, as shown in the graphic in the slide.

Library Cache

The library cache contains shared SQL and PL/SQL areas—the fully parsed or compiled representations of PL/SQL blocks and SQL statements.

PL/SQL blocks include:

- Procedures and functions
- Packages
- Triggers
- Anonymous PL/SQL blocks

Data Dictionary Cache

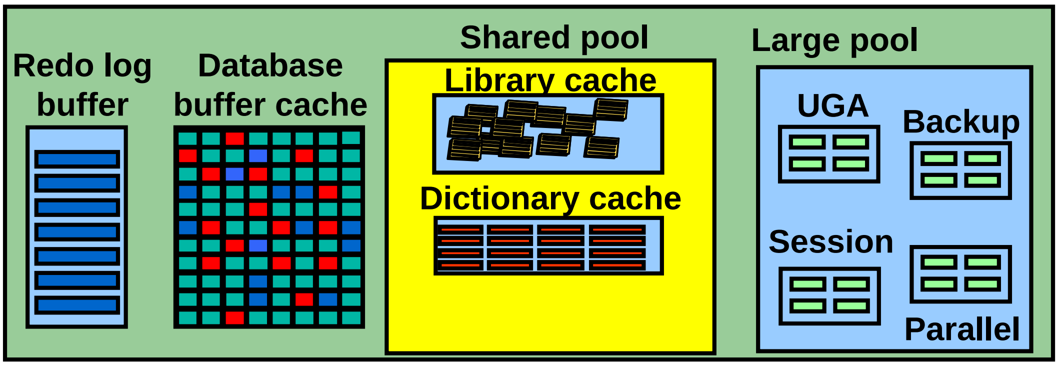
The data dictionary cache holds definitions of dictionary objects in memory.

User Global Area

The UGA contains the session information for the Oracle shared server. The UGA is located in the shared pool when using a shared server session and if the large pool is not configured.

Large Pool

- Can be configured as a separate memory area in the SGA
- Is sized by the `LARGE_POOL_SIZE` parameter
- Is used to store data in memory for:
  - UGA
  - Backup and restore operations
  - Session data for the shared servers
  - Parallel query messaging



Large Pool

Existence of the Large Pool

The large pool must be explicitly configured. The memory of the large pool does not come out of the shared pool, but directly out of the SGA, thus adding to the amount of shared memory that the Oracle server needs for an instance at startup.

Advantages of the Large Pool

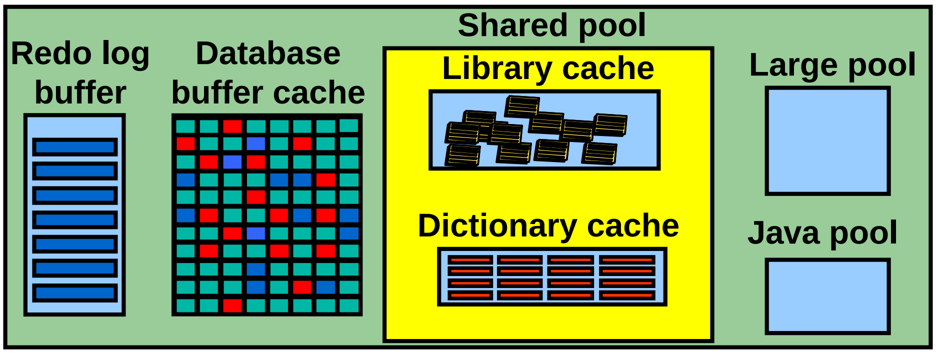
The large pool is used to provide large allocations of session memory for:

- I/O server processes
- Backup and restore operations
- Oracle shared server processes and the Oracle XA interface (used where transactions interact with more than one database)

By allocating session memory from the large pool for the Oracle shared server, the shared pool has less fragmentation that would come from having large objects frequently allocated and deallocated in it. Segregating large objects out of the shared pool results in more efficient shared pool usage, which means more of its memory is available to service new requests, and to retain existing data if needed.

Java Pool

- Can be configured as a separate memory area in the SGA
- Is sized by the `JAVA_POOL_SIZE` parameter
- Is used to store data in memory for all session-specific Java code and data within the JVM



Java Pool

The Java pool is a structure in the SGA that is used for all session-specific Java code and data within the Java engine.

Shared Pool

Shared pool memory is used by the class loader within the JVM. The class loader uses about 8 KB of memory per loaded class. The shared pool is also used when compiling Java source code in the database or when using Java resource objects in the database. Shared pool memory is also consumed when you create call specifications and as the system tracks dynamically loaded Java classes at run time.

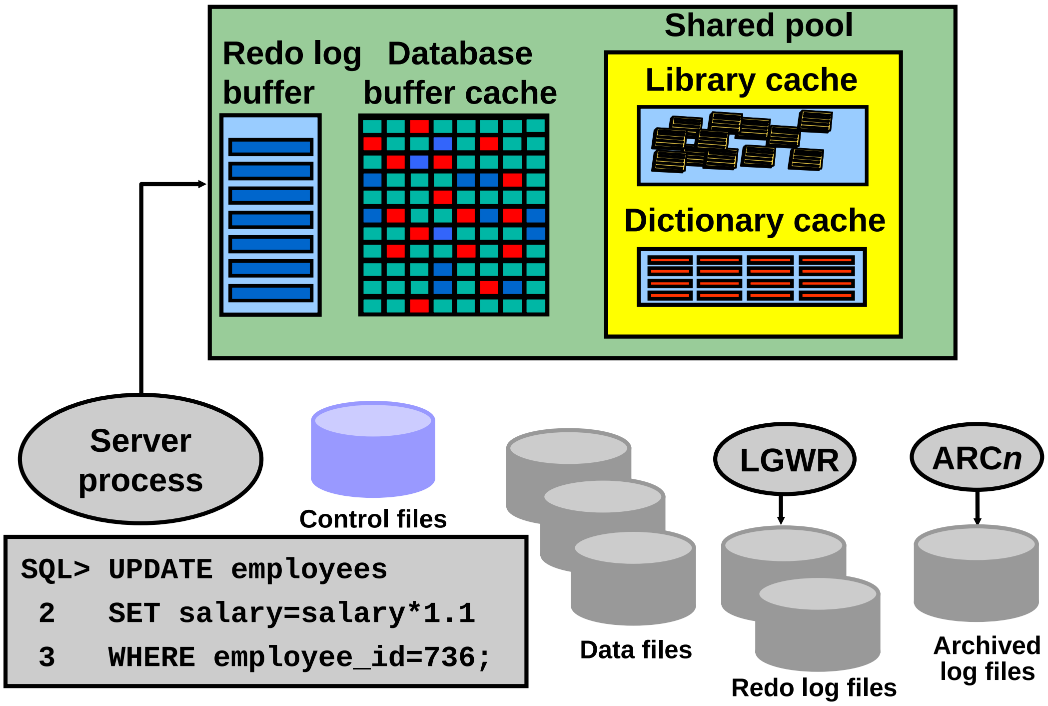
Java Pool

The OracleJVM memory manager allocates all other Java states during run-time execution from the Java pool, including the shared in-memory representation of Java method and class definitions, as well as the Java objects migrated to session space at end-of-call.

Java pool memory is used in different ways, depending on whether the Oracle database server is using shared servers or not.

For more information about Java pool memory usage, refer to the *Oracle Database Java Developer's Guide*.

Redo Log Buffer



Redo Log Buffer

The Oracle server processes copy redo entries from the user's memory space to the redo log buffer for each DML or DDL statement. The redo entries contain the information necessary to reconstruct or redo changes made to the database by DML and DDL operations. They are used for database recovery and take up continuous sequential space in the buffer.

The redo log buffer is a circular buffer; the server processes can copy new entries over the entries in the redo log buffer that have already been written to disk. The LGWR process normally writes fast enough to ensure that space is always available in the buffer for new entries. The LGWR process writes the redo log buffer to the active online redo log file (or members of the active group) on disk. The LGWR process copies to disk all redo entries that have been entered into the buffer since the last time LGWR wrote to disk.

What Causes LGWR to Write?

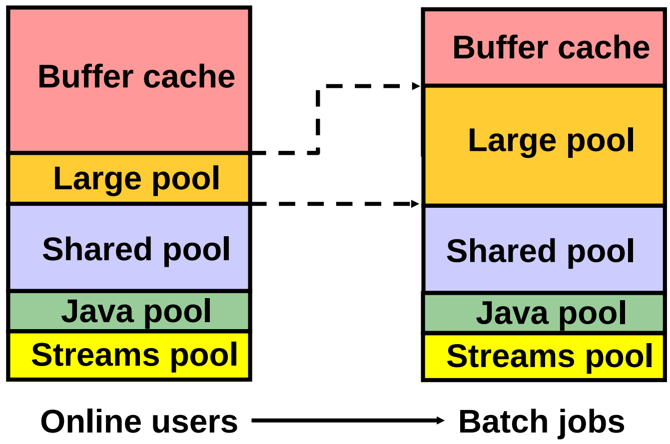
LGWR writes out the redo data from the redo log buffer:

- When a user process commits a transaction
- Every three seconds or when the redo log buffer is one-third full or contains at least 1 MB of data
- When a `DBWn` process writes modified buffers to disk, if the corresponding redo log data has not already been written to disk

Automatic Shared Memory Management: Overview

- Automatically adapts to workload changes
- Maximizes memory utilization
- Helps eliminate out-of-memory errors

Example:



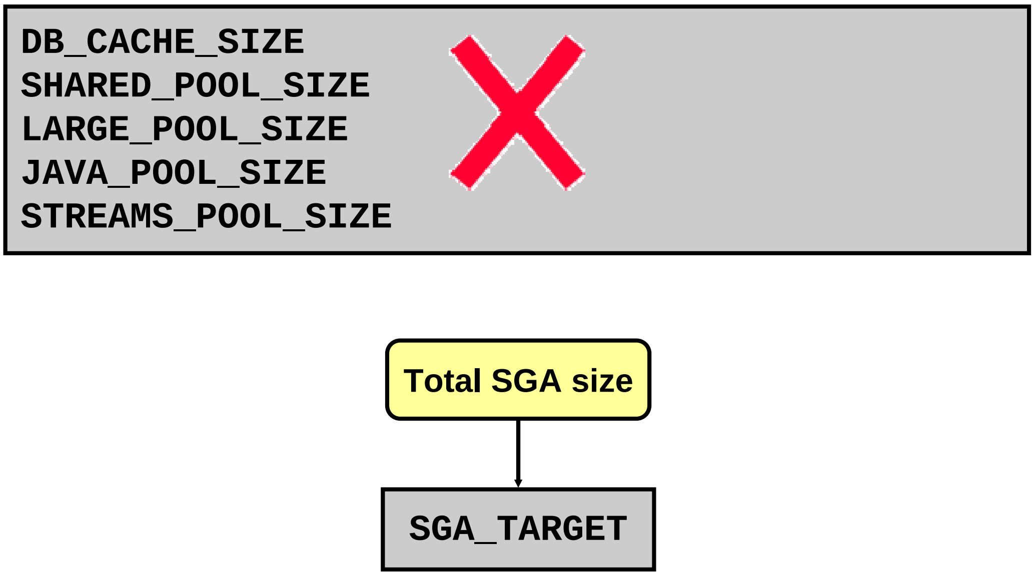
Automatic Shared Memory Management: Overview

Automatic Shared Memory Management (ASMM) is another key self-management enhancement in the Oracle database. This functionality automates the management of the most important shared memory structures used by an Oracle database instance, and relieves you of having to configure these components manually. Besides making more effective use of available memory and thereby reducing the cost incurred for acquiring additional hardware memory resources, the ASMM feature significantly simplifies Oracle database administration by introducing a more dynamic, flexible, and adaptive memory management scheme.

For example, in a system that runs large online transactional processing (OLTP) jobs during the day (requiring a large buffer cache) and runs parallel batch jobs at night (requiring a large value for the large pool), you would have to simultaneously configure both the buffer cache and the large pool to accommodate your peak requirements.

With ASMM, when the OLTP job runs, the buffer cache grabs most of the memory to allow for good I/O performance. When the data analysis and reporting batch job starts up later, the memory is automatically migrated to the large pool so that it can be used by parallel query operations without producing memory overflow errors.

Benefits of Automatic Shared Memory Management



ORACLE

8-15

Benefits of Automatic Shared Memory Management

Automatic Shared Memory Management simplifies the configuration of the System Global Area (SGA). In the past, you needed to manually specify the amount of memory to be allocated for the database buffer cache, shared pool, Java pool, large pool, and Streams pool. It is often a challenge to size these components optimally. Undersizing can lead to poor performance and out-of-memory errors (`ORA-4031`), whereas oversizing can waste memory.

This feature enables you to specify a total memory amount to be used for all SGA components. The Oracle database periodically redistributes memory between the components in the slide according to workload requirements.

In earlier releases, you did not have exact control over the total size of the SGA because memory was allocated for the fixed SGA and for other internal metadata allocations over and above the total size of the user-specified SGA parameters. This additional memory was usually between 10 and 20 MB.

The SGA size initialization parameter (`SGA_TARGET`) includes all memory in the SGA, including the automatically sized components, the manually sized components, and any internal allocations during startup.

How ASMM Works

- ASSM is based on workload information that `MMAN` captures in the background.
- `MMAN` uses memory advisors.
- Memory is moved to where it is needed the most.
- If an SPFILE is used (which is recommended):
  - Component sizes are saved across shutdowns.
  - Saved values are used to bootstrap component sizes.
  - There is no need to relearn optimal values.

8-16

How ASMM Works

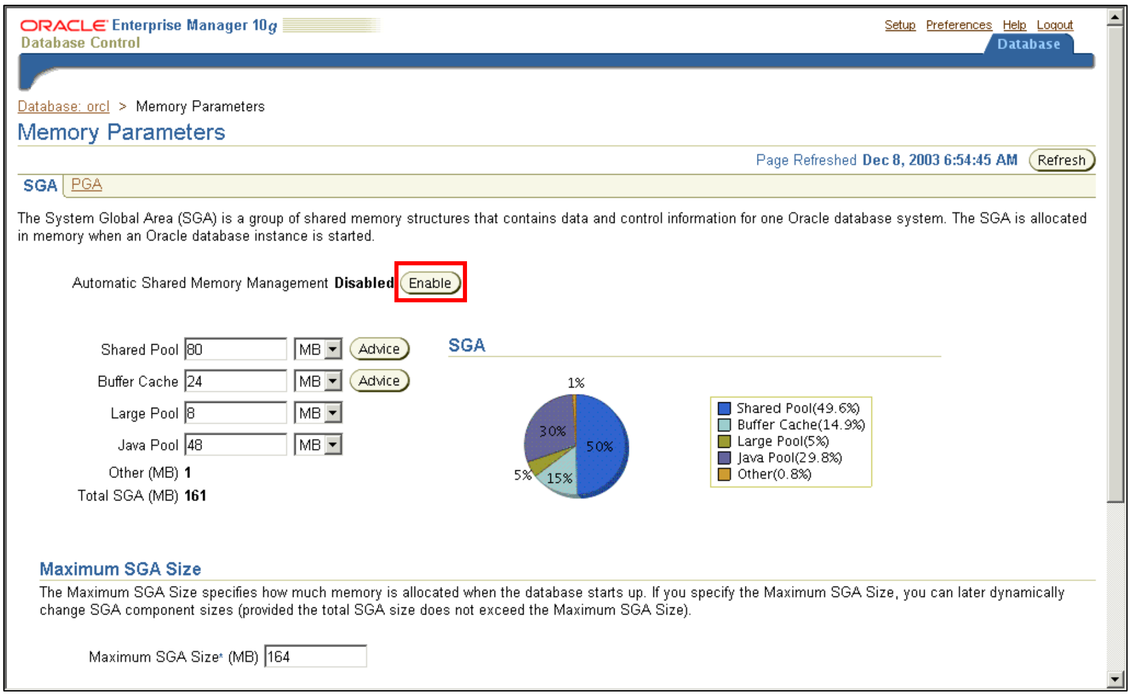
The Automatic Shared Memory Management feature uses a background process named Memory Manager (`MMAN`). `MMAN` serves as the SGA memory broker and coordinates the sizing of the memory components. The SGA memory broker keeps track of the sizes of the components and pending resize operations.

The SGA memory broker observes the system and workload in order to determine the ideal distribution of memory. It is never complacent and performs this check every few minutes so that memory can always be present where needed. In the absence of Automatic Shared Memory Management, components had to be sized to anticipate their individual worst-case memory requirements.

On the basis of workload information, Automatic Shared Memory Management:

- Captures statistics periodically in the background
- Uses memory advisors
- Performs what-if analysis to determine the best distribution of the memory
- Moves memory to where it is most needed
- Saves component sizes across shutdown if an SPFILE is used (the sizes can be resurrected from before the last shutdown)

Configuring ASMM by Using Database Control



8-17

Configuring ASMM by Using Database Control

To configure Automatic Shared Memory Management by using Database Control, perform the following steps:

1. Click the Administration tab.
2. Select Memory Parameters under the Instance heading.
3. Click the SGA tab.
4. Click the Enable button for Automatic Shared Memory Management, and then enter the total SGA size (in MB).

When you use Database Control to enable ASMM, statements to change the autotuned parameters are automatically issued. All of these parameters, except for `DB_CACHE_SIZE`, are set to zero to indicate that they have no minimum size. `DB_CACHE_SIZE` is set to 4 MB in order to define a minimum such that enough of the `SYSTEM` tablespace can be resident in memory. Without these changes, the previously set values would be interpreted as (relatively high) minimum sizes, most likely putting an unnecessary burden on the memory-sizing algorithm.

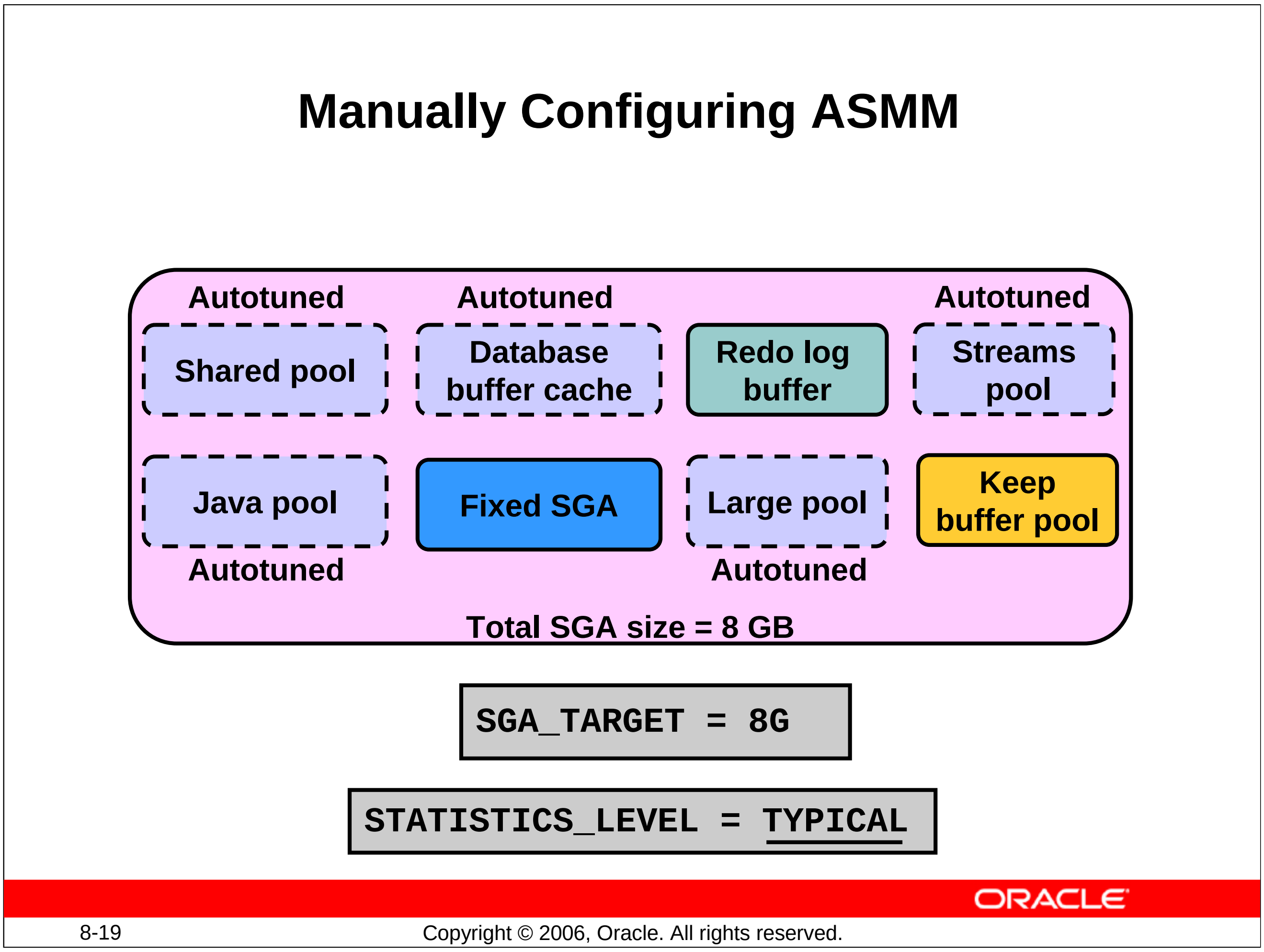
Note: When you click Enable, you can enter a value for `SGA_TARGET`.

Manually Configuring ASMM

To have minimum sizes for some of the memory components, you should manually configure those component sizes:

- If the automatically computed sizes do not serve your purpose for some reason
- If there are short peaks or valleys in required memory that are not detected by ASMM
- If you simply want a guaranteed minimum amount of memory for a specific component

ORACLE



Manually Configuring ASMM

You can manually configure Automatic Shared Memory Management by using the SGA_TARGET initialization parameter. By default, SGA_TARGET is set to 0, which means that Automatic Shared Memory Management is disabled and you must manually configure the database memory.

Manually Configuring ASMM (continued)

If you specify a nonzero value for SGA_TARGET, the following five memory pools are automatically sized: database buffer cache (default pool), shared pool, large pool, Streams pool, and the Java pool.

The parameters used to configure these memory pools (for example, SHARED_POOL_SIZE) are referred to as autotuned parameters.

The following buffers are referred to as manually sized components:

- Log buffer
- Other buffer caches (KEEP/RECYCLE, nondefault block size)
- Fixed SGA and other internal allocations

Note: Automatic Shared Memory Management requires that STATISTICS_LEVEL be set to TYPICAL or ALL.

Behavior of Autotuned SGA Parameters

- When SGA_TARGET is not set or is set to zero:
  - Autotuned parameters behave as normal
  - SHARED_POOL_SIZE may need to be increased from settings used in earlier database versions

```
SELECT SUM(bytes)/1024/1024 size_mb
FROM   v$sgastat WHERE pool = 'shared pool';
```

- When SGA_TARGET is set to a nonzero value:
  - Default value of autotuned parameters is zero
  - The specified value is used as a minimum size

```
SELECT component, current_size/1024/1024 size_mb
FROM   v$sga_dynamic_components;
```

8-21

Behavior of Autotuned SGA Parameters

When SGA_TARGET is not set or is equal to zero, autotuned SGA parameters behave as normal: They specify the actual size of those components.

When Automatic Shared Memory Management is enabled, you can still specify values for the autotuned SGA parameters, but the values carry a different meaning. If you set any of the autotuned parameters to a nonzero value, the specified value is used as a lower bound by the autotuning algorithm. For example, if SGA_TARGET is set to 8 GB and SHARED_POOL_SIZE is set to 1 GB, the Automatic Shared Memory Management algorithm does not shrink the shared pool to below 1 GB. Use the second query given in the slide to determine the actual size of the autotuned components in the SGA.

Behavior of Manually Tuned SGA Parameters

- Some components are not autotuned.
  - KEEP and RECYCLE buffer caches
  - Multiple block size caches
  - Log buffer
- These components must be manually configured using database parameters.
- The memory used by these components reduces the amount of memory available for autotuning the SGA.

8-22

Behavior of Manually Tuned SGA Parameters

The manually tuned SGA parameters are:

- `DB_KEEP_CACHE_SIZE`
- `DB_RECYCLE_CACHE_SIZE`
- `DB_nK_CACHE_SIZE` (*n* = 2, 4, 8, 16, 32)
- `LOG_BUFFER`

If you want to use memory components that are not autotuned, you must configure the appropriate parameters. The values specified for these parameters precisely control the sizes of the memory components.

When `SGA_TARGET` is set, the total size of manual SGA size parameters is subtracted from the `SGA_TARGET` value, and the balance is given to the autotuned SGA components.

For example, if `SGA_TARGET` is set to 8 GB and `DB_RECYCLE_CACHE_SIZE` is set to 1 GB, then the total size of the five autotuned components (shared pool, Java pool, default buffer cache, Streams pool, and large pool) is limited to 7 GB. The 7 GB size includes the fixed SGA and log buffer, and only after memory has been allocated to them is the rest of the memory divided between the autotuned components. The size of the recycle cache is 1 GB, as specified by the parameter.

Using the V$PARAMETER View

```
SGA_TARGET = 8G
```

```
DB_CACHE_SIZE = 0
JAVA_POOL_SIZE = 0
LARGE_POOL_SIZE = 0
SHARED_POOL_SIZE = 0
STREAMS_POOL_SIZE = 0
```

```
SELECT name, value, isdefault
FROM   v$parameter
WHERE  name LIKE '%size';
```

ORACLE

Using the V$PARAMETER View

When you specify a nonzero value for SGA_TARGET and do not specify a value for an autotuned SGA parameter, the value of the autotuned SGA parameters in the V$PARAMETER view is 0, and the value of the ISDEFAULT column is TRUE.

If you have specified a value for any of the autotuned SGA parameters, the value that is displayed when you query V$PARAMETER is the value that you specified for the parameter.

Modifying the SGA_TARGET Parameter

- The SGA_TARGET initialization parameter:
  - Is dynamic
  - Can be increased up to SGA_MAX_SIZE
  - Can be reduced until all components reach their minimum size
- A change in the value of SGA_TARGET affects only automatically sized components.

Modifying the SGA_TARGET Parameter

SGA_TARGET is a dynamic parameter and can be changed through Database Control or with the ALTER SYSTEM command.

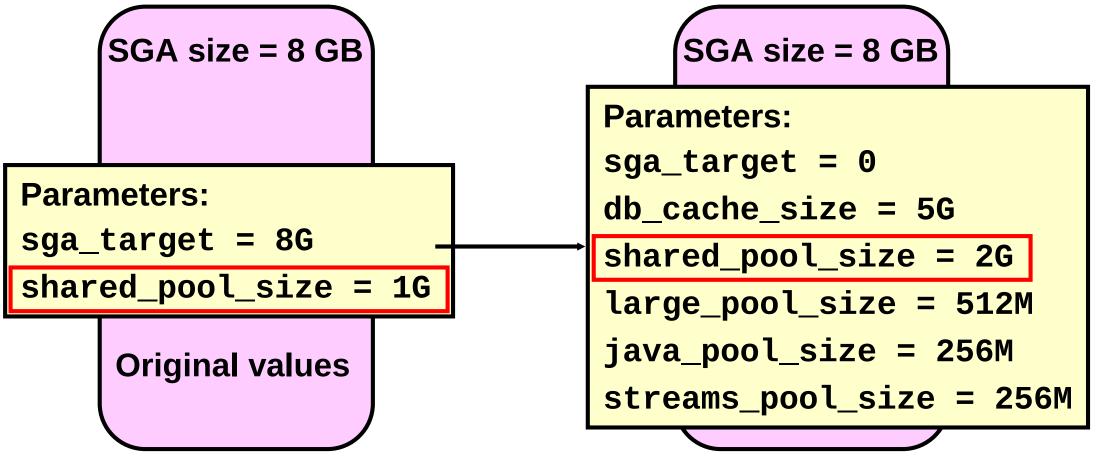
SGA_MAX_SIZE is the maximum amount of memory that can be allocated to the SGA. It cannot be changed without restarting the database. SGA_TARGET can be increased up to the value of SGA_MAX_SIZE. It can be reduced until any one of the autotuned components reaches its minimum size: either a user-specified minimum or an internally determined minimum.

- If you increase the value of SGA_TARGET, the additional memory is distributed according to the autotuning policy across the autotuned components.
- If you reduce the value of SGA_TARGET, the memory is taken away by the autotuning policy from one or more of the autotuned components.

Suppose that SGA_MAX_SIZE is set to 10 GB and SGA_TARGET is set to 8 GB. If DB_KEEP_CACHE_SIZE is set to 1 GB and you increase SGA_TARGET to 9 GB, then the additional 1 GB is distributed only among the components controlled by SGA_TARGET. The value of DB_KEEP_CACHE_SIZE is not affected. Likewise, if SGA_TARGET is reduced to 7 GB, then the 1 GB is taken from only those components that are controlled by SGA_TARGET. This decrease does not affect the settings of manually controlled parameters such as DB_KEEP_CACHE_SIZE.

Disabling ASMM

- **Setting SGA_TARGET to zero disables autotuning.**
- **Autotuned parameters are set to their current sizes.**
- **The SGA size as a whole is unaffected.**



ORACLE

8-25

Disabling ASMM

You can dynamically choose to disable Automatic Shared Memory Management by setting `SGA_TARGET` to zero. In this case, the values of all the autotuned parameters are set to the current sizes of the corresponding components, even if the user had earlier specified a different nonzero value for an autotuned parameter.

In the example in the slide, the value of `SGA_TARGET` is 8 GB and the value of `SHARED_POOL_SIZE` is 1 GB. If the system has internally adjusted the size of the shared pool component to 2 GB, then setting `SGA_TARGET` to zero results in `SHARED_POOL_SIZE` being set to 2 GB, thereby overriding the original user-specified value.

Manually Resizing Dynamic SGA Parameters

- For autotuned parameters, manual resizing:
  - Results in immediate component resize if the new value is greater than the current size
  - Changes the minimum size if the new value is smaller than the current size
- Resizing manually tuned parameters affects only the tunable portion of the SGA.

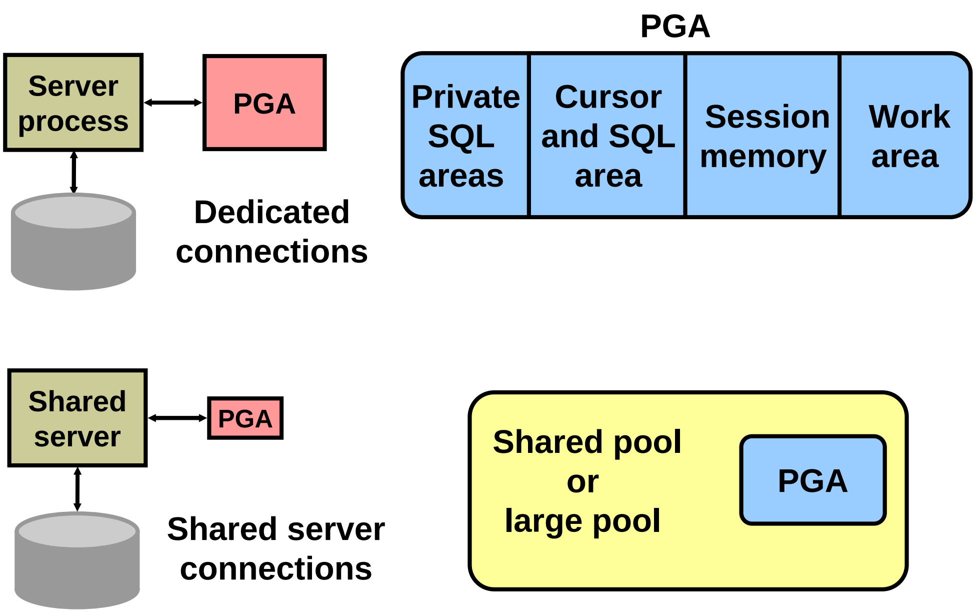
8-26

Manually Resizing Dynamic SGA Parameters

When an autotuned parameter is resized and `SGA_TARGET` is set, the resizing results in an immediate change to the size of the component only if the new value is larger than the current size of the component. For example, if you set `SGA_TARGET` to 8 GB and set `SHARED_POOL_SIZE` to 2 GB, ensure that the shared pool has at least 2 GB at all times to accommodate the necessary memory allocations. After this, adjusting the value of `SHARED_POOL_SIZE` to 1 GB has no immediate effect on the size of the shared pool. It allows the automatic memory-tuning algorithm to later reduce the shared pool size to 1 GB if it needs to. Alternatively, if the size of the shared pool is 1 GB to begin with, then adjusting the value of `SHARED_POOL_SIZE` to 2 GB results in the shared pool component growing immediately to a size of 2 GB. The memory used in this resize operation is taken away from one or more autotuned components, and the sizes of the manual components are not affected.

Parameters for manually sized components can be dynamically altered as well, but the difference is that the value of the parameter specifies the precise size of that component immediately. Therefore, if the size of a manual component is increased, extra memory is taken away from one or more automatically sized components. If the size of a manual component is decreased, the memory that is released is given to the automatically sized components.

Program Global Area (PGA)



Program Global Area (PGA)

The Program Global Area (PGA) is a memory region that contains data and control information for a server process. It is nonshared memory created by the Oracle server when a server process is started. Access to it is exclusive to that server process. The total PGA memory allocated by all server processes attached to an Oracle instance is also referred to as the *aggregated PGA* memory allocated by the instance.

Part of the PGA can be located in the SGA when using shared servers.

PGA memory typically contains the following:

Private SQL Area

A private SQL area contains data such as bind information and run-time memory structures. This information is specific to each session's invocation of the SQL statement; bind variables hold different values, and the state of the cursor is different, among other things. Each session that issues a SQL statement has a private SQL area. Each user that submits the same SQL statement has his or her own private SQL area that uses a single shared SQL area. Thus, many private SQL areas can be associated with the same shared SQL area. The location of a private SQL area depends on the type of connection established for a session. If a session is connected through a dedicated server, private SQL areas are located in the server process's PGA. However, if a session is connected through a shared server, part of the private SQL area is kept in the SGA.

Program Global Area (continued)

Cursor and SQL Areas

The application developer of an Oracle precompiler program or OCI program can explicitly open *cursors* or handles to specific private SQL areas, and use them as a named resource throughout the execution of the program. Recursive cursors that the database issues implicitly for some SQL statements also use shared SQL areas.

Work Area

For complex queries (for example, decision support queries), a big portion of the PGA is dedicated to work areas allocated by memory-intensive operators, such as:

- Sort-based operators, such as `ORDER BY`, `GROUP BY`, `ROLLUP`, and window functions
- Hash-join
- Bitmap merge
- Bitmap create
- Write buffers used by bulk load operations

A sort operator uses a work area (the sort area) to perform the in-memory sort of a set of rows. Similarly, a hash-join operator uses a work area (the hash area) to build a hash table from its left input.

The size of a work area can be controlled and tuned. Generally, bigger work areas can significantly improve the performance of a particular operator at the cost of higher memory consumption.

Session Memory

Session memory is the memory allocated to hold a session’s variables (logon information) and other information related to the session. For a shared server, the session memory is shared and not private.

Automatic PGA Memory Management

- Dynamically adjusts the amount of PGA memory dedicated to work areas, on the basis of the `PGA_AGGREGATE_TARGET` parameter
- Helps maximize the performance of all the memory-intensive SQL operations
- Is enabled by default

ORACLE

Automatic PGA Memory Management

Ideally, the size of a work area is big enough that it can accommodate the input data and auxiliary memory structures allocated by its associated SQL operator. This is known as the optimal size of a work area. When the size of the work area is smaller than optimal, the response time increases because an extra pass is performed over part of the input data.

Automatic PGA memory management simplifies and improves the way PGA memory is allocated. By default, PGA memory management is enabled. In this mode, the Oracle database dynamically adjusts the size of the portion of the PGA memory dedicated to work areas, based on 20% of the SGA memory size. The minimum value is 10 MB.

When running in automatic PGA memory management mode, sizing of work areas for all sessions becomes automatic and the `*_AREA_SIZE` parameters (such as `SORT_AREA_SIZE`) are ignored by all sessions running in that mode. At any given time, the total amount of PGA memory available to active work areas in the instance is automatically derived from the `PGA_AGGREGATE_TARGET` initialization parameter. This amount is set to the value of `PGA_AGGREGATE_TARGET` minus the amount of PGA memory allocated by other components of the system (for example, PGA memory allocated by sessions). The resulting PGA memory is then assigned to individual active work areas on the basis of their specific memory requirements.

PGA Management Resources

- Statistics to manage the `PGA_AGGREGATE_TARGET` initialization parameter, such as `PGA cache hit percentage`
- Views for monitoring the PGA work area include:
  - `v$sql_workarea_histogram`
  - `v$pgastat`
  - `v$sql_workarea_active`
  - `v$sql_workarea`
  - `v$tempseg_usage`
- Views to assist in sizing the PGA work area are:
  - `v$pga_target_advice`
  - `v$pga_target_advice_histogram`

8-30

PGA Management Resources

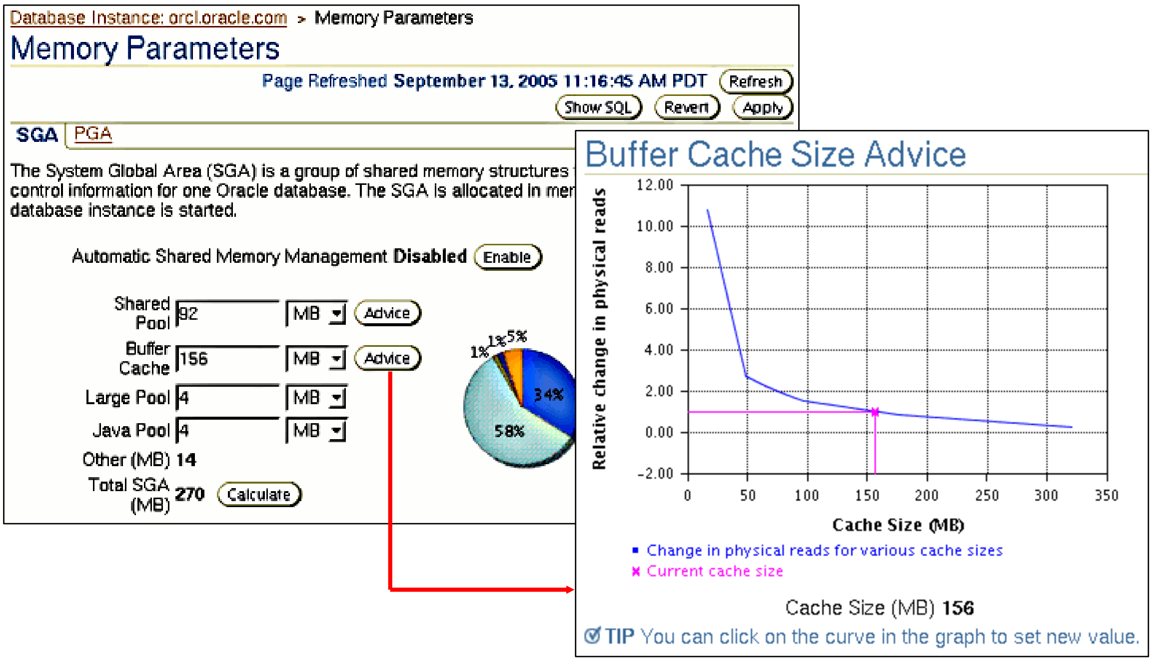
When configuring a new instance, it is difficult to know precisely the appropriate setting for PGA_AGGREGATE_TARGET. You can determine this setting in three stages:

1. Make the first estimate for PGA_AGGREGATE_TARGET, based on convention. By default, the Oracle database sets this to 20% of the SGA size. However, this initial setting may be too low for a large DSS system.
2. Run a representative workload on the instance and monitor performance, using PGA statistics collected by Oracle, to see whether the maximum PGA size is underconfigured or overconfigured.
3. Tune PGA_AGGREGATE_TARGET, using Oracle PGA advice statistics.

For backward compatibility, automatic PGA memory management can be disabled by setting the value of the PGA_AGGREGATE_TARGET initialization parameter to 0. When automatic PGA memory management is disabled, the maximum size of a work area can be sized with the associated *_AREA_SIZE parameter, for example:

- SORT_AREA_SIZE
- HASH_AREA_SIZE
- BITMAP_MERGE_AREA_SIZE
- CREATE_BITMAP_AREA_SIZE

Using the Memory Advisor to Size the SGA



8-31

Using the Memory Advisor to Size the SGA (continued)

With the Memory Advisor, you can tune the size of your memory structures. If Automatic Shared Memory Management is enabled, you can use this to tune the total size of the SGA. If ASMM is disabled, you can use this advisor to tune the different components of the SGA.

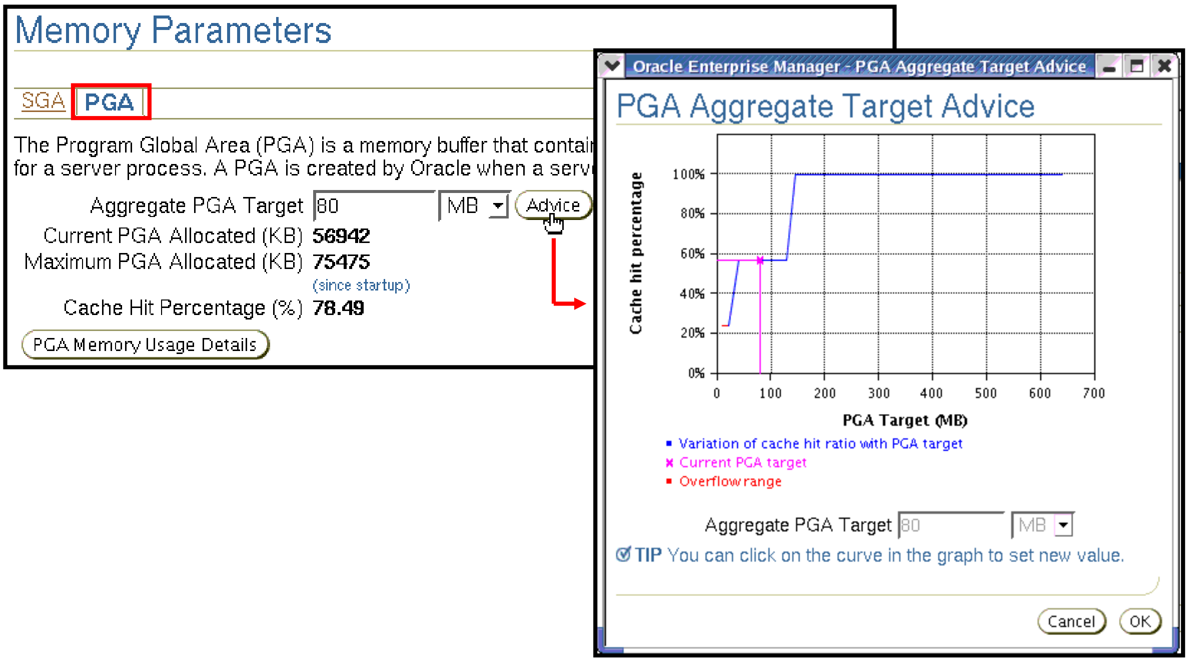
The Memory Advisor comprises three advisors that give you recommendations on the following SGA memory structures:

- Shared pool
- Buffer cache

You can invoke the memory advisors by performing the following steps:

1. Click Advisor Central in the Related Links region on the Database home page.
2. Click Memory Advisor on the Advisor Central page. The Memory Parameters page appears. This page provides a breakdown of memory usage for the SGA.
3. Click Advice next to the Shared Pool value or Buffer Cache value to invoke the respective advisors.

Using the Memory Advisor to Size the PGA



Using the Memory Advisor to Size the PGA

The Memory Advisor can be used to get advice on the size of the PGA. To do this, click the PGA tab, and then click Advice. In this example, the graph shows that raising the Aggregate PGA Target from 80 MB to approximately 140 MB will raise the cache hit percentage from 60% to close to 100%.

Efficient Memory Usage: Guidelines

- Try to fit the SGA into physical memory.
- Tune for a high buffer cache hit ratio, with the following caveats:
  - Even valid and necessary full table scans lower it.
  - It is possible that unnecessary repeated reads of the same blocks are artificially raising it.
- Use the Memory Advisor.

8-33

Efficient Memory Usage: Guidelines

If possible, it is best to fit the SGA into physical memory, which provides the fastest access. Even though the operating system may provide additional virtual memory, that memory, by its nature, can often be swapped out to the disk. On some platforms, you can use the `LOCK_SGA` initialization parameter to lock the SGA into physical memory.

When a SQL statement executes, Oracle data blocks are requested for reading or writing, or both. This is called a logical I/O. As the block is requested, the Oracle database first checks to see whether it already exists in memory. If it is not in memory, it reads it from the disk, which is called a physical I/O. The number of times the block is found already in memory compared to the total number of logical I/Os is referred to as the buffer cache hit ratio. A higher ratio is usually better because that means more blocks are being found in memory without incurring disk I/O.

It is not uncommon to have a buffer cache hit ratio above 99%. But that does not always mean the system is well tuned. If there is a query that is executed more often than necessary, and it constantly requests the same blocks over and over again, the ratio is raised. If it is an inefficient or unnecessary query, then it artificially inflates the ratio. This is because it should not execute in that manner or that often in the first place.

Efficient Memory Usage: Guidelines (continued)

Also, consider the fact that large full table scans (a full reading of the entire table) can lower this ratio because the entire table may be read from the disk; the scan may not take advantage of the fact that some of the blocks may be in the buffer cache. So, if there are some necessary large full table scans in your application, your well-tuned database may always have a low database buffer cache hit ratio.

Use Enterprise Manager’s Memory Advisor. This can help you size the SGA on the basis of the activity in your particular database.

Memory Tuning Guidelines for the Library Cache

- Establish formatting conventions for developers so that SQL statements match in the cache.
- Use bind variables.
- Eliminate unnecessary duplicate SQL.
- Consider using `CURSOR_SHARING`.
- Use PL/SQL when possible.
- Cache sequence numbers.
- Pin objects in the library cache.

Memory Tuning Guidelines for the Library Cache

The library cache, which is a part of the shared pool, is where the Oracle database stores all the SQL, PL/SQL, and Java code that get executed. The code goes into this central location so that it can be shared among all users. The benefit of sharing is that all users can take advantage of any work that is already done on behalf of SQL. Therefore, tasks such as parsing the statement and determining the data access path (also known as the "explain plan") are done only once per statement, no matter how many times the statement is executed, and no matter how many users execute it. A library cache that is too small does not have room for all the statements being executed and, therefore, you cannot take advantage of this sharing of work for some statements. A library cache that is too large causes a burden on the system just to manage its contents.

A library cache may end up being filled with what appear to be different statements when, in fact, they are copies of the same statement. A common cause of this is having slightly different formatting for each statement. There is no match if the string does not compare exactly. Another cause is the use of literals instead of bind variables. If the only difference between two statements is literal values, then, in most cases, each of those statement executions and the overall system would benefit from replacing those literals with bind variables.

Memory Tuning Guidelines for the Library Cache (continued)

The `CURSOR_SHARING` initialization parameter can be set to have the system automatically replace literals with bind variables when statements otherwise match. You should typically take advantage of this setting as a temporary measure until the application is corrected to use bind variables where appropriate. As with all of these guidelines, the use of this variable can have other side effects, which you should investigate.

Rather than having the same SQL statement issued from several different places in an application, put the statement or statements into a stored procedure by using PL/SQL. Then just call the procedure. This guarantees that the SQL statement is shared because it exists only in one location. Also, the SQL is already parsed and has an explain plan because it is in an already compiled stored procedure.

Sequence numbers can be cached. Therefore, if there are some sequences with high activity, determine a good setting for the cache size and take advantage of it.

You can use the `DBMS_SHARED_POOL` package to pin objects in the library cache. This reduces the chance of reloading and recompiling objects. Refer to the *PL/SQL Packages and Types Reference* document for more information about how to use that package.

Summary

In this lesson, you should have learned how to:

- Describe the memory components in the SGA
- Implement Automatic Shared Memory Management
- Manually configure SGA parameters
- Use automatic PGA memory management

Practice Overview: Using ASMM to Correct a Memory Allocation Problem

This practice covers the following topics:

- Diagnosing a memory allocation problem
- Enabling Automatic Shared Memory Management

9

Automatic Performance Management

Objectives

Tuning
Statistics
SGA Attach
AWR
Advisors
Async. Commit

After completing this lesson, you should be able to:

- Diagnose database performance issues
- Configure the Automatic Workload Repository
- Access the database advisors
- Use the SQL Access Advisor to improve database performance
- Use asynchronous `COMMIT` effectively

ORACLE

9-2

Tuning Activities

The three activities in performance management are:

- **Performance planning**
- **Instance tuning**
- **SQL tuning**

9-3

Tuning Activities

The three facets of tuning involve performance planning, instance tuning, and SQL tuning.

- Performance planning is the process of establishing the environment: the hardware, software, operating system, network infrastructure, and so on.
- Instance tuning is the actual adjustment of Oracle database parameters and operating system parameters to gain better performance of the Oracle database.
- SQL tuning involves making your application submit efficient SQL. This is an applicationwide, as well as a statement-specific, consideration. Systemwide, you want to be sure that different parts of the application are taking advantage of each other’s work and are not competing for resources unnecessarily. In this lesson, you learn about some common actions that you can take to tune specific SQL statements.

Note: For more information about performance tuning, refer to the *Oracle Database Performance Tuning Guide*.

Performance Planning

- Investment options
- System architecture
- Scalability
- Application design principles
- Workload testing, modeling, and implementation
- Deploying new applications

Performance Planning

There are many facets to performance planning. You have to consider the investment in your system architecture: the hardware and software infrastructure needed to meet your requirements. The number of hard drives and controllers has an impact on the speed of data access. Striping data across many devices is often a way to make performance gains. This, of course, requires analysis to determine the value for your given environment, application, and performance requirements.

The ability of an application to scale is also important. This means that you are able to handle more and more users, clients, sessions, or transactions, without incurring a huge impact on overall system performance. The most obvious violator against scalability is serializing operations among users. If all users have to go through a single path one at a time, then as more users are added, there are definitely adverse effects on performance. This is because more and more users line up to go through that path. Poorly written SQL also affects scalability. It requires many users to wait for inefficient SQL to complete; each user competing with the other on a large number of resources that they are not actually in need of.

The principles of application design can greatly affect performance. Simplicity of design, use of views and indexes, and data modeling are all very important.

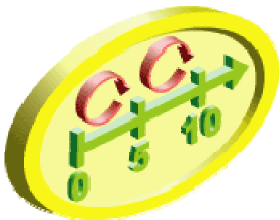
Performance Planning (continued)

Any application must be tested under a representative production workload. This requires estimating database size and workload, and generating test data and system load.

Performance must be considered as new applications (or new versions of applications) are deployed. Sometimes design decisions are made to maintain compatibility with old systems during the rollout. A new database should be configured (on the basis of the production environment) specifically for the applications that it hosts.

Instance Tuning

- Have well-defined goals.
- Allocate memory to database structures.
- Consider I/O requirements in each part of the database.
- Tune the operating system for optimal performance of the database.



Instance Tuning

At the start of any tuning activity, it is necessary to have specific goals. A goal such as "Process 500 sales transactions per minute" is easier to work toward than one that says "Make it go as fast as you can, and we'll know when it's good enough."

You must allocate Oracle database memory suitably for your application to attain optimum performance. You have a finite amount of memory to work with. Too little memory allotted to certain parts of the Oracle database can cause inefficient background activity, which you may not even be aware of without doing some analysis.

Disk I/O is often the bottleneck of a database and, therefore, requires a lot of attention at the outset of any database implementation.

The operating system configuration can also affect the performance of an Oracle database. For more information, see the *Oracle Database Installation Guide* for your particular platform.

Performance Tuning Methodology

The tuning steps:

- **Tune from the top down. Tune:**
  - **The design before tuning the application code**
  - **The code before tuning the instance**
- **Tune the area with the greatest potential benefit.**
  - **Identify the longest waits.**
  - **Identify the largest service times.**
- **Stop tuning when the goal is met.**

Performance Tuning Methodology

Oracle has developed a tuning methodology based on years of experience. The basic steps are:

- Check the OS statistics and general machine health before tuning the instance to be sure that the problem is in the database.
- Tune from the top down. Start with the design, then the application, and then the instance. For example, try to eliminate the full tables scans causing the I/O contention before tuning the tablespace layout on disk.
- Tune the area with the greatest potential benefit. The tuning methodology presented in this course is simple. Identify the biggest bottleneck and tune it. Repeat this step. All the various tuning tools have some way to identify the SQL statements, resource contention, or services that are taking the most time. The Oracle database provides a time model and metrics to automate the process of identifying bottlenecks.
- Stop tuning when you meet your goal. This step implies that you set tuning goals.

This is a general approach to tuning the database instance and may require multiple passes.

Statistics Collection

- Performance tuning depends on the collection of accurate statistics.
- There are different types of statistics:
  - Optimizer statistics
  - System statistics
- There are different methods of collecting statistics:
  - Automatically, through `GATHER_STATS_JOB`
  - Manually, with the `DBMS_STATS` package
  - By setting database initialization parameters
  - By importing statistics from another database

ORACLE

Statistics Collection

Optimizer statistics are collections of data that describe more details about the database and the objects in the database. These statistics are used by the query optimizer to choose the best execution plan for each SQL statement.

System statistics describe the system's hardware characteristics, such as I/O and CPU performance and utilization, to the query optimizer. When choosing an execution plan, the optimizer estimates the I/O and CPU resources required for each query. System statistics enable the query optimizer to more accurately estimate I/O and CPU costs, and thereby choose a better execution plan. System statistics are collected using the `DBMS_STATS.GATHER_SYSTEM_STATS` procedure. When the Oracle database gathers system statistics, it analyzes system activity in a specified period of time. System statistics are not automatically gathered. Oracle Corporation recommends that you use the `DBMS_STATS` package to gather system statistics.

The recommended approach to gathering optimizer statistics is to allow the Oracle database to automatically gather the statistics. The `GATHER_STATS_JOB` job is created automatically at database creation time and is managed by the Scheduler. It gathers statistics on all objects in the database that have either missing or stale optimizer statistics.

Statistics Collection (continued)

If you choose not to use automatic statistics gathering, then you must manually collect statistics in all schemas, including system schemas. If the data in your database changes regularly, you also need to gather statistics regularly to ensure that the statistics accurately represent characteristics of your database objects. To manually collect statistics, use the DBMS_STATS package. This PL/SQL package is also used to modify, view, export, import, and delete statistics.

You can also manage optimizer and system statistics collection through database initialization parameters. For example:

- The OPTIMIZER_DYNAMIC_SAMPLING parameter controls the level of dynamic sampling performed by the optimizer. You can use dynamic sampling to estimate statistics for tables and relevant indexes when they are not available or are too out of date to trust. Dynamic sampling also estimates single-table predicate selectivities when collected statistics cannot be used or are likely to lead to significant errors in estimation.
- The STATISTICS_LEVEL parameter controls all major statistics collections or advisories in the database and sets the statistics collection level for the database. The values for this parameter are BASIC, TYPICAL, and ALL.
- The TIMED_STATISTICS parameter directs the Oracle server to gather wait time for events, in addition to wait counts already available. This data is useful for comparing the total wait time for an event to the total elapsed time between the performance data collections.
- The TIMED_OS_STATISTICS parameter specifies the interval (in seconds) at which Oracle collects operating system statistics when a request is made from the client to the server or when a request completes.

Timed system statistics are automatically collected for the database if the STATISTICS_LEVEL initialization parameter is set to TYPICAL or ALL. If STATISTICS_LEVEL is set to BASIC, then you must set TIMED_STATISTICS to TRUE to enable the collection of timed statistics. Note that setting STATISTICS_LEVEL to BASIC disables many automatic features and is not recommended.

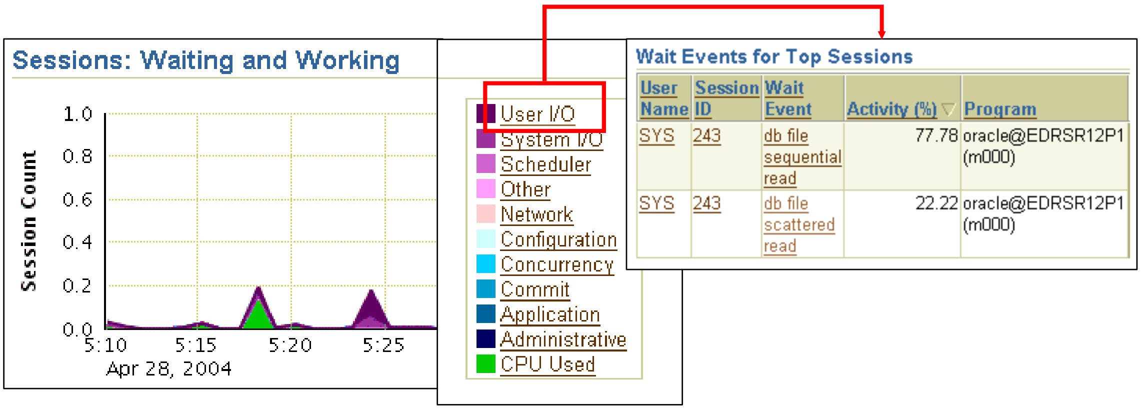
If you explicitly set TIMED_STATISTICS or TIMED_OS_STATISTICS, either in the initialization parameter file or by using the ALTER SYSTEM or ALTER SESSION commands, then the explicitly set value overrides the value derived from STATISTICS_LEVEL.

You can query the V$STATISTICS_LEVEL view to determine which parameters are affected by the STATISTICAL_LEVEL parameter.

Oracle Wait Events

Tuning
> Statistics
SGA Attach
AWR
Advisors
Async. Commit

- A collection of wait events provides information about the sessions or processes that had to wait or must wait for different reasons.
- These events are listed in the V$EVENT_NAME view.



Oracle Wait Events

Wait events are statistics that are incremented by a server process or thread to indicate that it had to wait for an event to complete before being able to continue processing. Wait event data reveals various symptoms of problems that might be impacting performance, such as latch contention, buffer contention, and I/O contention. Remember that these are only symptoms of problems, not the actual causes.

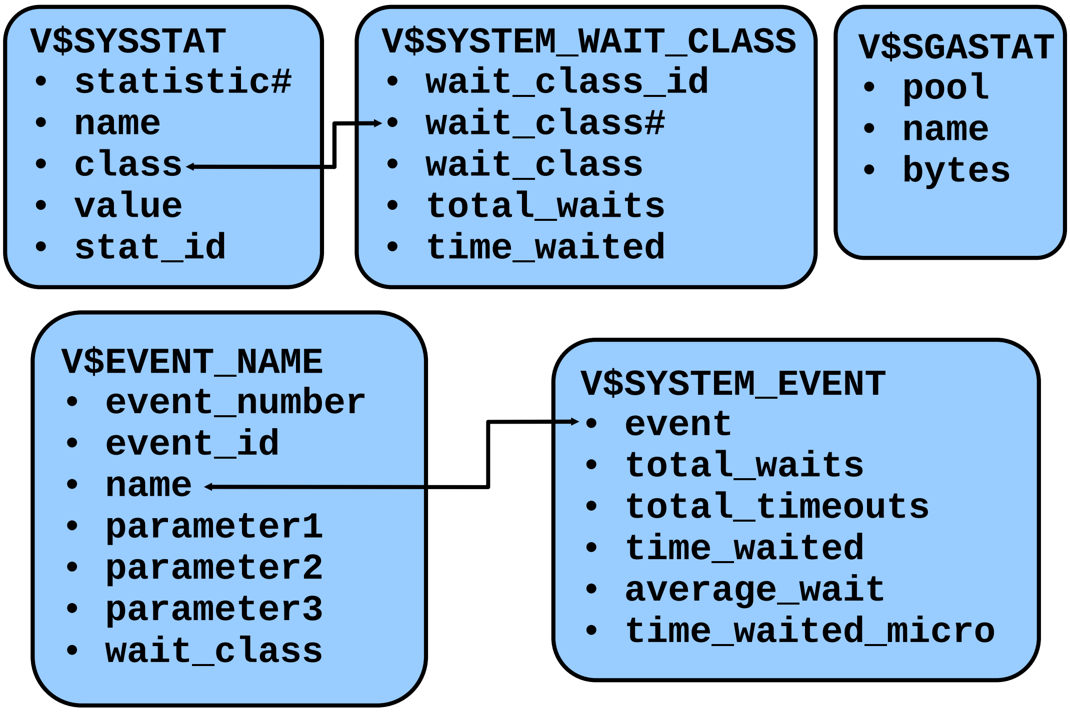
Wait events are grouped into classes. The wait event classes include: Administrative, Application, Cluster, Commit, Concurrency, Configuration, Idle, Network, Other, Scheduler, System I/O, and User I/O.

There are more than 800 wait events in the Oracle database, including `free buffer wait`, `latch free`, `buffer busy waits`, `db file sequential read`, and `db file scattered read`.

Using EM, you can view wait events by opening the Performance page and viewing the "Sessions: Waiting and Working" graph, as shown in the slide. By clicking the link for a particular wait event class, you can drill down to the specific wait events by using the Top Sessions interface. In this example, the most significant wait events were file reads.

For a list of the most common Oracle events, refer to the *Oracle Database Reference 10g* documentation.

System Statistics



9-11

System Statistics

To effectively diagnose performance problems, statistics must be available. The Oracle database generates many types of cumulative statistics for the system, sessions, and individual SQL statements. The Oracle database also tracks cumulative statistics on segments and services. When analyzing a performance problem in any of these scopes, you typically look at the change in statistics (delta value) over the period of time you are interested in.

Wait Events Statistics

All the possible wait events are cataloged in the `V$EVENT_NAME` view.

Cumulative statistics for all sessions are stored in `V$SYSTEM_EVENT`, which shows the total waits for a particular event since instance startup.

When you are troubleshooting, you need to know whether a process has waited for any resource.

Systemwide Statistics

All the systemwide statistics are cataloged in the `V$STATNAME` view: About 330 statistics are available in Oracle Database 10*g*.

The server displays all calculated system statistics in the `V$SYSSTAT` view. You can query this view to find cumulative totals since the instance started.

System Statistics (continued)

Systemwide Statistics (continued)

For example:

```
SQL>  SELECT name, class, value FROM v$sysstat;
NAME                              CLASS      VALUE
------------------------------  ------ ----------
...
table scans (short tables)           64     135116
table scans (long tables)            64        250
table scans (rowid ranges)           64          0
table scans (cache partitions)       64          3
table scans (direct read)            64          0
table scan rows gotten               64   14789836
table scan blocks gotten             64     558542
...
```

Systemwide statistics are classified by the tuning topic and the debugging purpose. The classes include general instance activity, redo log buffer activity, locking, database buffer cache activity, and so on.

You can also view all wait events for a particular wait class by querying `V$SYSTEM_WAIT_CLASS`. For example (with formatting applied):

```
SQL> SELECT * FROM V$SYSTEM_WAIT_CLASS
  2  WHERE wait_class LIKE '%I/O%';
CLASS_ID   CLASS# WAIT_CLASS   TOTAL_WAITS TIME_WAITED
---------- ------ ------------ ----------- -----------
1740759767      8 User I/O         1119152       39038
4108307767      9 System I/O        296959       27929
```

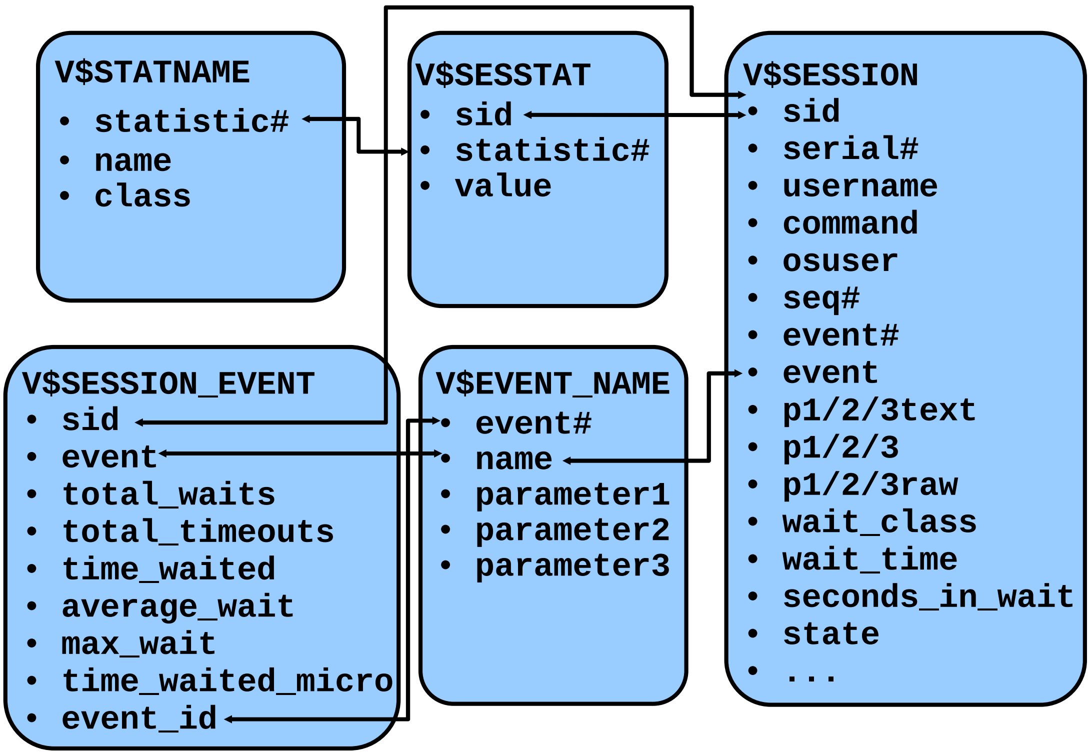
SGA Global Statistics

The server displays all calculated memory statistics in the `V$SGASTAT` view. You can query this view to find cumulative totals of detailed SGA usage since the instance started. For example:

```
SQL>  SELECT * FROM v$sgastat;
POOL            NAME                              BYTES
------          -------------------------  ----------
                fixed_sga                     7780360
                buffer_cache                 25165824
                log_buffer                     262144
shared pool     sessions                      1284644
shared pool     sql area                     22376876
...
```

The results shown are only a partial display of the output.

Displaying Session-Related Statistics



Displaying Session-Related Statistics

You can display current session information for each user logged on by querying V$SESSION. For example, you can use V$SESSION to determine whether a session represents a user session, or was created by a database server process (BACKGROUND).

You can query either V$SESSION or V$SESSION_WAIT to determine the resources or events for which active sessions are waiting.

The Oracle server displays user session statistics in the V$SESSTAT view. The V$SESSION_EVENT view lists information on waits for an event by a session.

Cumulative values for statistics are generally available through dynamic performance views, such as the V$SESSTAT and V$SYSSTAT views. Note that the cumulative values in dynamic views are reset when the database instance is shut down.

The V$MYSTAT view displays the statistics of the current session.

You can also query the V$SESSMETRIC view to display the performance metric values for all active sessions. This view lists performance metrics such as CPU usage, number of physical reads, number of hard parses, and the logical read ratio.

Displaying Service-Related Statistics

For *n*-tier environments, because session statistics are not as helpful, you can see service-level statistics in these views:

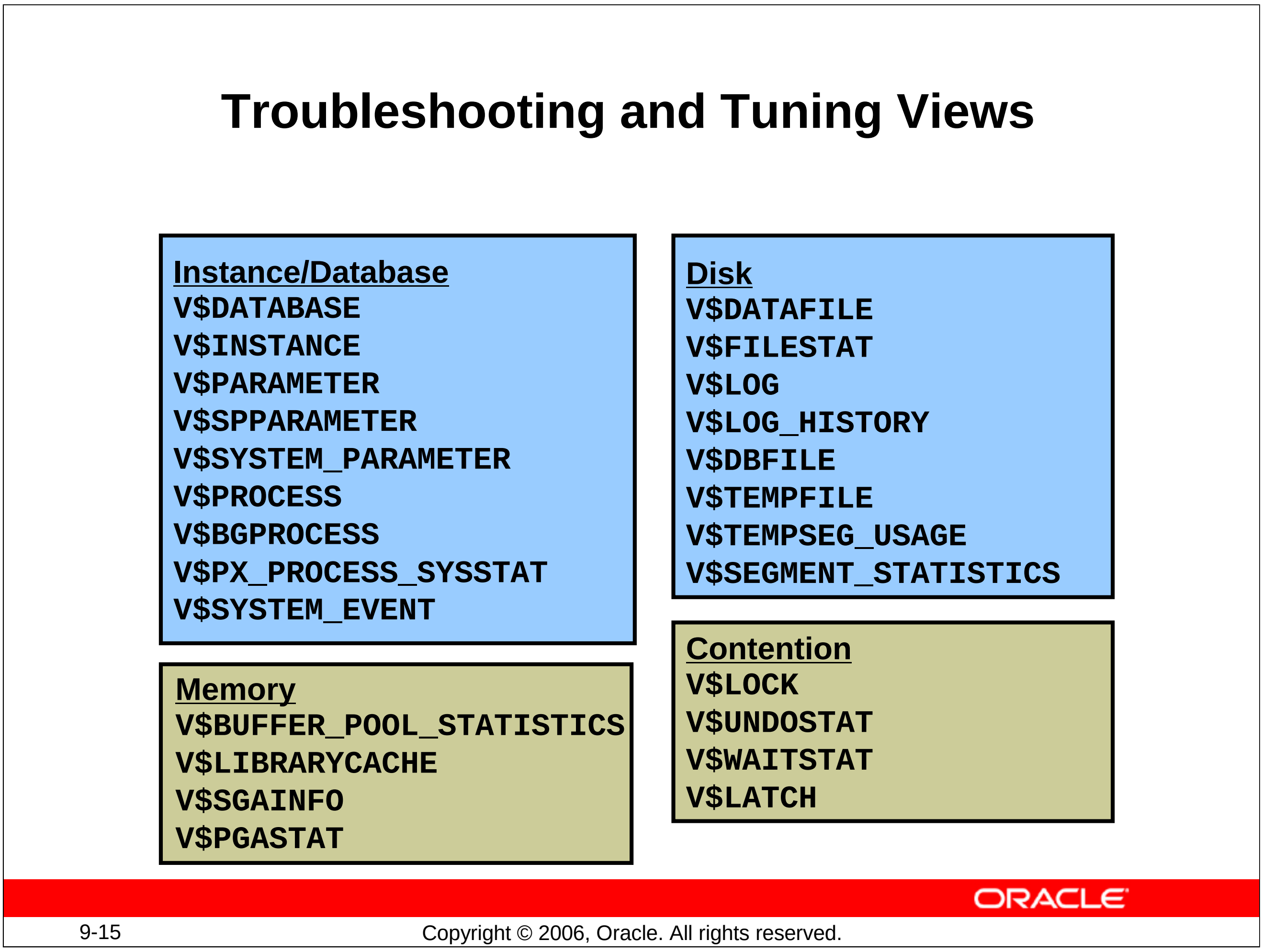
- **`V$SERVICE_EVENT`: Aggregated wait counts and wait times for each service, on a per event basis**
- **`V$SERVICE_WAIT_CLASS`: Aggregated wait counts and wait times for each service on a wait class basis**

Displaying Service-Related Statistics

In an *n*-tier environment where there is an application server that is pooling database connections, viewing sessions may not provide the information you need to analyze performance. Grouping sessions into service names enables you to monitor performance more accurately. These two views provide the same information that their like-named session counterparts provide, except that the information is presented at the service level rather than at the session level.

`V$SERVICE_WAIT_CLASS` shows wait statistics for each service, broken down by wait class.

`V$SERVICE_EVENT` shows the same information as `V$SERVICE_WAIT_CLASS`, except that it is further broken down by event ID.



Troubleshooting and Tuning Views

The slide lists some of the views you may need to access to determine the cause of performance problems or analyze the current status of your database.

For a complete description of these views, refer to the *Oracle Database Reference Manual*.

Dictionary Views

- The following dictionary and special views provide useful statistics after using the DBMS_STATS package:
  - DBA_TABLES, DBA_TAB_COLUMNS
  - DBA_CLUSTERS
  - DBA_INDEXES
  - DBA_TAB_HISTOGRAMS
- This statistical information is static until you reexecute the appropriate procedures in DBMS_STATS.

9-16

Dictionary Views

When you need to look at data storage in detail, use the DBMS_STATS package, which collects statistics and populates columns in some DBA_xxx views.

DBMS_STATS populates columns in the views concerned with:

- Table data storage within extents and blocks:
  - DBA_TABLES
  - DBA_TAB_COLUMNS
- Cluster data storage within extents and blocks:
  - DBA_CLUSTERS
- Index data storage within extents and blocks, and index usefulness:
  - DBA_INDEXES
- Non-indexed and indexed columns data distribution:
  - DBA_TAB_HISTOGRAMS

For more information about using the DBMS_STATS package, refer to the *Oracle Database Performance Tuning Guide*.

Performing an ANALYZE INDEX … VALIDATE STRUCTURE command populates the INDEX_STATS and INDEX_HISTOGRAM views that contain statistics for indexes.

Diagnosis of Hung or Extremely Slow Databases

- Tuning Statistics
- > SGA Attach
- AWR
- Advisors
- Async. Commit

Use for problem analysis when the database is performing very slowly, or is hung:

- **Direct access to SGA for performance monitoring (memory access mode)**
  - `V$SESSION`
  - `V$SESSION_WAIT`
  - `V$SYSTEM_EVENT`
  - `V$SYSSTAT`
  - **Hang analysis using Enterprise Manager**

ORACLE

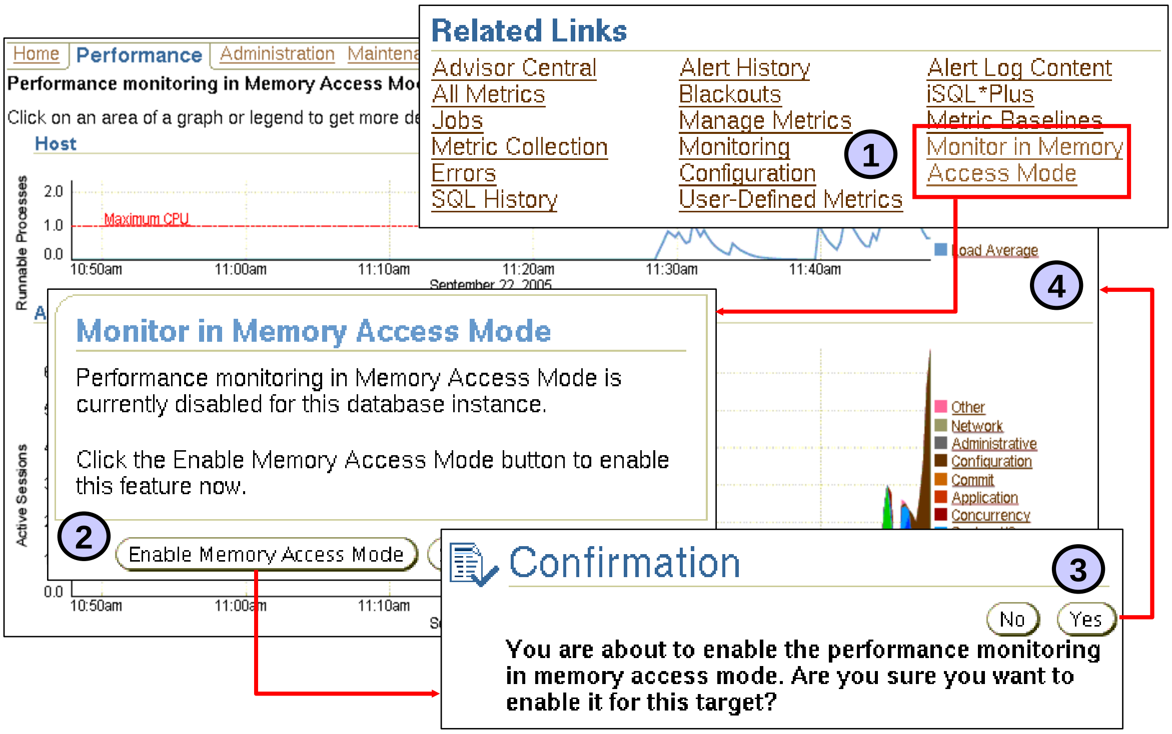
9-17

Diagnosis of Hung or Extremely Slow Databases

There is functionality available for problem analysis when the database is performing very poorly, or is actually hung.

The system supports the collection of real-time performance statistics directly from the System Global Area (SGA) using optimized or lightweight system-level calls as an alternative to SQL. In Enterprise Manager, this is referred to as the memory access mode. There is one SGA collector thread per Oracle instance, and it is started automatically by the EM agent when it starts monitoring a database instance. The V$ views shown in the slide are the main performance views used for high-level performance diagnostics and, therefore, are the ones for which direct access to SGA is available. If more extensive drill-down information is required, then you must use SQL to retrieve it. Host information, such as the number of CPUs and the host name, are also collected and made visible through the EM interface.

Using Memory Access Mode



Using Memory Access Mode

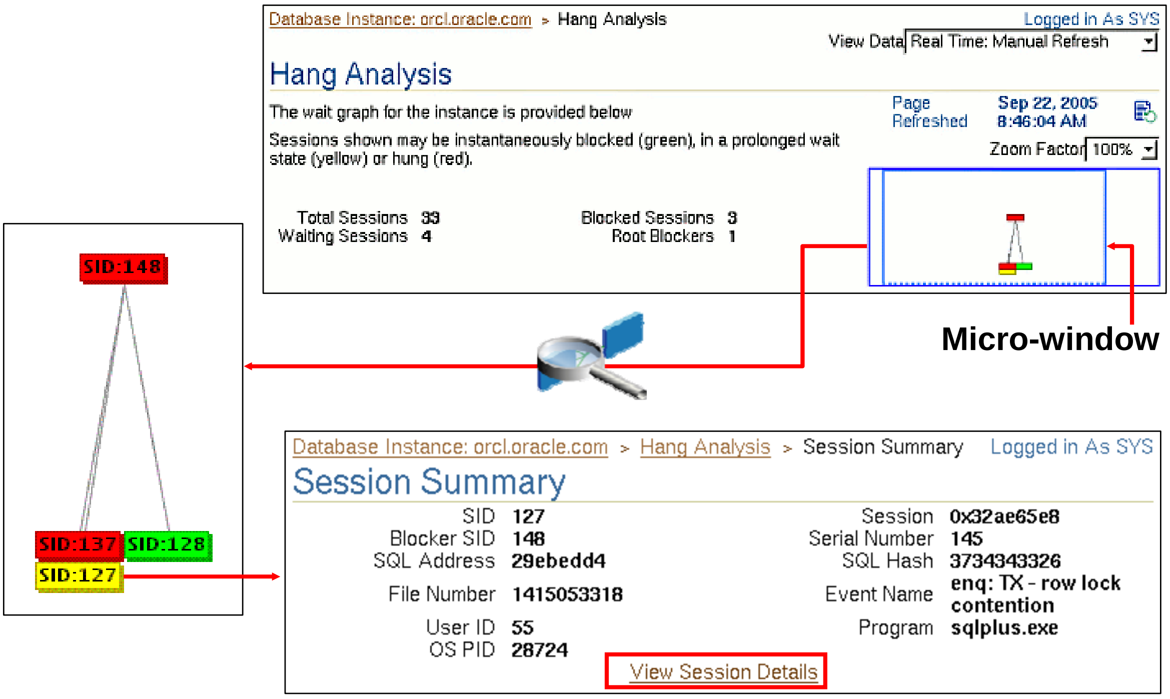
You can access the memory access mode graphic page from the home page in the Related Links section by clicking the “Monitor in Memory Access Mode” link. The link takes you to the Performance page in “Memory Access” view mode. As shown in the slide, you have to “Enable Memory Access Mode” for the first time, and you can disable it later if you want.

When you want to return to SQL Access view mode, just click the “Switch to SQL Access Mode” button on the Performance page.

Memory Access mode avoids the computation associated with parsing and executing SQL statements, thereby making it robust for severe cases of library cache contention that can prevent the instance from being monitored using SQL. You should switch to Memory Access mode for slow or hung systems.
Pages in Memory Access mode contain data sampled at a higher frequency than pages in SQL mode. Charts may appear to be slightly different from SQL mode for this reason. Consequently, the Memory Access mode page provides better information about where events begin and end, and you may also detect short-duration events that might otherwise be missed.

Note: Memory access mode is also called direct SGA attach mode.

Using the Hang Analysis Page



Using the Hang Analysis Page

To analyze hangs and system slowdowns, you can use the Hang Analysis page in the Additional Monitoring Links section of the Performance page in EM. You can also use the Blocking Sessions page to display a list of all sessions currently blocking other sessions.

You use the Hang Analysis page to:

- Determine which sessions are causing bottlenecks
- Examine session summaries for blocking or blocked sessions

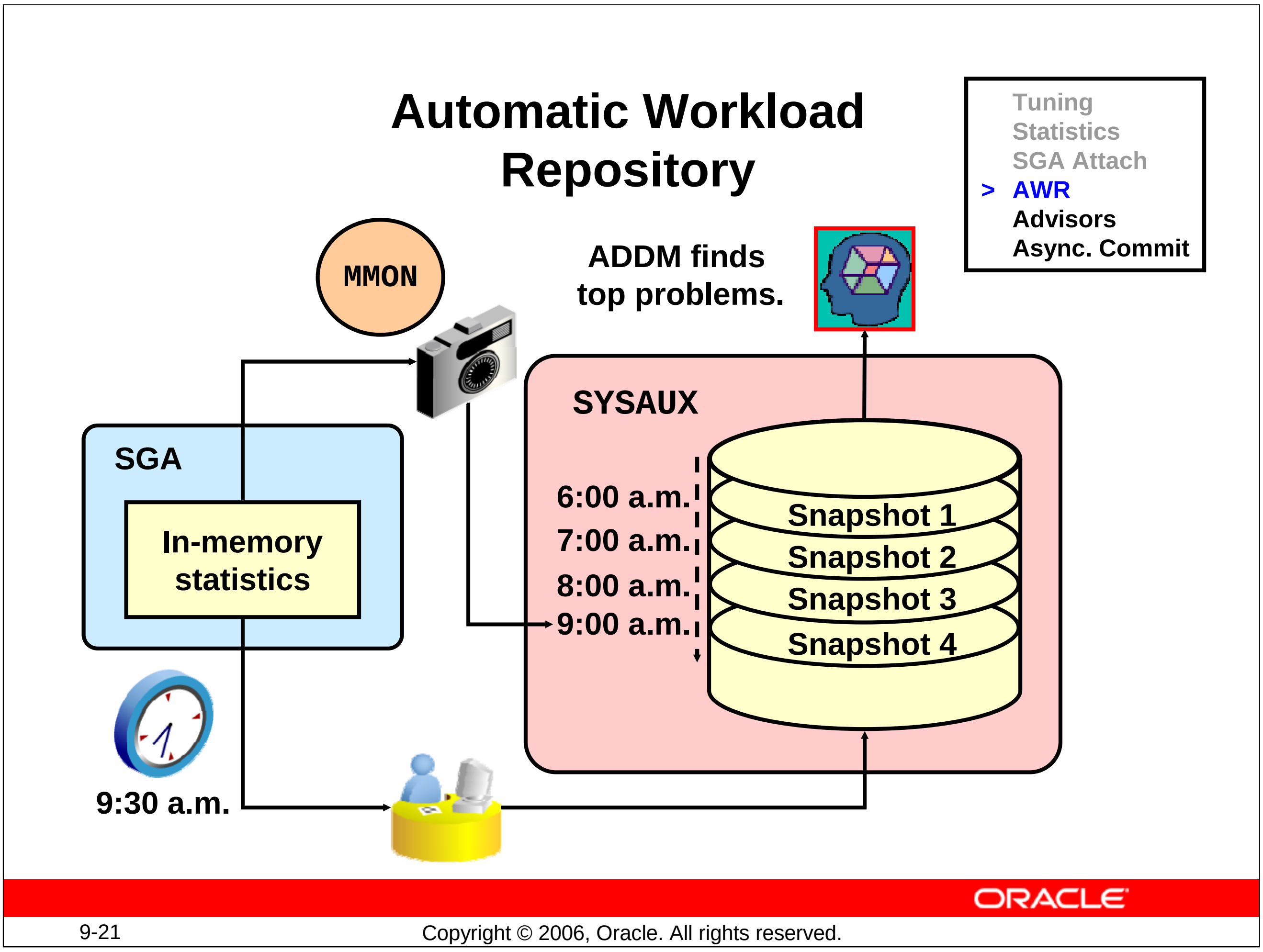
This page provides you with a graphical topology of waiting sessions in the system, with blocked sessions appearing below blocking sessions. Enterprise Manager assesses the situation on the basis of historical activity and determines which sessions are hung or likely to be hung, rather than being only instantaneously in a wait state. To view summary information about a session, click a session ID in the topology. The Session Summary page appears, which displays general information about the selected session. You can click View Session Details on the Session Summary page to get further session information, and determine whether terminating the session is beneficial.

Using the Hang Analysis Page (continued)

The sessions are displayed in green, yellow, or red depending on the perceived seriousness of the state of the session within the topology.

You can also select a Zoom Factor percentage based on the desired size of the topology. In cases where there are many blocked sessions, you can use a smaller factor to visualize the overall wait information for the system. You can then zoom in on relevant portions and read the topology or drill down further.

You click in an area of the Zoom Factor microwindow to move the topology to the desired viewing position. For instance, if you click the left side of the window, the topology shifts to the right to enable you to fully view the left side of the topology.



Automatic Workload Repository

The Automatic Workload Repository (AWR) is a collection of persistent system performance statistics owned by `SYS`. The AWR resides in the `SYSAUX` tablespace.

A *snapshot* is a set of performance statistics captured at a certain time and stored in the AWR. Snapshots are used to compute the rate of change of a statistic. Each snapshot is identified by a snapshot sequence number (`snap_id`) that is unique in the AWR.

Statspack users should start using the workload repository in Oracle Database 10*g*. However, there is no supported path to migrate Statspack data into the workload repository. Also, the workload repository is not backward compatible with the Statspack schema.

By default, snapshots are generated every 60 minutes. You can adjust this frequency by changing the snapshot `INTERVAL` parameter. Because the database advisors rely on these snapshots, be aware that adjustment of the interval setting can affect diagnostic precision. For example, if the `INTERVAL` is set to 4 hours, you may miss spikes that occur within 60-minute intervals.

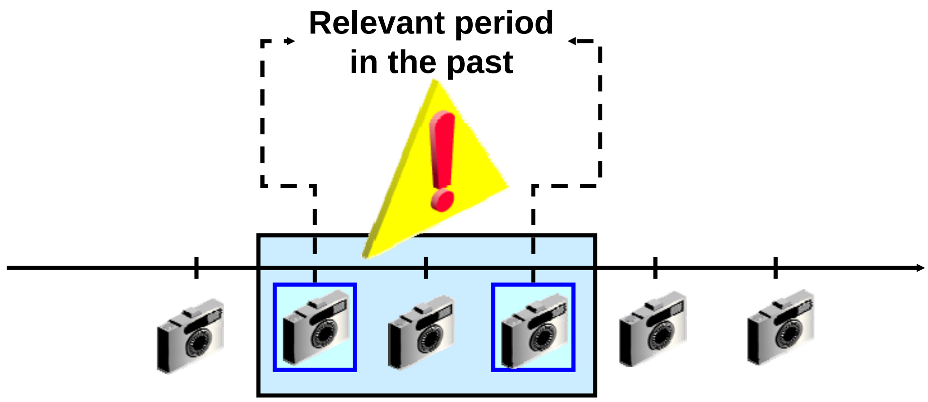
You can use the `DBMS_WORKLOAD_REPOSITORY.MODIFY_SNAPSHOT_SETTINGS` stored procedure or Database Control to change the settings that control snapshot collection. In Database Control, click Automatic Workload Repository in the Statistics Management region of the Administration tabbed page. Then, click Edit to make the changes.

The stored procedure offers more flexibility in defining `INTERVAL` values than does Database Control.

Automatic Workload Repository (continued)

You can take manual snapshots by using Database Control or the `DBMS_WORKLOAD_REPOSITORY.CREATE_SNAPSHOT` stored procedure. Taking manual snapshots is supported in conjunction with the automatic snapshots that the system generates. Manual snapshots are expected to be used when you want to capture the system behavior at two specific points in time that do not coincide with the automatic schedule.

AWR Snapshot Baselines




```
DBMS_WORKLOAD_REPOSITORY.CREATE_BASELINE ( -
        start_snap_id IN NUMBER   ,
        end_snap_id   IN NUMBER   ,
        baseline_name IN VARCHAR2);
```


AWR Snapshot Baselines

Baselines are a mechanism for you to tag sets of snapshot data for important periods. A baseline is defined as a pair of snapshots; the snapshots are identified by their snapshot sequence numbers (`snap_id`). Each baseline corresponds to one and only one pair of snapshots.

A baseline can be identified by either a user-supplied name or a system-generated identifier. You can create a baseline by using Database Control or by executing the `DBMS_WORKLOAD_REPOSITORY.CREATE_BASELINE` procedure and specifying a name and a pair of snapshot identifiers. A baseline identifier is assigned to the newly created baseline. Baseline identifiers are unique for the life of a database.

Baselines are used to retain snapshot data. Therefore, snapshots belonging to baselines are retained until the baselines are dropped.

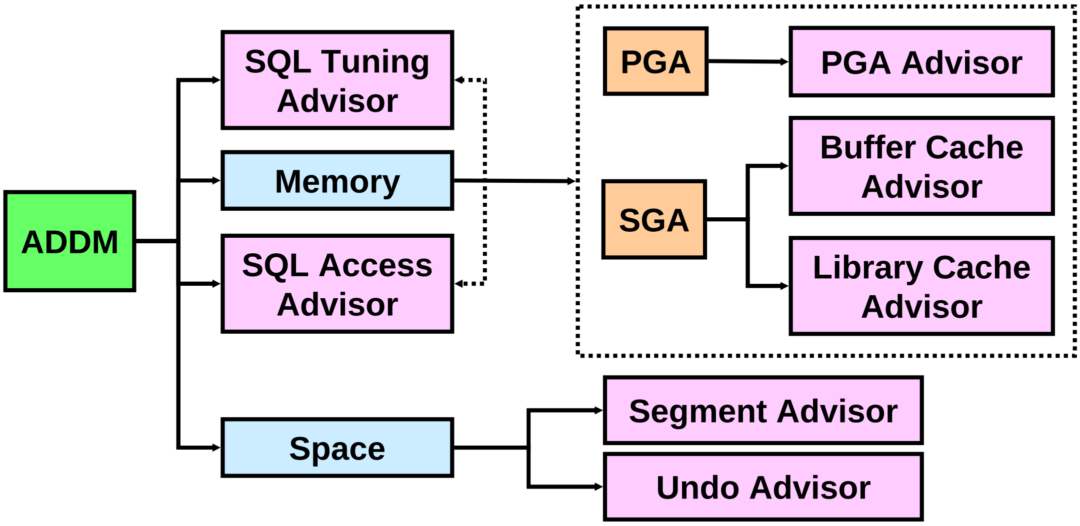
Usually, you set up baselines from some representative periods in the past, to be used for comparisons with current system behavior. You can also set up threshold-based alerts by using baselines from Database Control.

You can get the `snap_id`s directly from `DBA_HIST_SNAPSHOT`, or from Database Control.

Note: For more information about the `DBMS_WORKLOAD_REPOSITORY` package, see the *Oracle Database PL/SQL Packages and Types Reference Guide*.

Advisory Framework: Overview

Tuning
Statistics
SGA Attach
AWR
> Advisors
Async. Commit



ORACLE

Advisory Framework: Overview

Advisors are server components that provide you with useful feedback about resource utilization and performance for its respective component. The advisors use all the resources previously discussed, and more. Following is the list of available advisors:

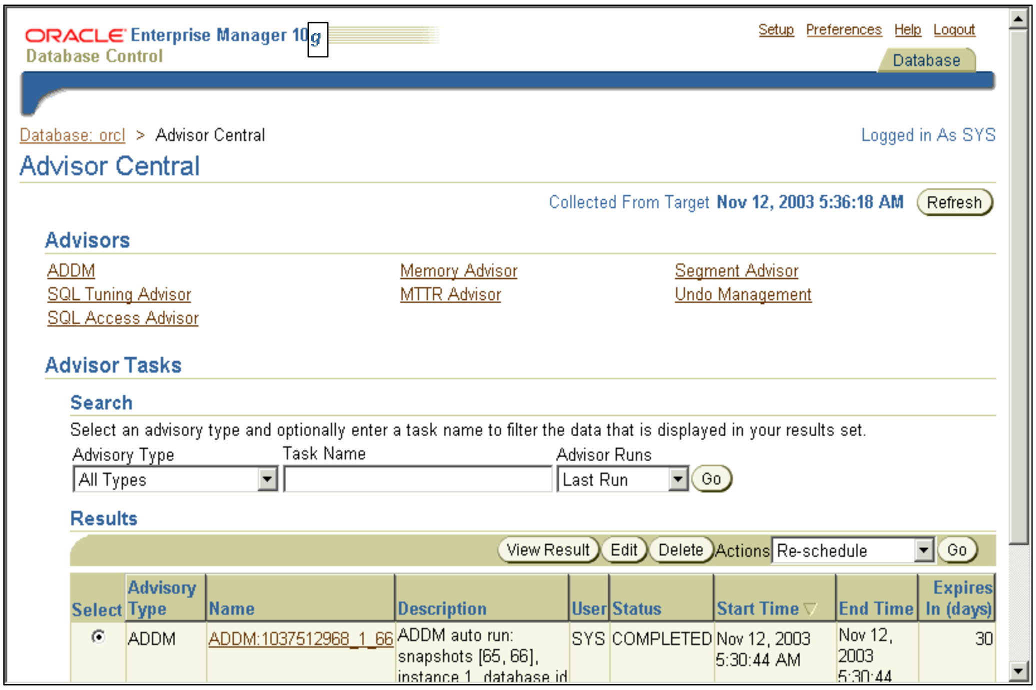
- **Automatic Database Diagnostic Monitor (ADDM):** Performs a top-down instance analysis, identifies problems and potential causes, and gives recommendations for fixing the problems. ADDM can potentially call other advisors.
- **SQL Tuning Advisor:** Provides tuning advice for SQL statements
- **SQL Access Advisor:** Deals with schema issues and determines optimal data access paths such as indexes and materialized views
- **PGA Advisor:** Gives detailed statistics for the work areas, and provides recommendations about optimal usage of the Program Global Area (PGA) memory on the basis of workload characteristics
- **SGA Advisor:** Is responsible for tuning and recommending the System Global Area (SGA) size depending on the pattern of access for the various components within the SGA
- **Segment Advisor:** Monitors object space issues and analyzes growth trends
- **Undo Advisor:** Suggests parameter values and the amount of additional space that is needed to support flashback for a specified time

Advisory Framework: Overview (continued)

The major benefits provided by the advisor infrastructure are:

- It uses a uniform interface for all advisors.
- All advisors are invoked and they report results in a consistent manner.

Database Control and Advisors

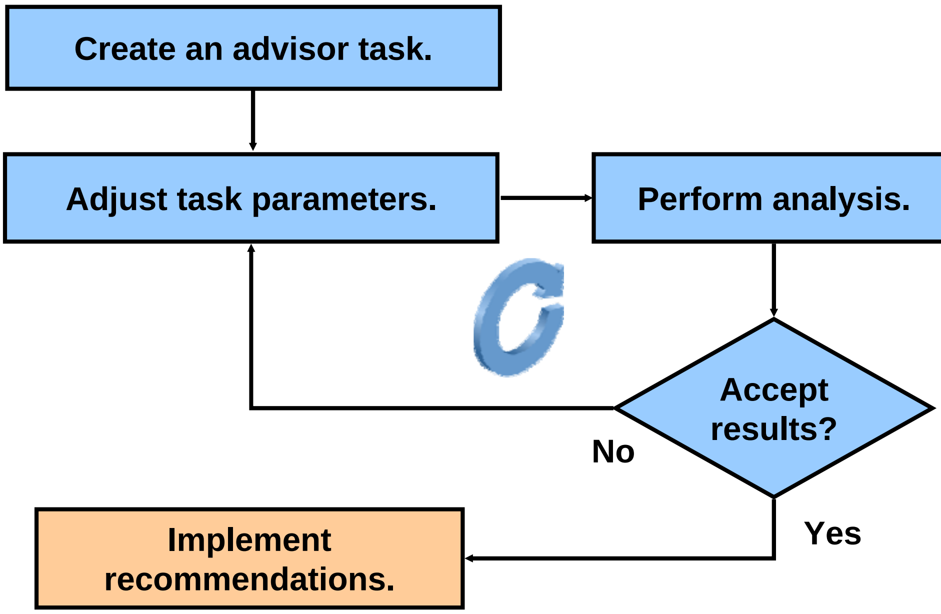


Database Control and Advisors

The Advisor Central page is the main page for all advisors. You can reach this page by clicking the Advisor Central link in the Related Links region of the Database home page. However, this is not the only place inside the Database Control Console where advisors can be invoked.

On the Advisor Central page, you can list all the advisor tasks that were registered in the AWR. You can also filter this list by advisor type and for predefined time periods.

Typical Advisor Tuning Session

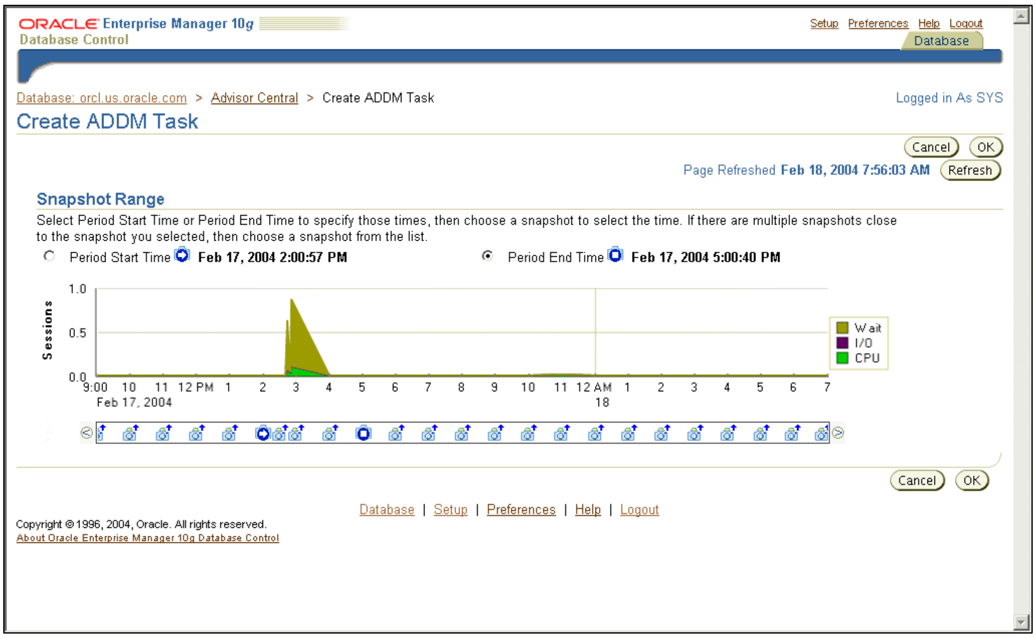


Typical Advisor Tuning Session

A typical tuning session comprises the following steps:

1. **Create an advisor task.**
   An advisor task is an executable data area in the advisor repository that manages your tuning efforts.
2. **Adjust appropriate task parameters.**
   Parameters are set in the main advisor task. They control the advisor's behavior.
3. **Perform an analysis.**
   The execution of the task is a synchronous operation; control is not returned until the operation has completed or a user interruption is detected. At any time, you can interrupt the operation and review the results up to that point in the analysis process. If not satisfied, you can resume the execution for further recommendations, or the task data can be adjusted and execution be restarted.
4. **Review the results.**
   The results of the analysis can be reviewed using the built-in views or the procedure shown in the slide. You have the option of accepting, rejecting, or ignoring the recommendations. If a recommendation is rejected, you may want to rerun an analysis using the rejected recommendation as advice for the next analysis operation.

Manually Invoking ADDM



Manually Invoking ADDM

By default, ADDM tasks are run for every Oracle database snapshot that is stored in the AWR. However, you can create a custom ADDM task to analyze a period of time that you identify with a starting snapshot and an ending snapshot. To create an ADDM task, perform the following steps:

1. Navigate to the Database home page. In the Related Links section, click Advisor Central.
2. Under Advisors, choose ADDM.
3. Select the Period Start Time option and then click the snapshot that you want to use as the starting point of the period of time. Then, select the End Time option and click the snapshot to use as the terminating point of the time period.
4. Use the ADDM Task Page to view the results of a selected ADDM task.

Using the SQL Tuning Advisor: Review

- Use the SQL Tuning Advisor to analyze SQL statements and obtain performance recommendations.
- Sources for SQL Tuning Advisor to analyze:
  - Top SQL: Analyzes the top SQL statements currently active
  - SQL Tuning Sets: Analyzes a set of SQL statements you provide
  - Snapshots: Analyzes a snapshot
  - Baselines: Analyzes a baseline

9-29

Using the SQL Tuning Advisor: Review

You can use the SQL Tuning Advisor to analyze SQL statements and obtain performance recommendations. Typically, you run this advisor as an ADDM performance-finding action.

Additionally, you can run the SQL Tuning Advisor when you want to analyze the top SQL statements consuming the most CPU time, I/O, and memory.

The SQL Tuning Advisor is covered in detail in the *Oracle Database 10g: Administration Workshop I* course.

SQL Access Advisor: Overview

Workload specification
-SQL statement
-SQL Tuning Set
-SQL cache contents
-Statistics
-Schema name

Recommendations
-Indexes
-Materialized views
-Materialized view logs

SQL Access
Advisor

9-30

SQL Access Advisor: Overview

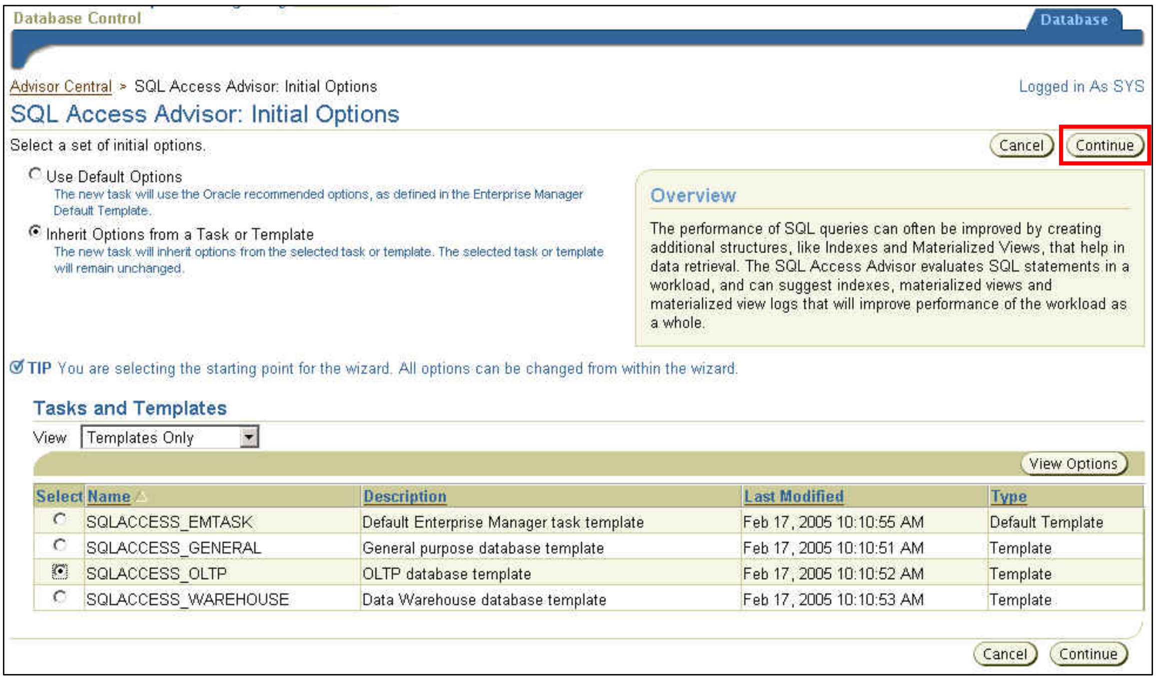
The SQL Access Advisor can recommend the proper set of materialized views, materialized view logs, and indexes for a given workload. Understanding and using these structures is essential when optimizing SQL because they can result in significant performance improvements in data retrieval.

The SQL Access Advisor recommends bitmap, function-based, and B-tree indexes. A bitmap index offers a reduced response time for many types of ad hoc queries and reduced storage requirements compared to other indexing techniques. B-tree indexes are most commonly used in a data warehouse to index unique or near-unique keys.

Another component of the SQL Access Advisor also recommends how to optimize materialized views so that they can be fast refreshable and take advantage of general query rewrite.

Note: For more information about materialized views and query rewrite, see the *Oracle Database Performance Tuning Guide*.

Typical SQL Access Advisor Session



9-31

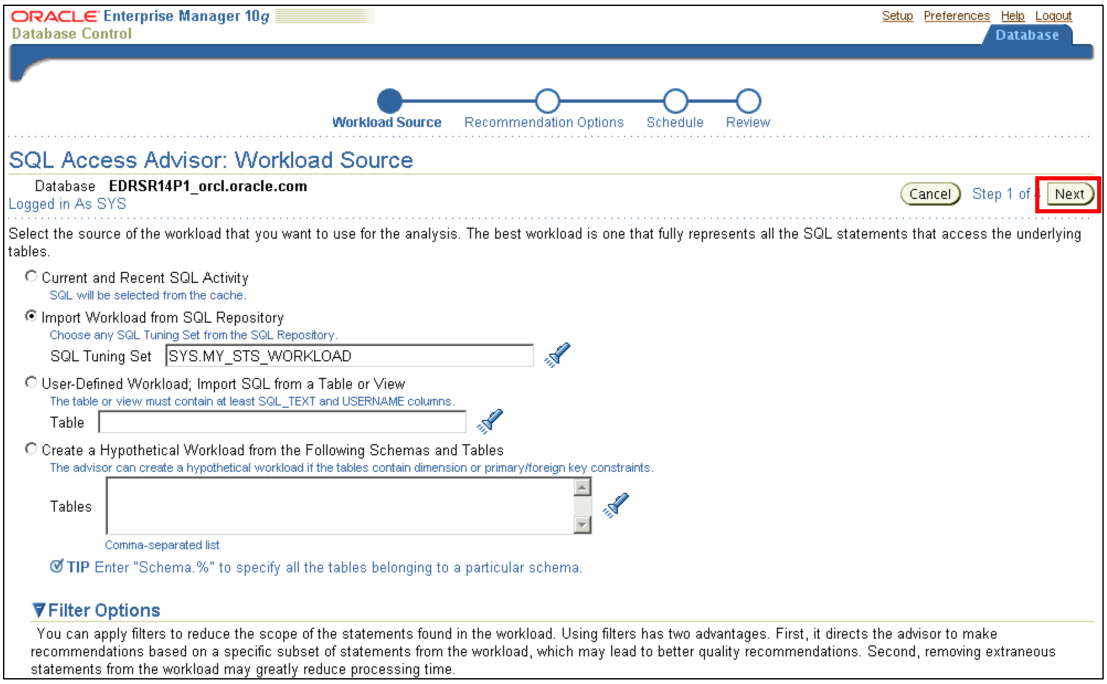
Typical SQL Access Advisor Session

When starting a SQL Access Advisor session, you can select Use Default Options and start with a predefined set of Advisor options that are recommended. Additionally, you can start a task and have it inherit a set of option values as defined by a template or task by selecting “Inherit Options from a Task or Template.” These include several generic templates designed for general purpose environments, OLTP, and data warehousing databases. You can save custom templates from a previous task and reuse them when needed.

Click Continue to launch the SQL Access Advisor wizard.

Note: You can access SQL Access Advisor from the Advisor Central page of Database Control.

Workload Source



Workload Source

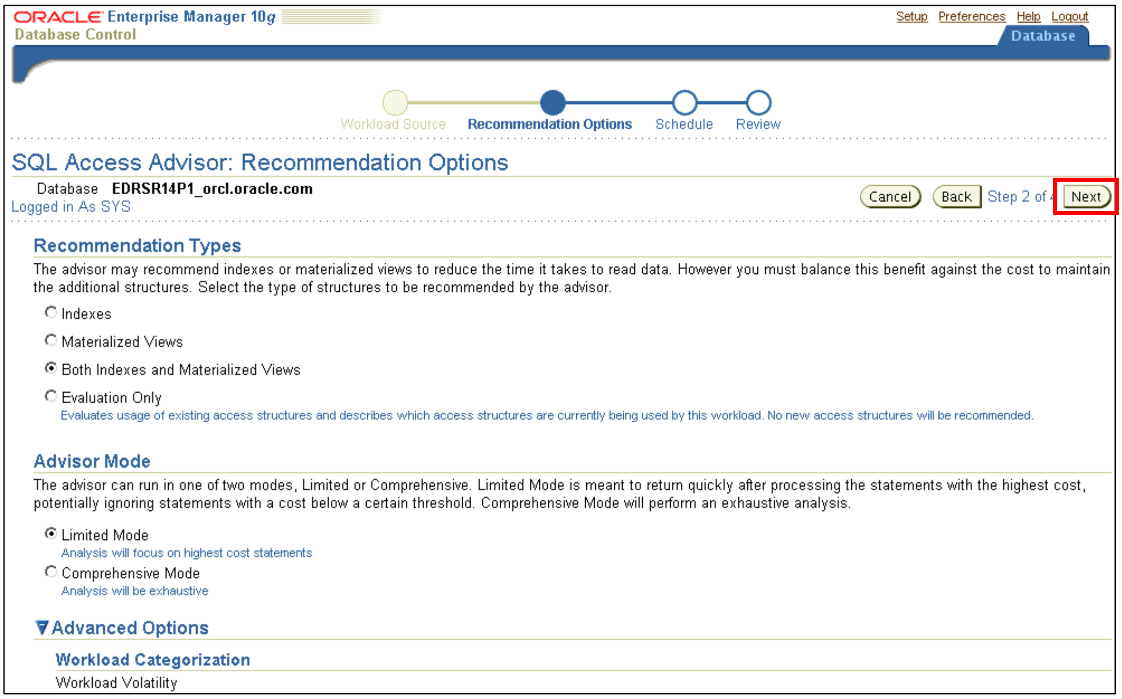
Use the SQL Access Advisor wizard's Workload Source page to provide a defined workload that allows the Access Advisor to make recommendations. Supported workload sources are:

- **Current and Recent SQL Activity:** Uses the current SQL from the cache as the workload
- **Import Workload from SQL Repository:** Enables you to specify a previously created SQL Tuning Set as the workload source
- **User-Defined Workload; Import SQL from a Table or View:** Enables you to receive recommendations for a workload that may not be running on the current database. This provides and implements access recommendations before an application goes live.
- **Create a Hypothetical Workload from the Following Schemas and Tables:** Provides a schema that allows the advisor to search for dimension tables and produce a workload

The scope of the workload can be further reduced by applying filters that you can access in the Filter Options section. With these options, you can reduce the scope of the SQL statements that are present in the workload. The filters are applied to the workload by the advisor to focus the tuning effort. Possible filter options are:

- Top resource consuming SQL statements
- Users, module identifier, or actions
- Tables

Recommendation Options



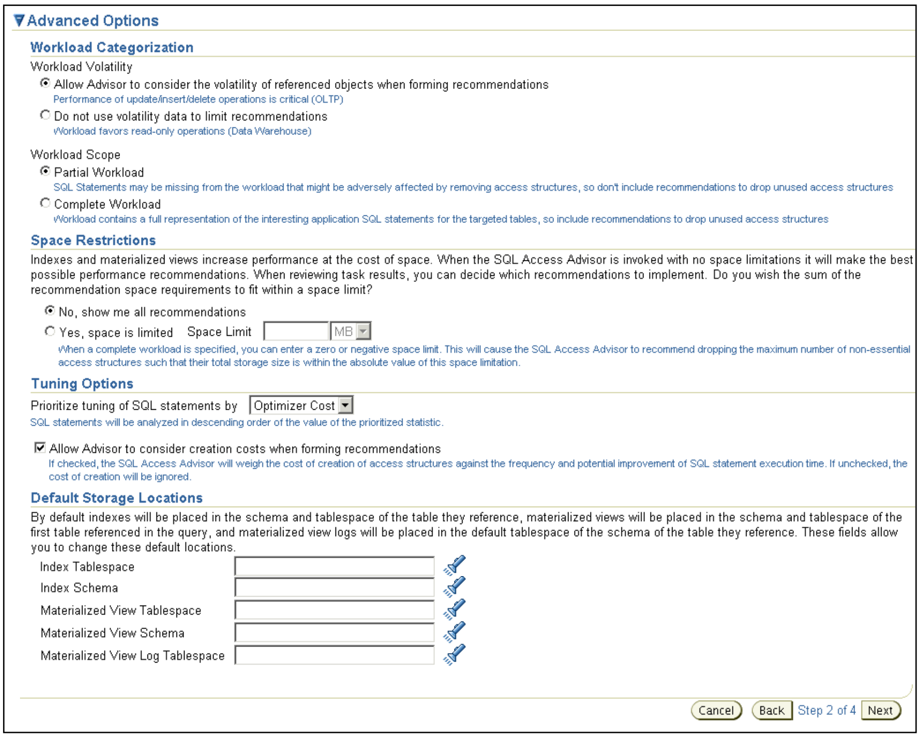
9-33

Recommendation Options

Use the Recommendations Options page to choose whether to limit the advisor to recommendations based on a single access method. Choose Indexes or Materialized Views or both from the Recommendation Types section. You can choose Evaluation Only to evaluate only existing access structures. In this mode, the advisor does not generate new recommendations but comments on the use of existing structures. This is useful to track the effectiveness of the current index, materialized view, and MV log usage over time.

You can use the Advisor Mode section to run the advisor in one of two modes. These modes affect the quality of recommendations as well as the length of time required for processing. In Comprehensive Mode, the advisor searches a large pool of candidates resulting in recommendations of the highest quality. In Limited Mode, the advisor performs quickly, limiting the candidate recommendations.

Recommendation Options



Recommendation Options (continued)

You can choose Advanced Options to show or hide options that enable you to set space restrictions, tuning options, and default storage locations. Use the Workload Categorization section to set options for Workload Volatility and Workload Scope. You can choose to favor read-only operations or you can consider the volatility of referenced objects when forming recommendations. You can also select Partial Workload, which does not include recommendations to drop unused access structures, or Complete Workload, which does include recommendations to drop unused access structures.

Use the Space Restrictions section to specify a hard space limit, which forces the advisor to produce recommendations only with total space requirements that do not exceed the specified limit.

Use the Tuning Options section to specify options that customize the recommendations made by the advisor. Use the "Prioritize Tuning of SQL Statements by" drop-down list to prioritize by Optimizer Cost, Buffer Gets, CPU Time, Disk Reads, Elapsed Time, and Execution Count.

Use the Default Storage Locations section to override the defaults defined for schema and tablespace locations. By default, indexes are placed in the schema and tablespace of the table they reference. Materialized views are placed in the schema and tablespace of the user who executed one of the queries that contributed to the materialized view recommendation.

After you define these parameters, you can schedule and review your tuning task.

Reviewing Recommendations

Reviewing Recommendations

Using the Advisor Central page, you can list all the completed SQL Access Advisor tasks. Select the one for which you want to see the recommendations, and then click the View Result button. Use the Results for Task Summary page to get an overview of the advisor findings. The page presents charts and statistics that provide overall workload performance and query execution time potential improvement for the recommendations. You can use the page to show statement counts and recommendation action counts.

To see other aspects of the results for the advisor task, click one of the three other tabs on the page: Recommendations, SQL Statements, or Details.

The Recommendations page displays a chart and a table that show the top recommendations ordered by their percentage improvement to the total cost of the entire workload. The top recommendations have the biggest total performance improvement.

By clicking the Show SQL button, you can see the generated SQL script for the selected recommendations. You can click the corresponding recommendation identifier in the table to see the list of actions that need to be performed in order to implement the recommendation. On the Actions page, you can actually see all the corresponding SQL statements to execute in order to implement the action. For recommendations that you do not want to implement, keep those check boxes deselected. Then, click the Schedule Implementation button to implement the retained actions. This step is executed in the form of a Scheduler job.

Asynchronous COMMIT

- Tuning
- Statistics
- SGA Attach
- AWR
- Advisors
- > Async. Commit

- The default COMMIT behavior is to wait until redo is saved in the redo log files.
- The default behavior can now be changed to "not wait."
- Asynchronous COMMIT is useful for high transaction throughput.
- However, transactions may be lost.
  – Machine crashes
  – File I/O problems with redo log files

9-36

Asynchronous COMMIT

When a transaction commits, the log writer (LGWR) process writes redo for the commit, along with the accumulated redo of all changes in the corresponding transaction, to disk. By default, the Oracle database writes the redo to disk before the call returns to the client. This behavior introduces a latency in the commit because the application must wait for the redo to be written to disk.

Suppose you are writing an application that requires very high transaction throughput. If you are willing to trade commit durability for lower commit latency, then you can change the default COMMIT options so that the application does not need to wait for the Oracle database to write data to the online redo logs.

Thus, the redo generated for a transaction may not persist when the commit returns to the user. This opens a small window of vulnerability where the transaction that purportedly committed could be rolled back. The most obvious case is where the machine crashes. In this case, any commit redo buffered in the redo log buffers before being written to the online redo log files is also lost. Another case could be when you experience file I/O problems with the online redo logs at the point where LGWR actually attempts to force any redo buffered in the redo log buffer to disk. If the redo logs are not multiplexed to provide a level of redundancy, then it is possible to lose the commit action.

Using Asynchronous COMMIT

- **Possible combinations:**
  - **IMMEDIATE, WAIT (this is the default)**
  - **IMMEDIATE, NOWAIT**
  - **BATCH, WAIT**
  - **BATCH, NOWAIT**
- **System- or session-level examples:**

```
ALTER SYSTEM SET COMMIT_WRITE = IMMEDIATE, WAIT
```

```
ALTER SESSION SET COMMIT_WRITE = IMMEDIATE, NOWAIT
```

- **COMMIT statement examples:**

```
COMMIT WRITE BATCH WAIT
```

```
COMMIT WRITE BATCH NOWAIT
```


Using Asynchronous COMMIT

You can change the commit behavior in the following locations:

- COMMIT_WRITE initialization parameter at the system or session level
- COMMIT statement

The IMMEDIATE option ensures that the redo for the commit of the transaction is written out immediately by the LGWR process; that is, an I/O is initiated. The BATCH option means that the redo is buffered and no I/O is initiated. However, LGWR is still permitted to write the redo to disk in its own time.

The WAIT option ensures that the commit does not return until the redo corresponding to the commit is persisted in the online redo logs. When you use the NOWAIT option, the commit returns without waiting for the commit redo to be written to the online redo logs.

In the absence of any options, the defaults are IMMEDIATE and WAIT, which is consistent with earlier database releases. You cannot specify both BATCH and IMMEDIATE together, nor can you specify both WAIT and NOWAIT together.

After the initialization parameter is set, a COMMIT statement with no options conforms to the options specified in the parameter.

Note: The options in the COMMIT statement override the current settings in the initialization parameter.

Summary

In this lesson, you should have learned how to:

- Diagnose database performance issues
- Configure the Automatic Workload Repository
- Access the database advisors
- Use the SQL Access Advisor to improve database performance
- Use asynchronous `COMMIT` effectively

9-38

Practice Overview: Using ADDM to Diagnose Performance Problems

This practice covers the following topics:

- Viewing and interpreting ADDM findings to diagnose a performance problem
- Implementing those findings

10

Managing Schema Objects

Objectives

Table Types
Partition
IOT
Cluster
DBA Tasks

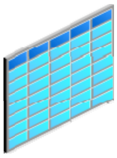
After completing this lesson, you should be able to manage schema objects and:

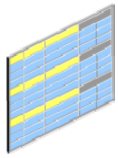
- Determine appropriate table types for your requirements: heap, partition, IOT, or cluster
- Perform related DBA tasks:
  - Estimating the size of new tables
  - Analyzing growth trends
  - Managing optimizer statistics
  - Reorganizing schema objects online

ORACLE

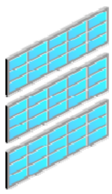
10-2

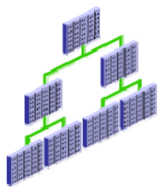
Table Types

Heap 

Clustered 

Type	Description
Ordinary (heap-organized) table	Data is stored as an unordered collection (heap).
Partitioned table	Data is divided into smaller, more manageable pieces.
Index-organized table (IOT)	Data (including non-key values) is sorted and stored in a B-tree index structure.
Clustered table	Related data from more than one table are stored together.

Partitioned 

IOT 

10-3

Table Types

Ordinary “heap-organized” tables are introduced in the *Oracle Database 10g: Administration Workshop I* course.

Partitions are pieces of a table or an index, created to facilitate management of a very large database (VLDB), which could contain several terabytes of data.

Unlike a heap-organized table whose data is stored as an unordered collection (heap), data for an index-organized table (IOT) is stored in a B-tree index structure in a primary key–sorted manner.

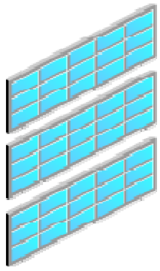
A cluster is a group of tables that share the same data blocks because they share common columns and are often used together.

What Is a Partition and Why Use It?

Table Types
> Partition
IOT
Cluster
DBA Tasks

A partition is:

- A piece of a “very large” table or index
- Stored in its own segment
- Used for improved performance and manageability



ORACLE

10-4

What Is a Partition and Why Use It?

A partition is a piece of a “very large” table or index, stored in its own segment, so that it can be managed individually. An example of a “very large” table is a data warehouse table of several hundred gigabytes of data. Partitions can be further broken down into subpartitions for finer levels of manageability and improved performance.

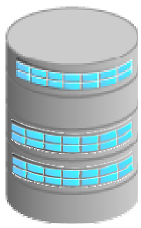
Partitioning can also bring better performance because many queries can ignore partitions that, according to the `WHERE` clause, do not have the requested rows, thereby reducing the amount of data to be scanned to produce a result set.

Operations on partitioned tables and indexes can be performed in parallel by assigning different parallel execution servers to different partitions of the table or index.

Partitions

Characteristics of partitions are:

- **Same logical attributes: Same columns, constraints, and indexes**
- **Different physical attributes: Stored in different tablespaces**
- **Transparent to applications**
- **Several partitioning methods**



10-5

Partitions

Each partition is stored in its own segment and can be managed individually. It can function independently of the other partitions, thereby providing a structure that can be better tuned for availability and performance.

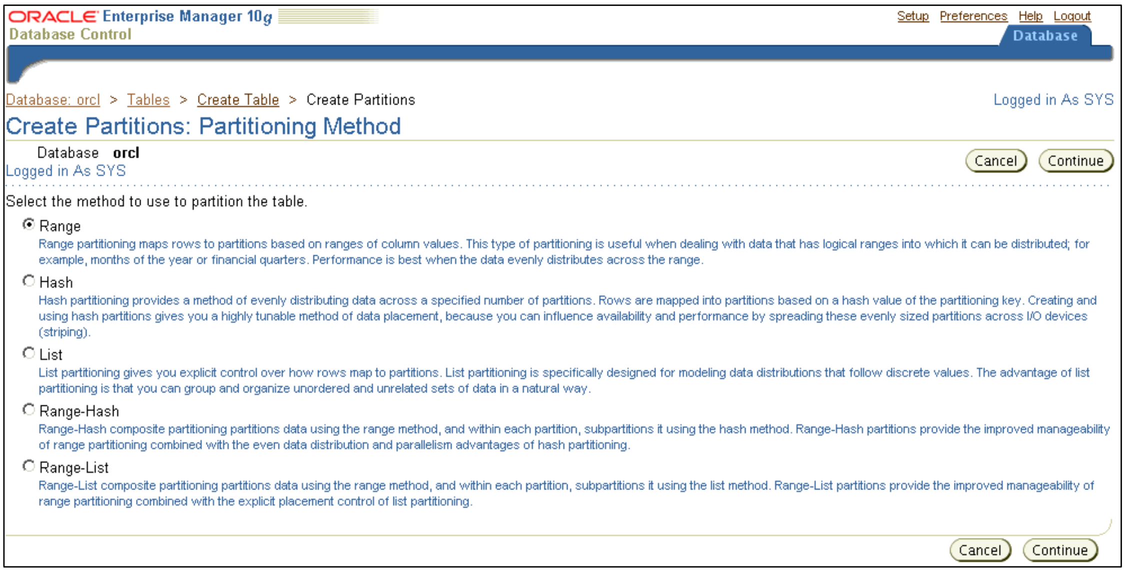
If you are using parallel execution, partitions provide another means of parallelization. Operations on partitioned tables and indexes are performed in parallel by assigning different parallel execution servers to different partitions of the table or index.

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. However, they can have different physical attributes (such as TABLESPACE). Storing partitions in separate tablespaces is advantageous for independent backup and recovery, controlling the mapping to disk drives (balancing IO) and reducing the possibility of data corruption.

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.

For more information about partitioned tables and indexes, including partitioning methods, see the *Oracle Database Administrator's Guide.*

Creating a Partition



ORACLE

Creating a Partition

Database Control supports various types of partitioning for tables and indexes and simplifies their creation process. Wizards take you through this process and advise you on possible options.

Select Administration > Tables. On the Tables page, click the Create button to create a partitioned table. This displays the "Create Table: Table Organization" page, where you can decide whether to create a heap-organized table or an index-organized table. Then, click the Continue button to access the Create Table page. On this page, you can specify the table name and various other information. Click the Partitions tab and then the Create Partitions button. The Create Partitions: Partitioning Method page opens, which is shown in the slide. This is the entry point to the creation wizard for partitioned tables. Decide on the partitioning type, and then click the Continue button. The wizard guides you through the creation process by defining the partition columns and their specifications.

Partitioning Methods

- Range partitioning: Maps rows based on logical ranges of columns values—for example, months in a year
- Hash partitioning: Maps rows based on the hash value of the partitioning key
- List partitioning: Maps rows based on a discrete list of values, provided by the DBA
- Range-hash partitioning: Maps rows using the range method, and within each range partition, creates hash subpartitions
- Range-list partitioning: Maps rows first based on a range of values, then based on discrete values

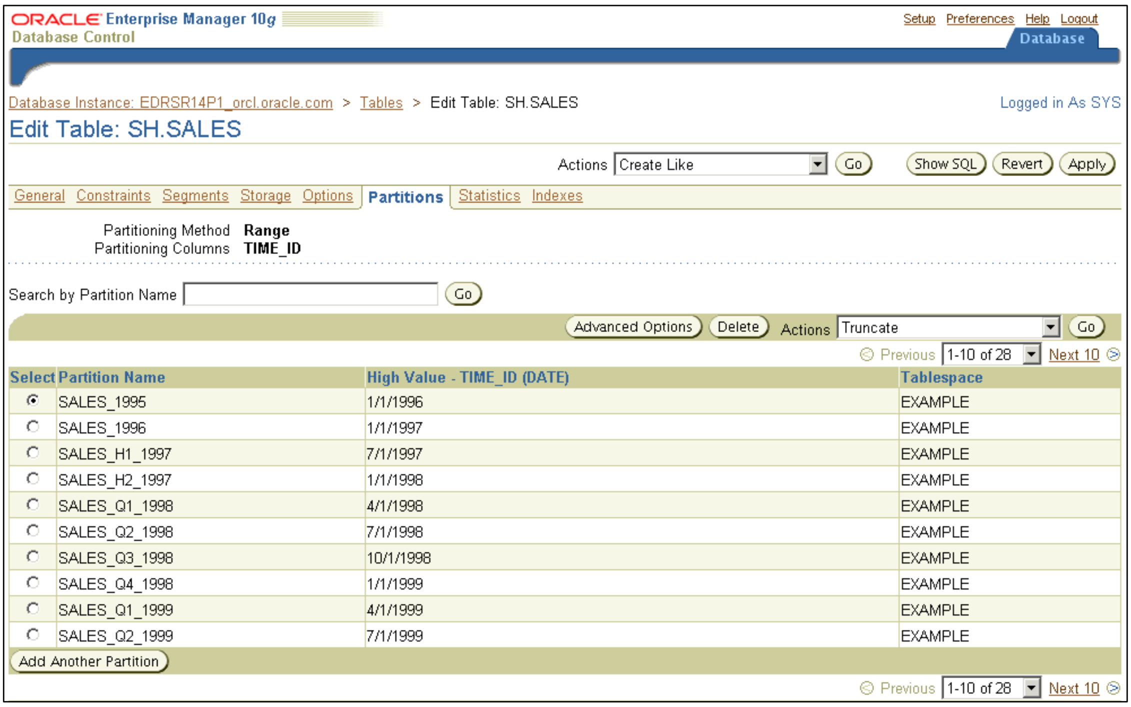
Partitioning Methods

- Performance of **range** partitioning is best when the data evenly distributes across the range.
- **Hash** partitioning means automatic, even distribution of data: The DBA has no control of how a specific row maps to a partition. For example:

  ```
  CREATE TABLE regions
  (region_id NUMBER, region_name VARCHAR2 (25))
  PARTITION BY HASH (region_id)
  PARTITIONS 4 STORE IN (tbs1, tbs2, tbs3, tbs4);
  ```

  This example shows a hash-partitioned table. The partitioning column is `id`; four partitions are created and assigned system-generated names, and they are placed in four tablespaces named `tbs1`, `tbs2`, `tbs3`, and `tbs4`.
- Specify a **list** of discrete values for the partitioning column in the description for each partition, if you require explicit control over how rows map to partitions. For example, specify country or state codes.
- The composite partitions, produced by **range-hash** partitioning, are ideal for both historical data and striping.
- The partitions of a **range-list** partitioned table are logical structures only, because their data is stored in the segments of their subpartitions.

Partition Maintenance



Partition Maintenance

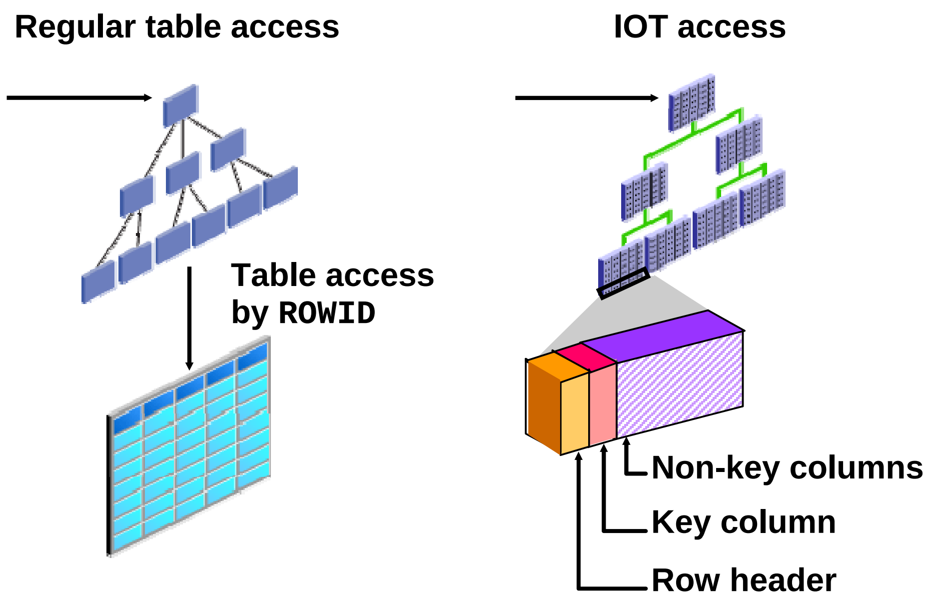
After a partitioned object has been created, you can maintain its partitions by using Database Control.

Select Administration > Tables. Click the partitioned table of interest. This displays the Edit Table page, where you can click the Partitions tab to open the page shown in the slide. You can select a partition of interest and apply a partition maintenance operation to it by selecting the operation from the Actions drop-down list.

Note: Use the Advanced Options button to change the storage characteristics of the selected partition.

Index-Organized Tables

Table Types
Partition
> IOT
Cluster
DBA Tasks



Index-Organized Tables

Unlike an ordinary (heap-organized) table whose data is stored as an unordered collection (heap), data for an index-organized table (IOT) is stored in a B-tree index structure in a primary key–sorted manner. Besides storing the primary key column values, each index entry in the IOT B-tree stores the non-key column values as well.

Index-organized tables have full table functionality. They support features such as constraints, triggers, LOB and object columns, partitioning, parallel operations, online reorganization, and replication. You can even create indexes on an index-organized table.

Index-organized tables are ideal for OLTP applications, which require fast primary key access and high availability. Queries and DML on an orders table used in online order processing are predominantly primary-key based, and a heavy volume of DML causes fragmentation that results in a frequent need to reorganize. Because an index-organized table can be reorganized online and without invalidating its secondary indexes, the window of unavailability is greatly reduced or eliminated.

An index-organized table is an alternative to:

- A table indexed on the primary key by using the `CREATE INDEX` statement
- A cluster table stored in an indexed cluster, which has been created using the `CREATE CLUSTER` statement that maps the primary key for the table to the cluster key

Index-Organized Tables and Heap Tables

- **Compared to heap tables, IOTs:**
  - Have faster key-based access to table data
  - Do not duplicate the storage of primary key values
  - Require less storage
  - Use secondary indexes and logical row IDs
  - Have higher availability because table reorganization does not invalidate secondary indexes
- **IOTs have the following restrictions:**
  - Must have a primary key that is not `DEFERRABLE`
  - Cannot be clustered
  - Cannot use composite partitioning
  - Cannot contain a column of type `ROWID` or `LONG`

ORACLE

10-10

Index-Organized Tables and Heap Tables

Index-organized tables do not have regular (physical) row IDs, but use *logical row IDs* instead. Logical row IDs give the fastest possible access to rows in IOTs by using two methods:

- A *physical guess* whose access time is equal to that of physical row IDs
- Access without the guess (or after an incorrect guess); this performs a primary key access of the IOT

The guess is based on knowledge of the file and block that a row resides in. The latter information is accurate when the index is created, but changes if the leaf block splits. If the guess is wrong and the row no longer resides in the specified block, then the remaining portion of the logical row ID entry, the primary key, is used to get the row.

The Oracle database constructs secondary indexes on index-organized tables by using logical row IDs that are based on the table's primary key. Because rows in index-organized tables do not have permanent physical addresses, the physical guesses can become stale when rows are moved to new blocks.

To obtain fresh guesses, you can rebuild the secondary index. Note that rebuilding a secondary index on an index-organized table involves reading the base table, unlike rebuilding an index on an ordinary table.

Index-Organized Tables and Heap Tables (continued)

A quicker, more lightweight means of fixing the guesses is to use the `ALTER INDEX ... UPDATE BLOCK REFERENCES` statement. This statement is performed online, while DML is still allowed on the underlying index-organized table.

After you rebuild a secondary index, or otherwise update the block references in the guesses, collect index statistics again.

The `UROWID` data type enables applications to use logical row IDs in the same way they use physical row IDs—for example, selecting row IDs for later update or as part of a cursor. `UROWID` can also be used to store row IDs from other databases, accessed through gateways. The `UROWID` type can also be used to reference physical row IDs.

Creating Index-Organized Tables

```
SQL> CREATE TABLE country
  2    ( country_id      CHAR(2)
  3        CONSTRAINT country_id_nn NOT NULL,
  4      country_name    VARCHAR2(40),
  5      currency_name   VARCHAR2(25),
  6      currency_symbol VARCHAR2(3),
  7      map             BLOB,
  8      flag            BLOB,
  9      CONSTRAINT country_c_id_pk
 10        PRIMARY KEY (country_id))
 11    ORGANIZATION INDEX
 12    TABLESPACE indx
 13    PCTTHRESHOLD 20
 14    OVERFLOW TABLESPACE users;
```

ORACLE

Creating Index-Organized Tables

Regular B-tree index entries are usually small. They consist of only the primary key value and a row ID value for each row. Many of these small index entries can be stored in a leaf block. This is not necessarily the case for index-organized tables because they store full rows.

Storing large entries in index leaf blocks slows down index searches and scans. You can specify that the rows go into an overflow area by setting a threshold value that represents a percentage of block size.

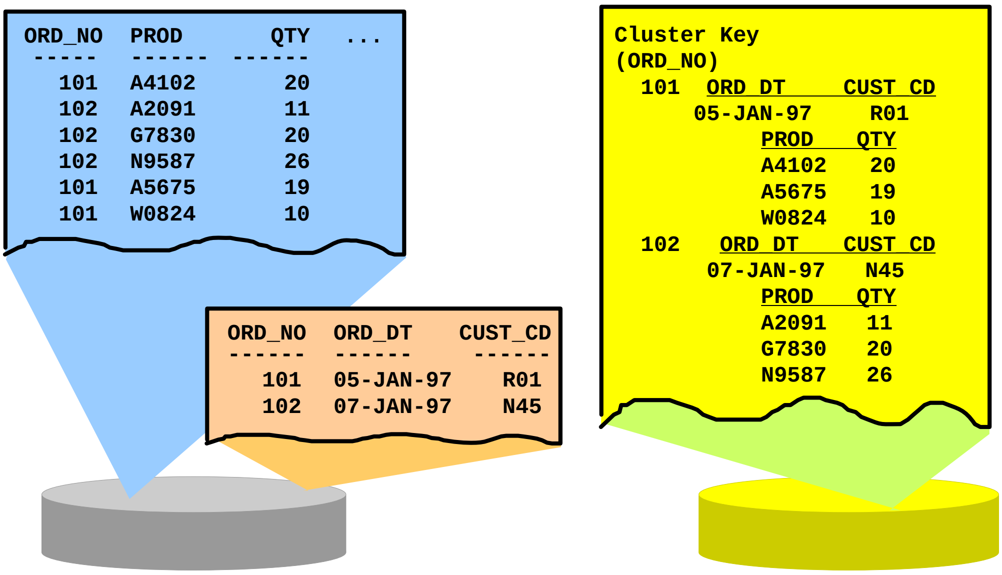
The primary key column must always be stored in the IOT index blocks as a basis for searching. But you can place non-key values in a separate area—the row overflow area—so that the B-tree itself remains densely clustered.

Index-organized tables differ from ordinary tables only in physical organization. Logically, they are manipulated in the same manner as ordinary tables. You can specify an index-organized table just as you would specify a regular table in `INSERT`, `SELECT`, `DELETE`, and `UPDATE` statements.

All of the alter options available for ordinary tables are available for index-organized tables. This includes `ADD`, `MODIFY`, `DROP COLUMNS`, and `DROP CONSTRAINTS`. However, the primary key constraint for an index-organized table cannot be dropped, deferred, or disabled.

Clusters

Table Types
Partition
IOT
> Cluster
DBA Tasks



Unclustered orders and order_item tables

Clustered orders and order_item tables

Definition of Clusters

A cluster is a group of one or more tables that share the same data blocks because they share common columns and are often used together in join queries. Storing tables in clusters offers the DBA a method to denormalize data. If you implement clustered tables in your database, you do not need to change any application code that accesses the tables. Clusters are transparent to the end user and programmer.

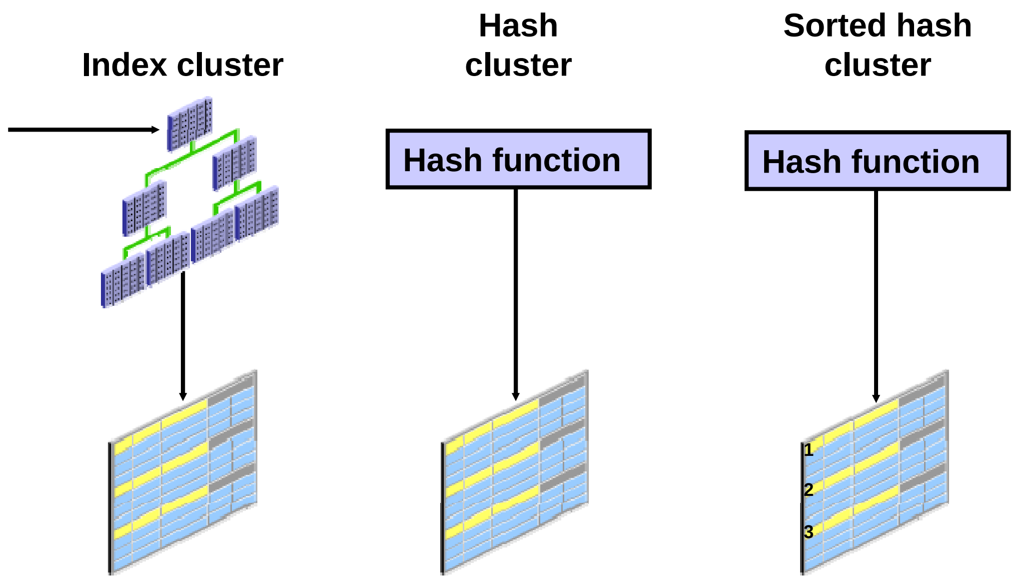
Performance Benefits of Clusters

- Disk I/O is reduced and access time improved for joins of clustered tables.
- Each cluster key value is stored only once for all the rows of the same key value; therefore, it uses less storage space.

Performance Consideration

Full table scans are generally slower on clustered tables than on nonclustered tables.

Cluster Types



Cluster Types

Index Clusters

An index cluster uses an index, known as the cluster index, to maintain the data within the cluster. The cluster index must be available to store, access, or maintain data in an index cluster.

The cluster index is used to point to the block that contains the rows with a given key value. The structure of a cluster index is similar to that of a normal index.

Although a normal index does not store null key values, cluster indexes store null keys. There is only one entry for each key value in the cluster index. Therefore, a cluster index is likely to be smaller than a normal index on the same set of key values.

Hash Clusters

A hash cluster uses a hash algorithm (either user-defined or system-generated) to calculate the location of a row, both for retrieval and for DML operations.

For equality searches that use the cluster key, a hash cluster can provide greater performance gains than an index cluster because there is only one segment to scan (no index access is needed).

Cluster Types (continued)

Sorted Hash Clusters

Inside a sorted hash cluster, the rows are organized in lists of sorted rows. Each list corresponds to a particular value of the hash key columns defined by the corresponding sorted hash cluster. Within each list, the rows are stored in the order specified by the sort key columns that are defined by the corresponding sorted hash cluster. This is also the default return order when querying a sorted hash cluster table by using the hash key columns in the predicate.

Sorted hash clusters offer the benefit of eliminating the CPU time and private memory needed to sort the data for queries that require a guaranteed returned order between SQL statements.

Situations Where Clusters Are Useful

Criterion	Index	Hash	Sorted hash
Uniform key distribution	X	X	X
Evenly distributed key values		X	X
Rarely updated key	X	X	X
Often joined master-detail tables	X		
Predictable number of key values		X	X
Queries using equality predicate on key		X	X
Data is retrieved in the order it was inserted			X

ORACLE

10-16

Situations Where Clusters Are Useful

When Not to Use Clusters

- If the application uses queries joining tables only occasionally or modifies their common column values frequently. Modifying a row's cluster key value takes longer than modifying the value in an unclustered table because the Oracle database might need to migrate the modified row to another block to maintain the cluster.
- If a full scan is executed often on only one of the clustered tables. This table is stored on more blocks than if it had been created alone.
- If the data for all rows of a cluster key value exceed one or two Oracle blocks. To access an individual row in a clustered key table, the Oracle server reads all blocks containing rows with the same value.

When Not to Use Hash Clusters

- If the table is constantly growing or if the application frequently modifies the cluster key values
- If your application often performs full table scans and you must allocate a great deal of space to the hash cluster in anticipation of the table growing

Hash and index clusters require a lot of planning before being used. There may be more performance overhead involved for major operations such as bulk (direct path) inserts and rebuilds.

Sorted Hash Cluster: Overview

- New data structure used to store data sorted by nonprimary key columns:
  - Cluster key values are hashed.
  - Rows corresponding to a particular cluster key value are sorted according to the sort key.
- Used to guarantee that row order is returned by queries without sorting data:
  - Rows are returned in ascending or descending order for a particular cluster key value.
  - `ORDER BY` clause is not mandatory to retrieve rows in ascending order.

ORACLE

Sorted Hash Cluster: Overview

When the Oracle database stores data in a heap-organized table, the rows are not stored in a user-controlled order. Rather, the decision about where to place a row is dependent on storage heuristics. The Oracle database does not guarantee the return order of the rows unless the query includes an `ORDER BY` clause.

Inside a sorted hash cluster, the rows are organized in lists of sorted rows. Each list corresponds to a particular value of the hash key columns defined by the corresponding sorted hash cluster. Within each list, the rows are stored in the order specified by the sort key columns defined by the corresponding sorted hash cluster. This is also the default return order when querying the table by using the hash key columns in the predicate.

Sorted hash clusters offer the benefit of eliminating the CPU time and private memory needed to sort the data for queries that require a guaranteed returned order between SQL statements.

When querying data in a sorted hash–clustered table by cluster key columns with an `ORDER BY` clause that references only the sort key columns or one of their prefixes, the optimizer avoids the sorting overhead because the rows are returned sorted by the sort key columns. However, for the same kind of queries, if you have an `ORDER BY` clause on a suffix of the sort key columns or nonsort key columns, additional sorting is required, assuming that no indexes are defined on the table. For this reason, when you create a sorted hash cluster, select its order key columns carefully.

Sorted Hash Cluster: Example

```
CREATE CLUSTER calls_cluster
( origin_number   NUMBER               Cluster key
, call_timestamp NUMBER SORT
, call_duration   NUMBER SORT)          Sort key
HASHKEYS 10000
SINGLE TABLE HASH IS origin_number
SIZE 50;
```

```
CREATE TABLE calls
( origin_number   NUMBER
, call_timestamp NUMBER
, call_duration   NUMBER
, other_info      VARCHAR2(30))
CLUSTER calls_cluster(
origin_number,call_timestamp,call_duration
);
```


Sorted Hash Cluster: Example

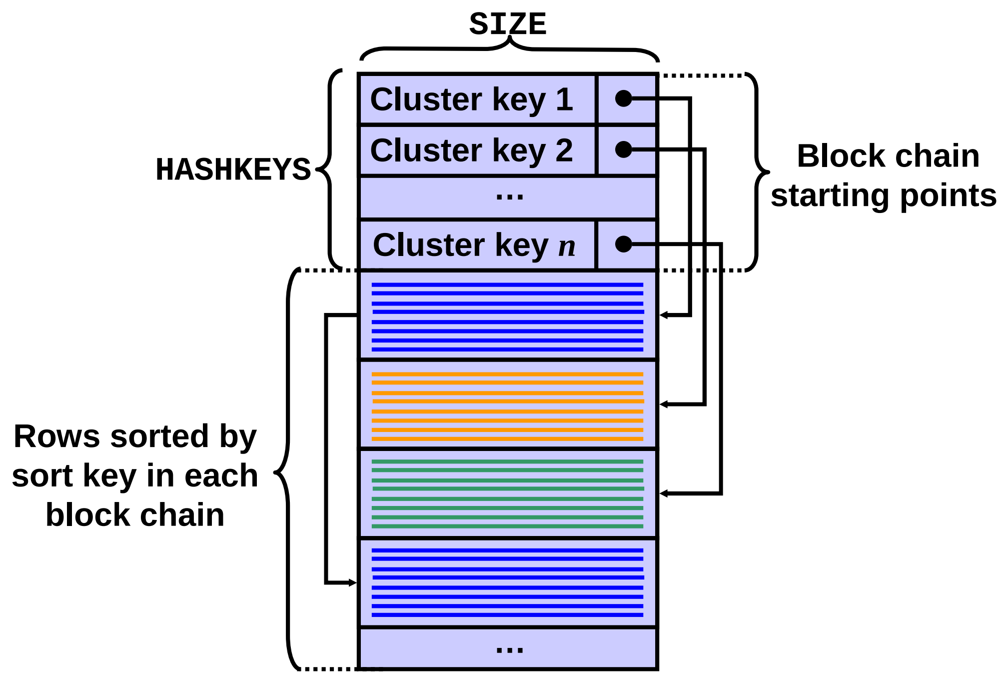
The way you define sorted hash clusters is very similar to the way you create hash clusters.

In the first step, you create the sorted hash cluster. As you can see, the most important difference with a traditional hash cluster is that you need to define the sort key columns in addition to the cluster key columns. Here, the cluster key is `ORIGIN_NUMBER`, and the sort key columns are `CALL_TIMESTAMP` and `CALL_DURATION`. Another difference with traditional hash clusters is that for sorted hash clusters, the `SIZE` parameter specifies how many metadata entries to store for a particular hash key value. The size of one metadata entry is mainly determined by the size of the cluster key columns.

In the second step, you create the actual table specifying the link to the sorted hash cluster with the `CLUSTER` clause. You must specify the cluster key columns in the correct order followed by the sort key columns in the correct order. The example in the slide represents the following scenario: A telecommunications company needs to store call records for a fixed number of originating telephone numbers through a telecommunications switch. From each originating telephone number, there can be an unlimited number of telephone calls. Calls are stored as they are made and processed later in a “first-in, first-out” order when bills are generated for each originating telephone number. Each call is identified by a time-stamp number.

Note: Although the example uses a single table hash cluster, you can store more than one table in a sorted hash cluster. This is similar to traditional hash clusters.

Sorted Hash Cluster: Basic Architecture



ORACLE

10-19

Sorted Hash Cluster: Basic Architecture

In the example in the previous slide, only one table is stored in the sorted hash cluster. Also, the hash function is very simple and no collision is expected. This is because the hash function is determined by the cluster key itself, and each cluster key value is unique. Basically, `HASHKEYS` represents the number of different originating telephone numbers, and `SIZE` represents the number of bytes used to store each cluster key metadata.

As you can see, the first part of the sorted hash cluster segment is reserved to store the metadata entries. Each metadata entry contains a link to the list of its corresponding rows. Each list is made up of a series of Oracle blocks that are linked together. Each list is sorted according to the sort key columns.

Whenever you want to retrieve the rows for a corresponding cluster key value, the cluster key value is hashed to its metadata entry location, which gives the sorted list of rows that you are selecting.

Schema Management Tasks

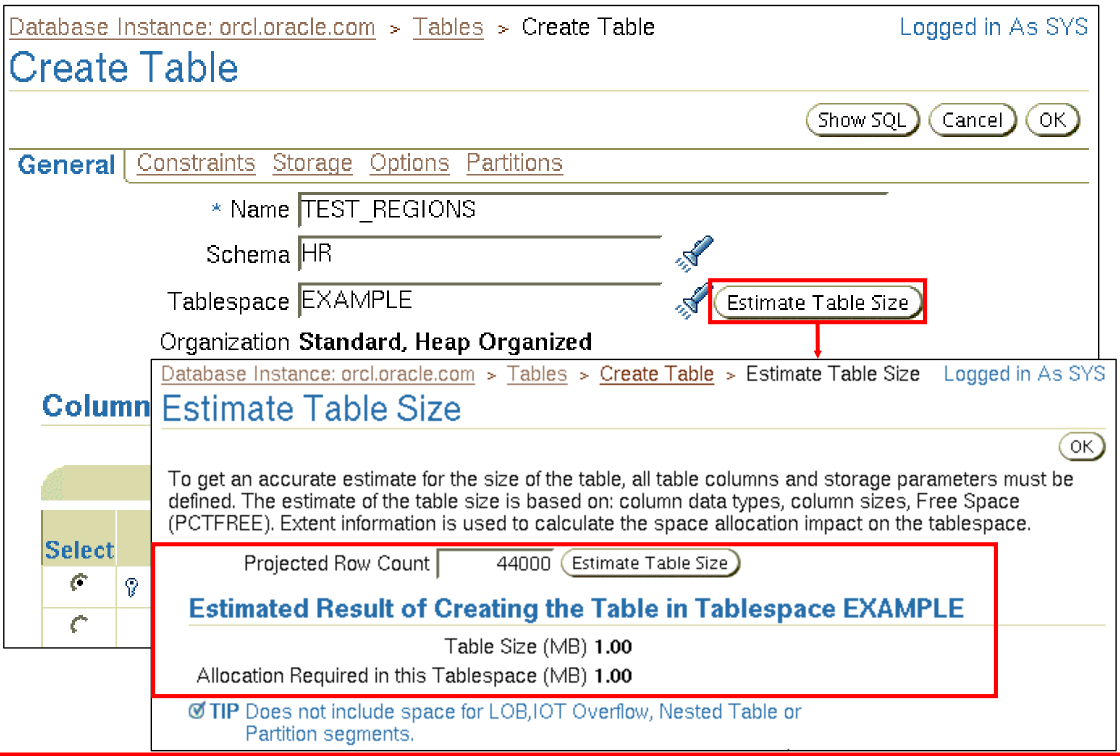
Table Types
Partition
IOT
Cluster
\> DBA Tasks

DBA tasks include:

- Estimating the size of new tables
- Analyzing growth trends
- Managing optimizer statistics
- Reorganizing schema objects online

ORACLE

Estimating Resource Usage



10-21

Estimating Resource Usage

The resource estimation feature enables you to estimate the amount of resources the creation of a new segment would require. Based on the structure of a table or index, and the number of estimated rows in the table, the Oracle database estimates the amount of disk space likely to be consumed by the object.

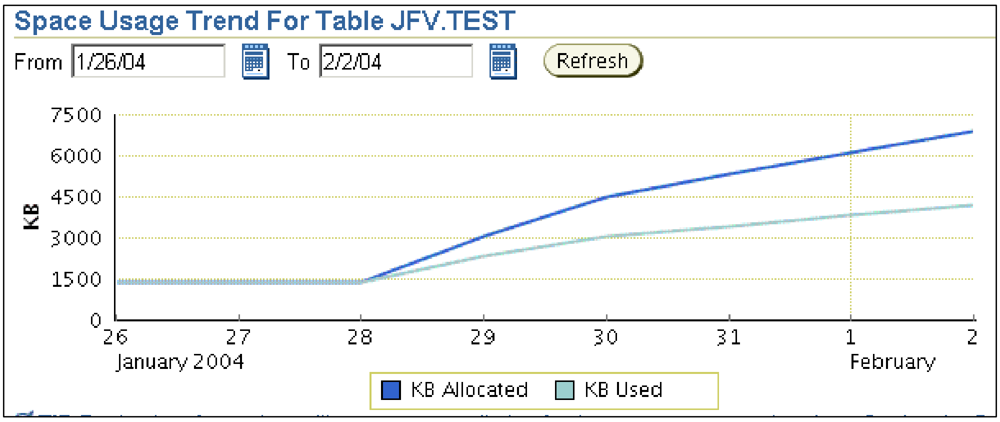
For example, the estimation of a table size is based on the following data: column data types, column sizes, and PCTFREE. Extent information is also used to calculate the space allocation impact on the currently selected tablespace.

To access this feature for tables, from the Administration page, select Tables in the Storage section, and then click Create to create the new table. You can also use the “Create like” functionality. Specify the tablespace and columns with data types and lengths, and then click the “Estimate Table Size” button. Now, specify the “Projected Row Count” and click the “Estimate Table Size” button to get both the estimated table size and the corresponding space allocated in the tablespace.

Analyzing Growth Trends

EM growth trend report:

- **Used by the Segment Advisor**
- **Space usage statistics collected into AWR**



Analyzing Growth Trends

Segment growth reporting makes critical growth data available for advisories and reporting tools such as the Segment Advisor and the Growth Trend Report graph.

Some characteristics of the growth trend report feature include:

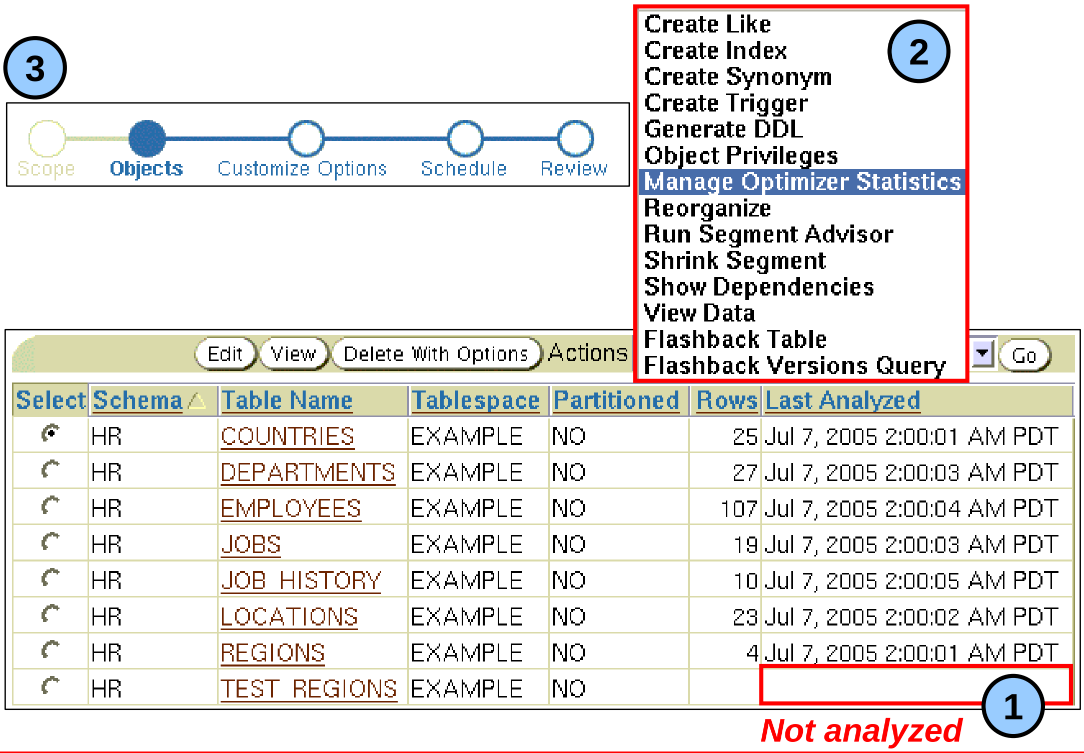
- Automatic workload repository data analysis. The workload repository collects the persistent space usage statistics and stores it in a system-defined schema. These statistics are captured at snapshot creation, and when alerts are triggered.
- Indications of past growth trend and predictions of future growth patterns
- Support for locally managed tablespaces only

The growth trend report consists of two components: growth history and growth forecast. The growth history charts past space usage data. The growth forecast predicts future space requirements by using history information and straight-line projection.

In Database Control, select Administration > Tables. Select your desired table, click Edit, and then click the Segments tabbed page.

The screenshot shows you such a report. You can choose the analysis period, and from the calculated graph, you can see the point in time at which you may have to allocate more space to your segment.

Managing Optimizer Statistics



ORACLE

10-23

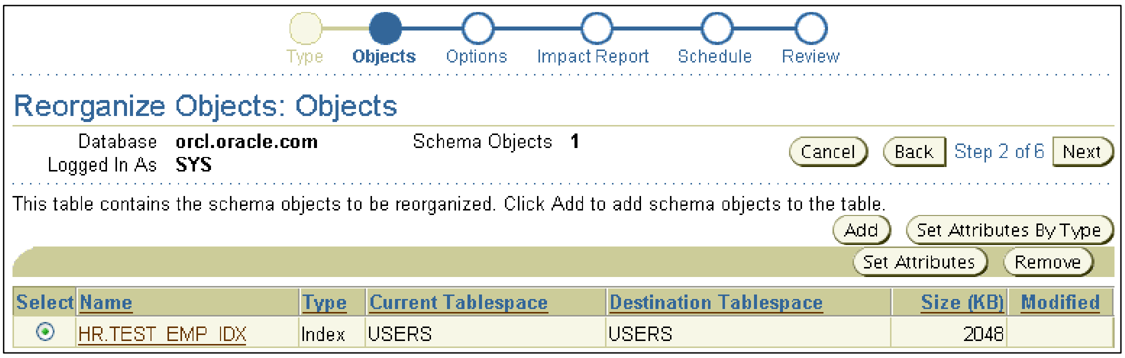
Managing Optimizer Statistics

Best practices recommend that you gather statistics after major DML activities, such as after inserting 9,000 rows. The list of tables in the example (1) shows you that the `TEST_REGIONS` table has not been analyzed.

In Enterprise Manager, choose Administration > Tables. Select “Manage Optimizer Statistics” from the Actions drop-down list (2), and follow the wizard (3) to create an Optimizer Statistics job.

Reorganizing Schema Objects Online

- Modifying logical or physical structure of a schema object, such as a table or index
- Transparent to users
- Space requirements



Reorganizing Schema Objects Online

Sometimes, you may need to modify the logical or physical structure of a table to manage storage, improve performance, or accommodate new applications. To perform this task, while the table remains accessible to both queries and DML, use the Reorganize Objects wizard in Enterprise Manager or the `DBMS_REDEFINITION` package.

Reorganizing tables online provides a substantial increase in availability compared to traditional methods of redefining tables. The table is locked in exclusive mode only during a very small window that is independent of the size of the table and complexity of the redefinition, and that is completely transparent to users.

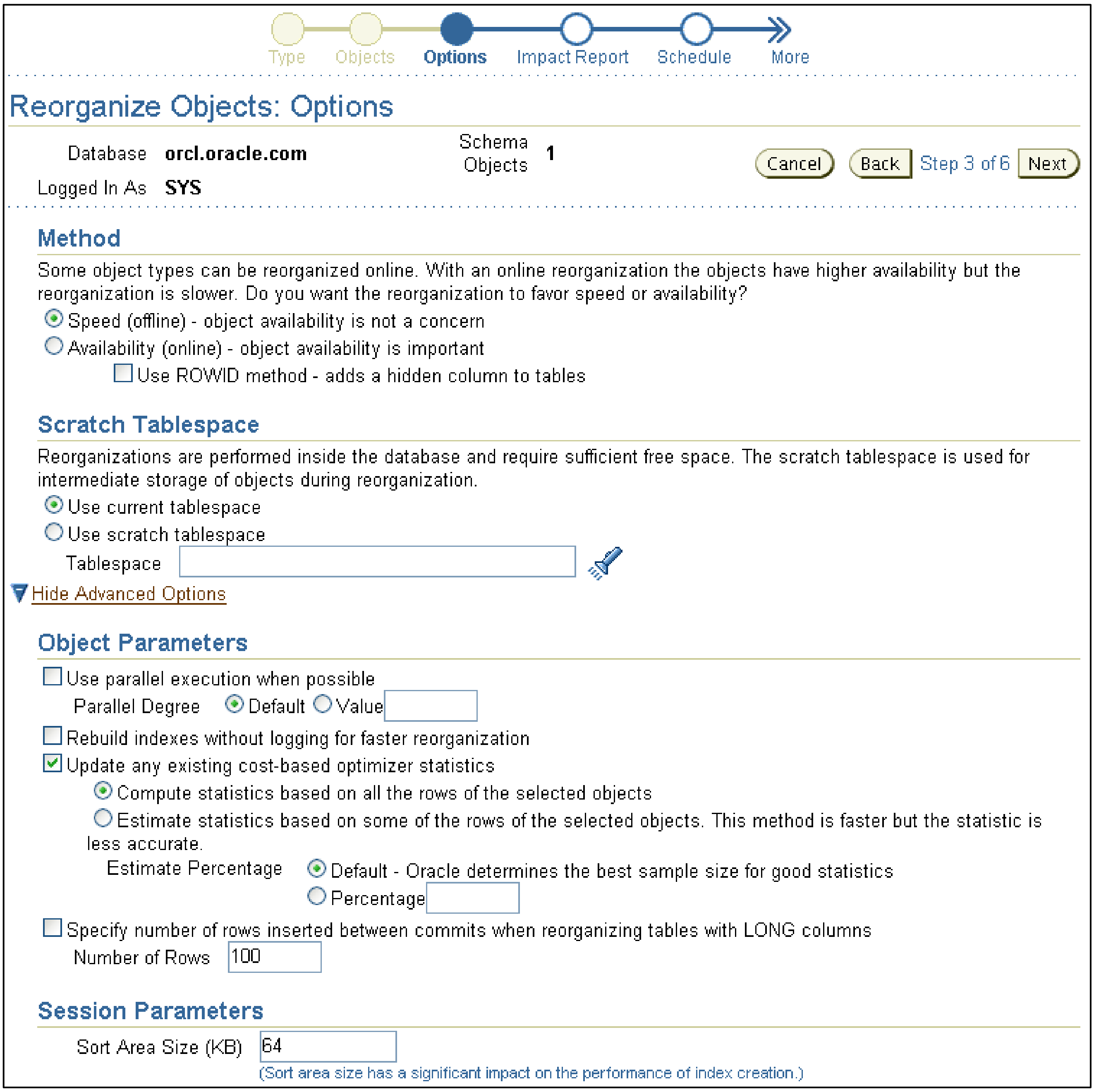
This process requires an amount of free space that is approximately equivalent to the space used by the table being redefined. More space may be required if new columns are added.

Online reorganization can be used for:

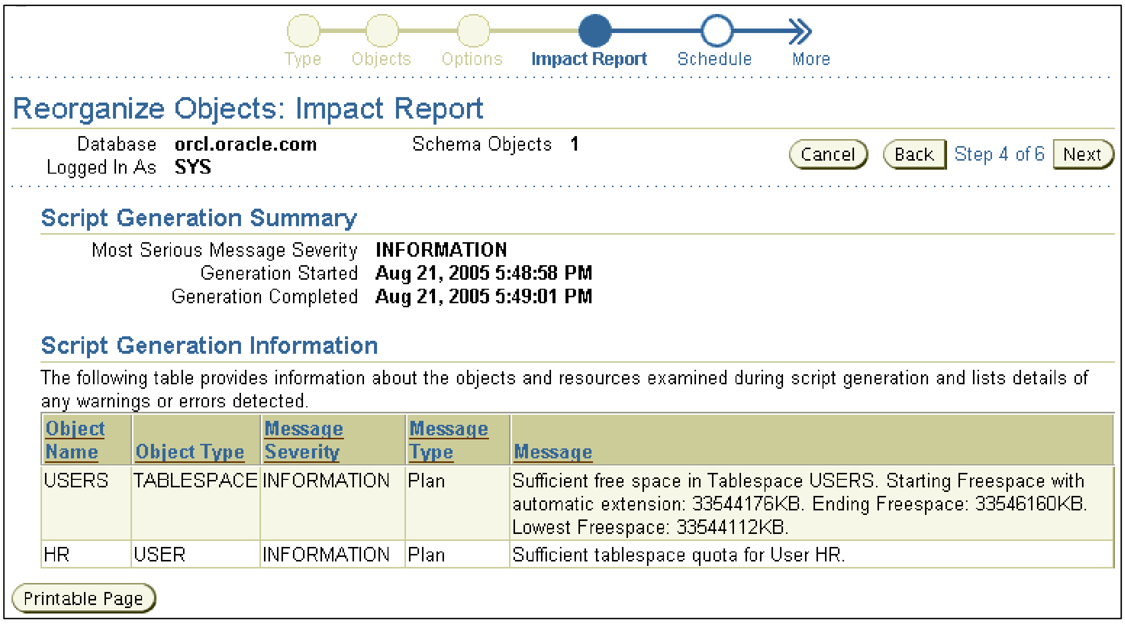
- Rebuilding fragmented indexes
- Rebuilding fragmented tables
- Relocating objects to another tablespace
- Re-creating objects with better storage attributes

Reorganizing Schema Objects Online (continued)

Options to customize your reorganization:



Reorganizing Objects: Impact Report



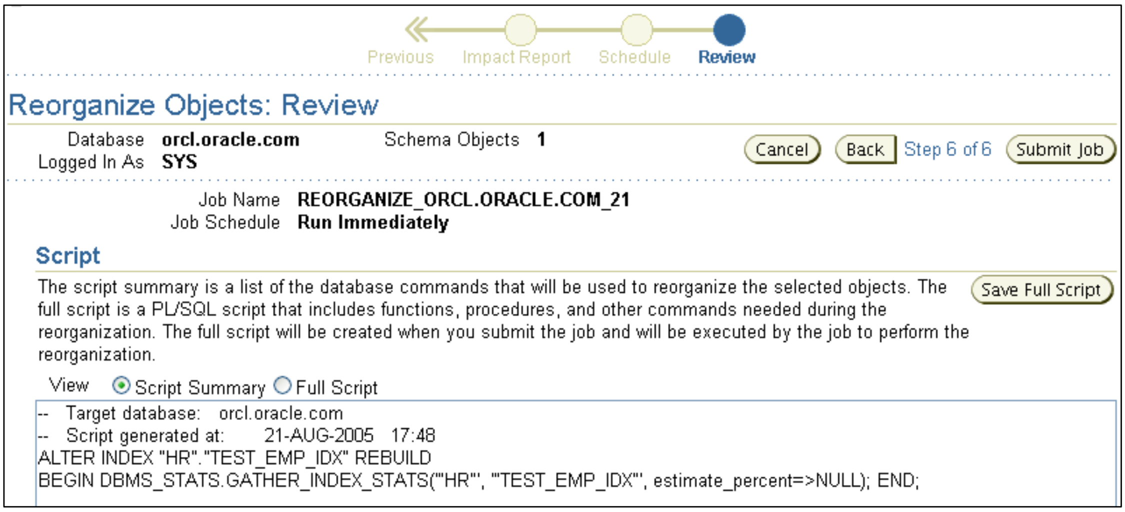
ORACLE

10-26

Reorganizing Objects: Impact Report

Before any commands are executed, the impact report provides you with errors or warnings and an overview of planned activities, such as rebuilding an index.

Reorganizing Objects: Review



Reorganizing Objects: Review

For a detailed understanding of the commands that will be executed, select Full Script and view all the relevant statements. If you prefer a simpler overview of this reorganization, select Script Summary.

Basic Steps for Manual Online Reorganization

1. **Verify that the table is a candidate for online reorganization.**
2. **Create an interim table.**
3. **Start the redefinition process.**
4. **Copy dependent objects. (This automatically creates any triggers, indexes, grants, and constraints on the interim table.)**
5. **Query the `DBA_REDEFINITION_ERRORS` view to check for errors.**
6. **Optionally, synchronize the interim table.**
7. **Complete the redefinition.**
8. **Drop the interim table.**

Basic Steps for Manual Online Reorganization

Commands and procedures used:

1. `DBMS_REDEFINITION.CAN_REDEF_TABLE`
2. `CREATE TABLE …`
3. `DBMS_REDEFINITION.START_REDEF_TABLE`
4. `DBMS_REDEFINITION.COPY_TABLE_DEPENDENTS` and `DBMS_REDEFINITION.CONS_ORIG_PARAMS`
5. `SELECT object_name, base_table_name, ddl_txt FROM DBA_REDEFINITION_ERRORS;`
6. `DBMS_REDEFINITION.SYNC_INTERIM_TABLE`
7. `DBMS_REDEFINITION.FINISH_REDEF_TABLE`
8. `DROP TABLE … PURGE`

Summary

In this lesson, you should have learned how to manage schema objects and:

- Determine appropriate table types for your requirements
- Perform related DBA tasks:
  - Estimating the size of new tables
  - Analyzing growth trends
  - Managing optimizer statistics
  - Reorganizing schema objects online

Practice Overview: Managing Schema Objects

This practice covers the following topics:

- Monitoring table and index space usage
- Managing optimizer statistics
- Reorganizing table and index

11

Managing Storage

Objectives

- Space Management
- Proactive Monitoring
- Seg. Advisor & Seg.Shrink
- Resumable Allocation
- Transportable TBS and DB

After completing this lesson, you should be able to:

- **Describe how the Oracle database automatically manages space**
- **Proactively monitor and manage tablespace space usage**
- **Use the Segment Advisor**
- **Reclaim wasted space from tables and indexes by using the segment shrink functionality**
- **Manage resumable space allocation**
- **Describe the concepts of transportable tablespaces and databases**

ORACLE

11-2

Space Management: Overview

Space is automatically managed by the Oracle database. It generates alerts about potential problems and recommends possible solutions. Features include:

- **Oracle Managed Files (OMF)**
- **Free-space management with bitmaps ("locally managed") and automatic data file extension**
- **Proactive space management (default thresholds and server-generated alerts)**
- **Space reclamation (shrinking segments, online table redefinition)**
- **Capacity planning (growth reports)**

Space Management: Overview

With Oracle Managed Files (OMF), you can specify operations in terms of database objects rather than file names. For more details, see the lesson titled "Introduction."

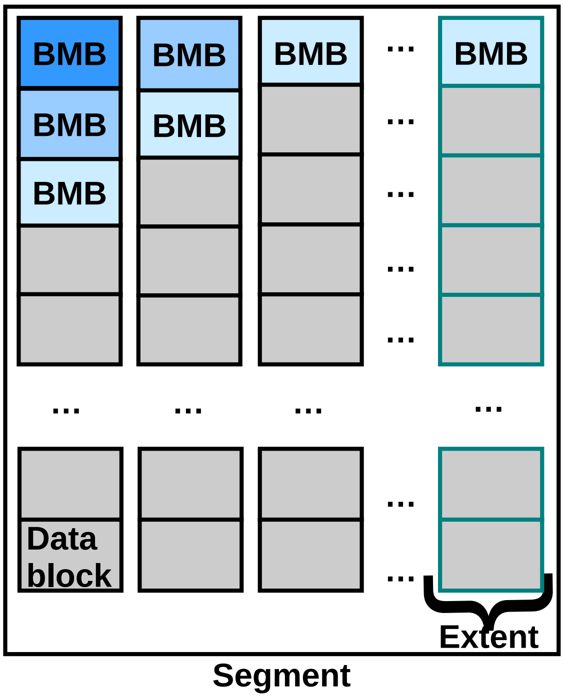
The Oracle database manages free space within a table with bitmaps. This is known as a "locally managed" tablespace. (Dictionary-managed tablespaces are supported only for backward compatibility.) The bitmapped implementation eliminates much space-related tuning of tables, while providing improved performance during peak loads. Additionally, the Oracle database provides automatic extension of data files, so the files can grow automatically based on the amount of data in the files.

When you create a database, proactive space monitoring is enabled by default. (This causes no performance impact.) The Oracle database monitors space utilization during normal space allocation and deallocation operations and alerts you if the free space availability falls below the predefined thresholds (which you can override). Advisors and wizards assist you with space reclamation.

For capacity planning, the Oracle database provides space estimates based on table structure and number of rows and a growth trend report based on historical space utilization stored in the Automatic Workload Repository (AWR).

The *Oracle Database 10g: Administration Workshop I* course provides an introduction to space and storage concepts, related utilities, and DBA tasks. Through this or other means, you should be familiar with the basic concepts and storage features.

Free Space Management



- Automatic
- Enabled by the use of locally managed tablespaces
- Tracked by bitmaps in segments

Benefits:

- More flexible space utilization
- Run-time adjustment
- Multiple process search of BMBs

11-4

Free Space Management

Free space can be managed automatically inside database segments. The in-segment free or used space is tracked with bitmaps. You specify Automatic Segment Space Management, when you create a locally managed tablespace. Your specification then applies to all segments subsequently created in this tablespace.

Automatic space management segments have a set of bitmap blocks (BMBs) describing the space utilization of the data blocks in that segment. BMBs are organized in a tree hierarchy. The root level of the hierarchy, which contains the references to all intermediate BMBs, is stored in the segment header. The leaves of this hierarchy represent the space information for a set of contiguous data blocks that belong to the segment. The maximum number of levels inside this hierarchy is three.

Benefits of using automatic space management (compared to manual space management, which uses “freelist” data structures and is synonymous with “dictionary-managed” tablespaces):

- Better space utilization, especially for the objects with highly varying row sizes
- Better run-time adjustment to variations in concurrent access
- Better multi-instance behavior in terms of performance or space utilization

Therefore, less work for you, the DBA.

Types of Segments

A segment is a set of extents allocated for a certain logical structure. The different types of segments are:

- Data segment
- Index segment
- Temporary segment

Segments are dynamically allocated by the database.

11-5

Types of Segments

Data segment: Each nonclustered table has a data segment. All table data is stored in the extents of the data segment. For a partitioned table, each partition has a data segment. Each cluster has a data segment. The data of every table in the cluster is stored in the cluster's data segment.

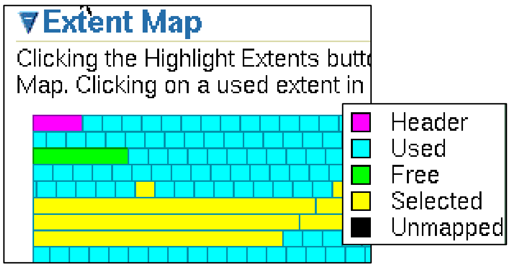
Index segment: Each index has an index segment that stores all of its data. For a partitioned index, each partition has an index segment.

Temporary segment: A temporary segment is created by the Oracle database when a SQL statement needs a temporary database area to complete execution. When the statement finishes execution, the extents in the temporary segment are returned to the system for future use.

The Oracle database dynamically allocates space when the existing extents of a segment become full. Because extents are allocated as needed, the extents of a segment may or may not be contiguous on disk.

Allocating Extents

- Searching the data file’s bitmap for the required number of adjacent free blocks
- Sizing extents with storage clauses:
  - `UNIFORM`
  - `AUTOALLOCATE`
- Viewing extent map
- Obtaining deallocation advice



Allocating Extents

With locally managed tablespaces, the Oracle database looks for free space to allocate to a new extent by first determining a candidate data file in the tablespace and then searching the data file’s bitmap for the required number of adjacent free blocks. If that data file does not have enough adjacent free space, then the Oracle database looks in another data file.

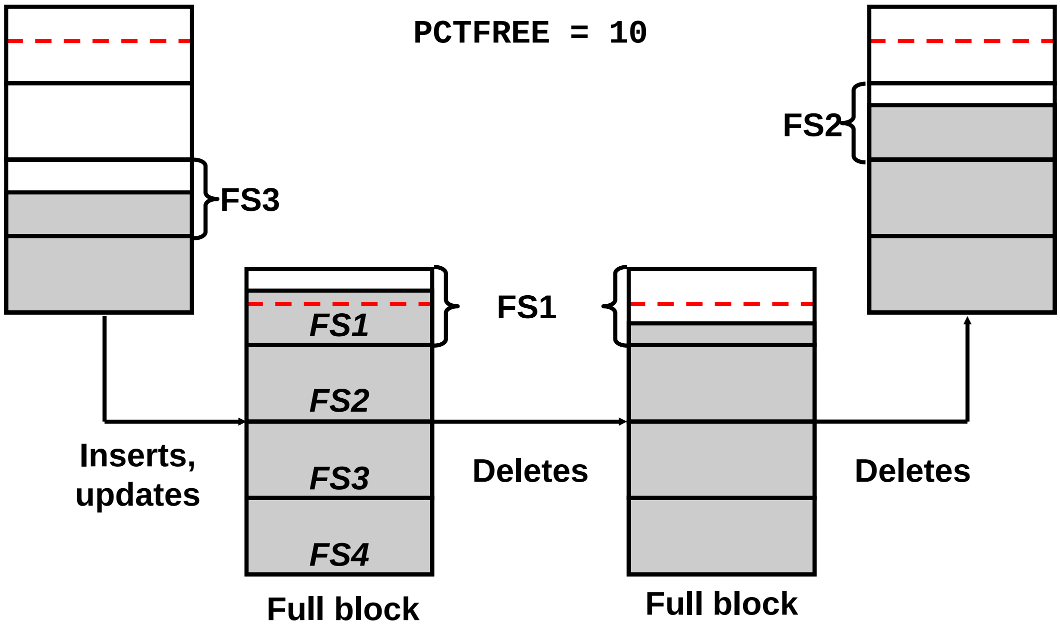
Two clauses affect the sizing of extents:

- With the `UNIFORM` clause, the database creates all extents of a uniform size that you specified (or a default size) for any objects created in the tablespace.
- With the `AUTOALLOCATE` clause, the database determines the extent-sizing policy for the tablespace.

To view the extent map in Enterprise Manager, choose Administration > Tablespaces > View Tablespace > Show Tablespace Contents.

The Oracle database provides a Segment Advisor that helps you determine whether an object has space available for reclamation on the basis of the level of space fragmentation within the object.

Block Space Management



Block Space Management

Space management involves the management of free space at the block level. With Automatic Segment Space Management, each block is divided into four sections, named FS1 (between 0 and 25% of free space), FS2 (25% to50% free), FS3 (50% to 75% free), and FS4 (75% to 100% free).

Depending on the level of free space in the block, its status is automatically updated. That way, depending on the length of an inserted row, you can tell whether a particular block can be used to satisfy an insert operation. Note that a "full" status means that a block is no longer available for inserts.

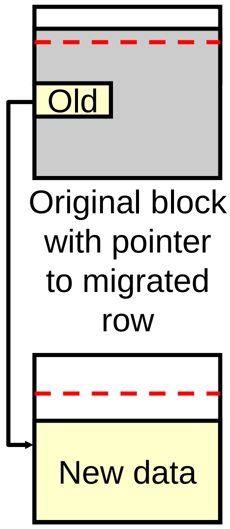
In the slide example, the block on the left is an FS3 block because it has between 50% and 75% free space. After some insert and update statements, `PCTFREE` is reached (the dashed line) and it is no longer possible to insert new rows in that block. The block is now considered as a "full" or FS1 block. The block is considered for insertion again, as soon as its free space level drops below the next section. In the above case, it gets status FS2 as soon as the free space is more than 25%.

Note: Large object (LOB) data types (`BLOB`, `CLOB`, `NCLOB`, and `BFILE`) do not use the `PCTFREE` storage parameter. For more information, see the *Oracle Database Application Developer's Guide - Large Objects 10g Release 2 (10.2).*

Row Chaining and Migration

Example:

- **On update: Row length increases, exceeding the available free space in the block.**
- **Data needs to be stored in a new block.**
- **Original physical identifier of row (`ROWID`) is preserved.**
- **The Oracle database needs to read two blocks to retrieve data.**
- **The Segment Advisor finds segments containing the migrated rows.**



Row Chaining and Migrating

In two circumstances, the data for a row in a table may be too large to fit into a single data block. In the first case, the row is too large to fit into one data block when it is first inserted. In this case, the Oracle database stores the data for the row in a chain of data blocks (one or more) reserved for that segment. Row chaining most often occurs with large rows, such as rows that contain a column of data type `LONG` or `LONG RAW`. Row chaining in these cases is unavoidable.

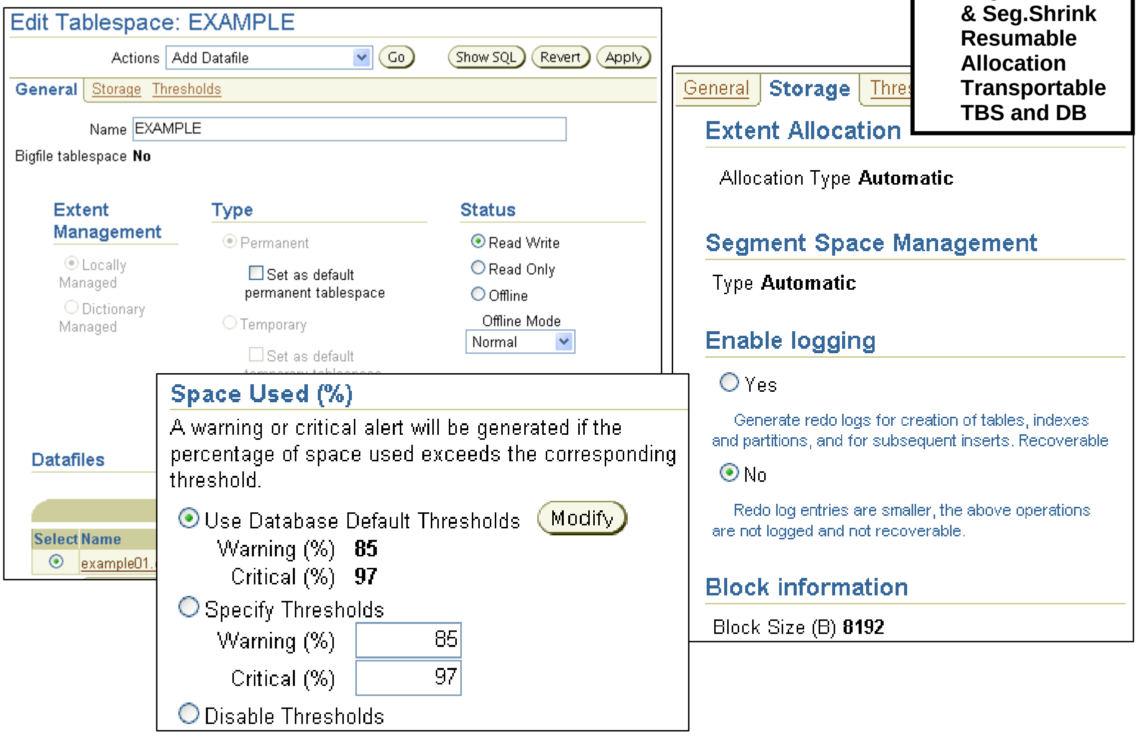
However, in the second case, a row that originally fit into one data block is updated, so that the overall row length increases, and the block's free space is already completely filled. In this case, the Oracle database migrates the data for the entire row to a new data block, assuming that the entire row can fit in a new block. The database preserves the original row piece of a migrated row to point to the new block containing the migrated row. The `ROWID` of a migrated row does not change.

When a row is chained or migrated, I/O performance associated with this row decreases because the Oracle database must scan more than one data block to retrieve the information for the row.

The Segment Advisor finds the segments containing migrated rows that result from an `UPDATE`.

Proactive Tablespace Monitoring

Space Management
> **Proactive Monitoring**
Seg. Advisor & Seg.Shrink
Resumable
Allocation
Transportable TBS and DB



ORACLE

11-9

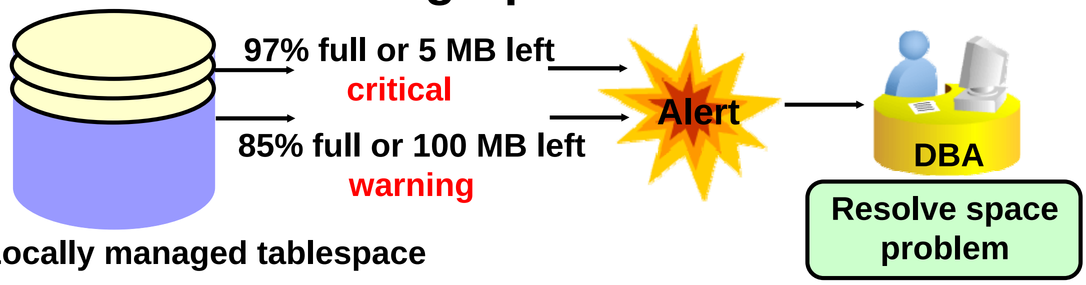
Proactive Tablespace Monitoring

Tablespace disk space usage is proactively managed by the database in the following ways:

- Through the use of database alerts, you are informed when a tablespace runs low on available disk space as well as when particular segments are running out of space. You can then provide the tablespace with more disk space, thus avoiding out-of-space conditions.
- Information gathered is stored in the Automatic Workload Repository (AWR) and is used to perform growth trend analysis and capacity planning of the database.

To view and modify tablespace information in Enterprise Manager, select Administration > Tablespaces. Select the tablespace of your choice and click the Edit button.

Thresholds and Resolving Space Problems



Resolve space problem by:

- Adding or resizing data file
- Setting `AUTOEXTEND ON`
- Shrinking objects
- Reducing `UNDO_RETENTION`
- Checking for long-running queries in temporary tablespaces

Thresholds and Resolving Space Problems

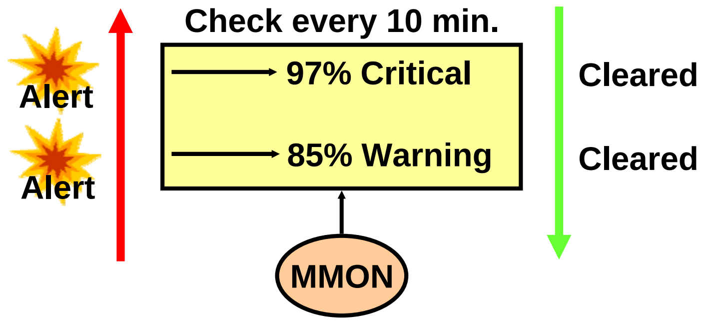
Tablespace thresholds are defined either as full or as available space in the tablespace. Critical and warning thresholds are the two thresholds that apply to a tablespace. The `DBMS_SERVER_ALERT` package contains procedures to set and get the threshold values. When the tablespace limits are reached, an appropriate alert is raised. The threshold is expressed in terms of a percentage of the tablespace size or in remaining bytes free. It is calculated in memory. You can have both a percentage and a byte-based threshold defined for a tablespace. Either or both of them may generate an alert.

The ideal setting for the warning threshold trigger value results in an alert that is early enough to ensure that there is enough time to resolve the problem before it becomes critical, but late enough so that you are not bothered when space is not a problem.

The alert indicates that the problem can be resolved by doing one or more of the following:

- Adding more space to the tablespace by adding a file or resizing existing files, or making an existing file autoextendable
- Freeing up space on disks that contain any autoextendable files
- Shrinking sparse objects in the tablespace

Monitoring Tablespace Space Usage



- Read-only and offline tablespaces: Do not set up alerts.
- Temporary tablespace: Threshold corresponds to space currently used by sessions.
- Undo tablespace: Threshold corresponds to space used by active and unexpired extents.
- Autoextensible files: Threshold is based on the maximum file size.

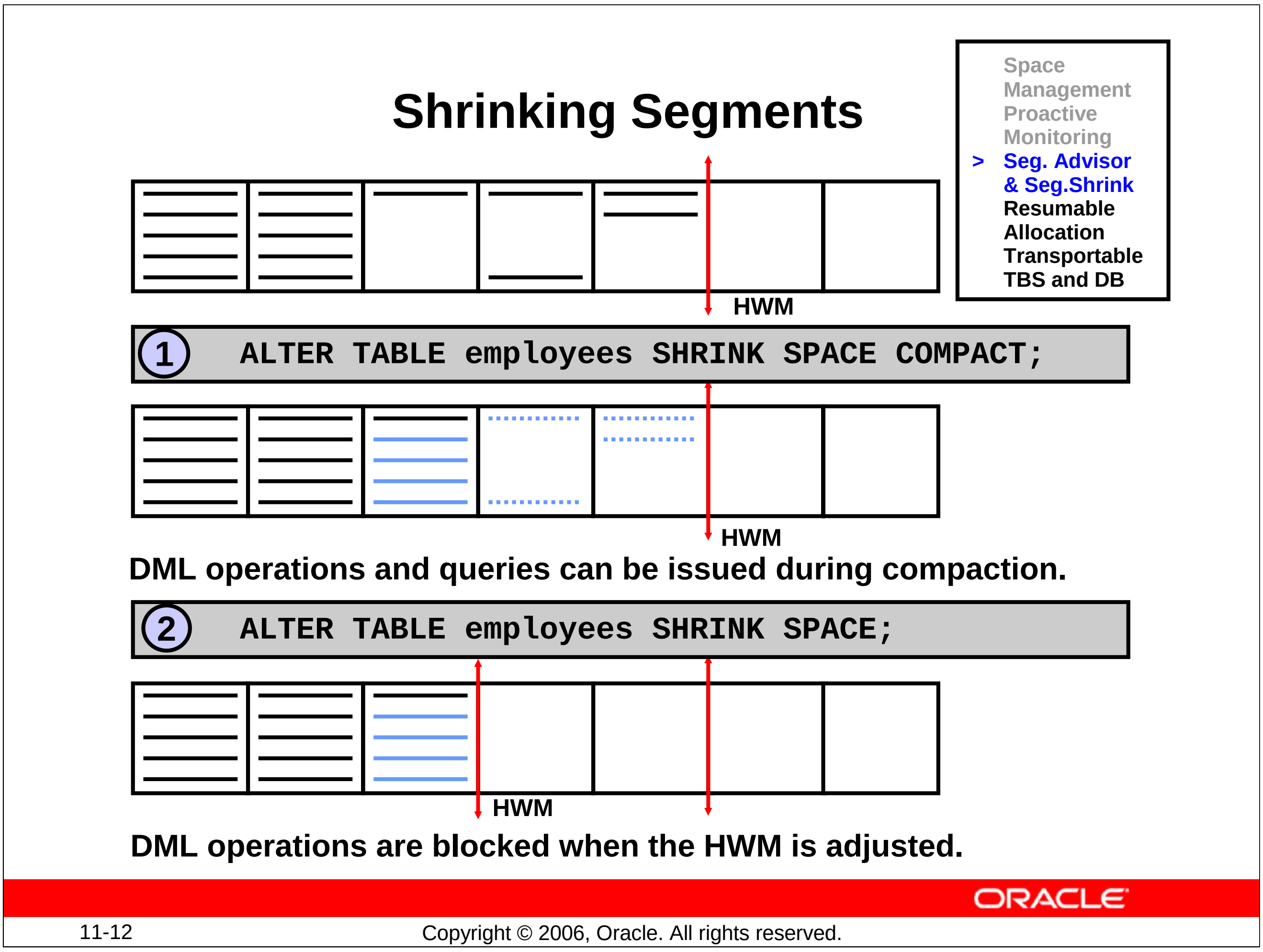
ORACLE

11-11

Monitoring Tablespace Space Usage

The database tracks space utilization while performing regular space management activities. This information is aggregated every 10 minutes by the `MMON` process. An alert is triggered when the threshold for a tablespace has been reached or cleared.

- Alerts should not be flagged on tablespaces that are in read-only mode, or tablespaces that were taken offline, because there is not much to do for them.
- In temporary tablespaces, the threshold value has to be defined as a limit on the used space in the tablespace.
- For undo tablespaces, an extent is reusable if it does not contain active or unexpired undo. For the computation of threshold violation, the sum of active and unexpired extents is considered as used space.
- For tablespaces with autoextensible files, the thresholds are computed according to the maximum file size you specified, or the maximum OS file size.



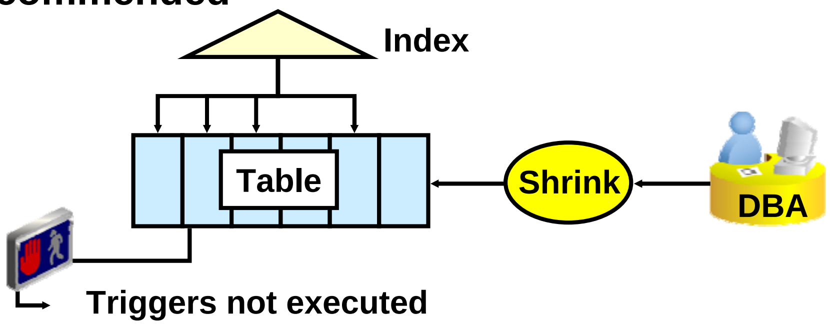
Shrinking Segments

The diagram in the slide describes the two phases of a table shrink operation. The first phase does the compaction. During this phase, rows are moved to the left part of the segment as much as possible. Internally, rows are moved by packets to avoid locking issues. After the rows have been moved, the second phase of the shrink operation is started. During this phase, the high-water mark (HWM) is adjusted and the unused space is released.

The `COMPACT` clause is useful if you have long-running queries that might span the shrink operation and attempt to read from blocks that have been reclaimed. When you specify the `SHRINK SPACE COMPACT` clause, the progress of the shrink operation is saved in the bitmap blocks of the corresponding segment. This means that the next time a shrink operation is executed on the same segment, the Oracle database remembers what has been done already. You can then reissue the `SHRINK SPACE` clause without the `COMPACT` clause during off-peak hours to complete the second phase.

Results of Shrink Operation

- Improved performance and space utilization
- Indexes maintained
- Triggers not executed
- Number of migrated rows may be reduced
- Rebuilding secondary indexes on IOTs recommended



Results of Shrink Operation

Shrinking a sparsely populated segment improves the performance of scan and DML operations on that segment. This is because there are fewer blocks to look at after the segment has been shrunk. This is especially true for:

- Full table scans (fewer and denser blocks)
- Better index access (fewer I/Os on range `ROWID` scans due to a more compact tree)

Also, by shrinking sparsely populated segments, you enhance the efficiency of space utilization inside your database because more free space is made available for objects in need.

Index dependency is taken care of during the segment shrink operation. The indexes are in a usable state after shrinking the corresponding table. Therefore, no further maintenance is needed.

The actual shrink operation is handled internally as an `INSERT/DELETE` operation. However, any DML triggers are not executed because the data itself is not changed.

As a result of a segment shrink operation, it is possible that the number of migrated rows is reduced. However, you should not always depend on reducing the number of migrated rows after a segment has been shrunk. This is because a segment shrink operation may not touch all the blocks in the segment. Therefore, it is not guaranteed that all the migrated rows are handled.

Note: It is recommended to rebuild secondary indexes on an index-organized table (IOT) after a shrink operation.

Space Reclamation with ASSM

- Online and in-place operation
- Applicable only to segments residing in ASSM tablespaces
- Candidate segment types:
  - Heap-organized tables and index-organized tables
  - Indexes
  - Partitions and subpartitions
  - Materialized views and materialized view logs

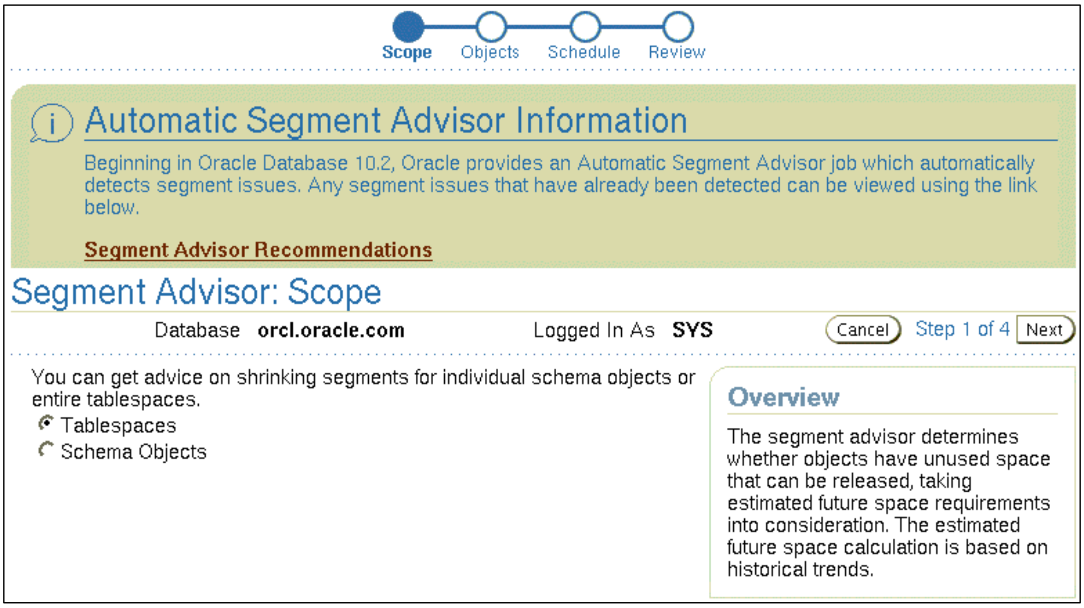
Space Reclamation with ASSM

A shrink operation is an online and in-place operation because it does not need extra database space to be executed.

- You cannot execute a shrink operation on segments managed by free lists. Segments in automatic segment-space managed tablespaces can be shrunk. However, the following objects stored in ASSM tablespaces cannot be shrunk:
  - Tables in clusters
  - Tables with `LONG` columns
  - Tables with on-commit materialized views
  - Tables with `ROWID`-based materialized views
  - IOT mapping tables
  - Tables with function-based indexes
- `ROW MOVEMENT` must be enabled for heap-organized segments.

Note: Automatic Segment Space Management (ASSM) is the default type of segment space management for all new, permanent, locally managed tablespaces in Oracle Database 10*g* Release 2.

Segment Advisor: Overview



Segment Advisor: Overview

The Segment Advisor determines whether an object is a good candidate for a shrink operation. The advisor also finds the segments containing migrated rows that result from an `UPDATE`. (Beginning with Oracle Database 10.2, the Segment Advisor jobs are automatically run for you.) The advisor makes recommendations based on the amount of unused space that can be released, and takes into consideration estimated future space requirements by using criteria from the gathered information about segment growth trends.

After the recommendations are made, you can choose to implement the recommendations. The shrink advisor can be invoked at the segment or tablespace level.

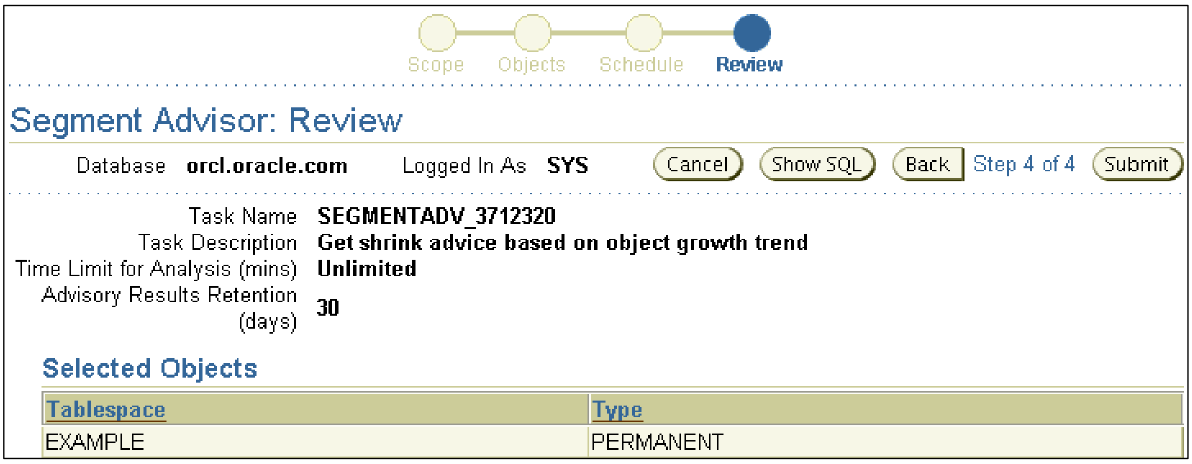
The EM Database Control Console is the interface to the Segment Advisor. You can access the Segment Advisor from several places within EM:

- Advisor Central page
- Tablespaces page
- Schema object pages

The Database Control Console provides the option to select various inputs and schedule a job that calls the Segment Advisor to get shrink advice. The Segment Advisor wizard can be invoked with no context, in the context of a tablespace, or in the context of a schema object.

The Segment Advisor makes recommendation on the basis of sampled analysis, historical information, and future growth trends.

Segment Advisor



Segment Advisor

From the Administration page, select Tablespaces in the Storage section. On the Tablespaces page, select the tablespace on which you want to perform the shrink analysis, and then select Run Segment Advisor in the Actions drop-down list. Click Go to open the Segment Advisor initial page. You must choose “comprehensive” or “limited’ analysis mode. In comprehensive mode, the analysis is longer because the advisor is sampling the segments to identify the right targets.

Keep clicking Continue to answer the various questions of the advisor. You end up on the Segment Advisor: Review page, where you can review the details of your analysis. The Segment Advisor analysis is run as a scheduled job, so you can review the scheduled task from the Advisor Central page. When completed, you can review the advisor’s recommendations.

Note: In the Segment Advisor, you can specify the duration of the analysis. This enables you to limit the time the advisor takes to produce recommendations. Generally speaking, a longer analysis period produces more comprehensive results. The results are stored in the AWR and can be viewed later. Use the “Number of days to retain” option to instruct the Oracle database how long these results should be preserved before being purged from the AWR.

Segment Advisor (continued)

Scope — Objects — Schedule — **Review**

Execute task script

Review: Show SQL

Return

Create task and objects script

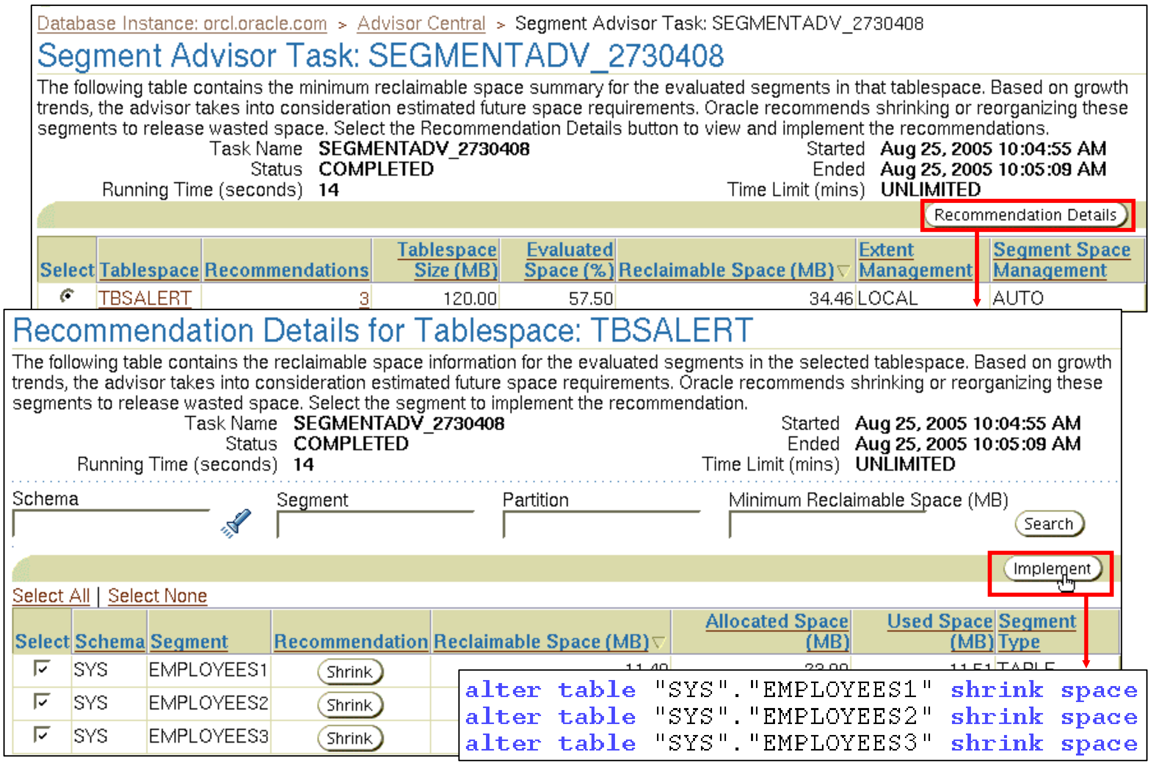
```
DECLARE

taskname varchar2(100);
taskdesc varchar2(128);
task_id number;
object_id number;
timeLimit varchar2(25);
numDaysToRetain varchar2(25);
objectName varchar2(100);
objectType varchar2(100);

BEGIN
taskname := 'SEGMENTADV_3712320';
taskdesc :='Get shrink advice based on object growth trend';
numDaysToRetain :='30';
dbms_advisor.create_task('Segment Advisor',?,taskname,taskdesc,NULL);
dbms_advisor.create_object(taskname, 'TABLESPACE', 'EXAMPLE', ' ', ' ',
NULL, object_id);
dbms_advisor.set_task_parameter(taskname, 'RECOMMEND_ALL', 'TRUE');
dbms_advisor.set_task_parameter(taskname, 'DAYS_TO_EXPIRE',
numDaysToRetain);
END;
```

Execute task script

Return to Top

```
DECLARE
taskname varchar2(100);
BEGIN
taskname := 'SEGMENTADV_3712320';
dbms_advisor.reset_task(taskname);
dbms_advisor.execute_task(taskname);
END;
```

Implementing Recommendations

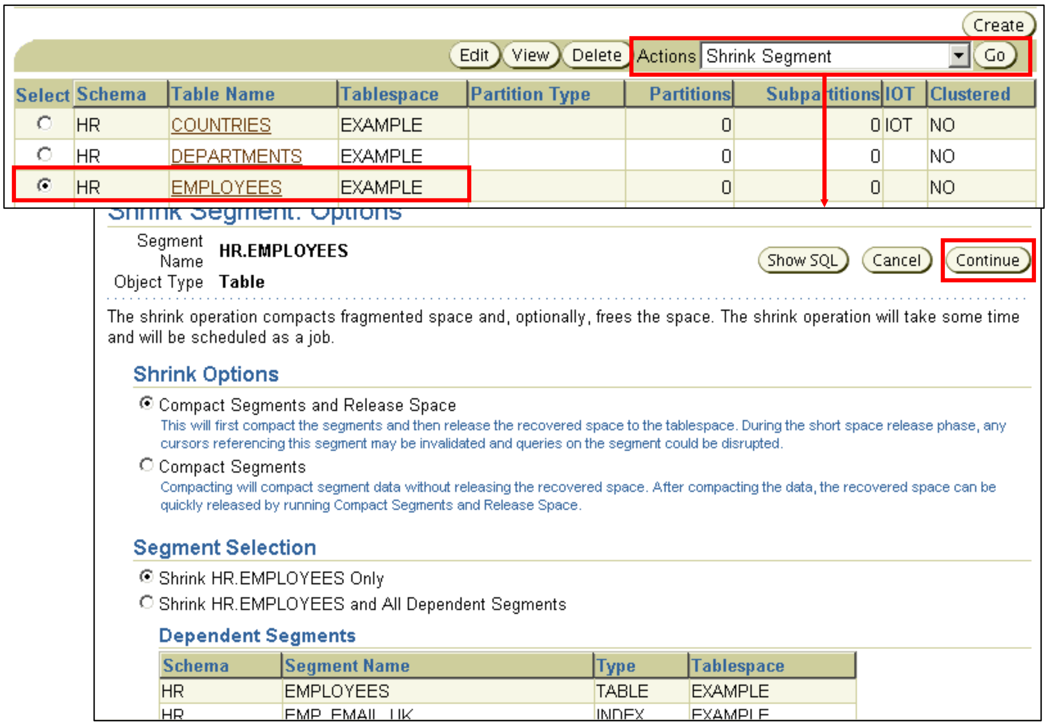


Implementing Recommendations

After the Segment Advisor completes its job, you can view the recommendation details and implement them directly.

Note: Before shrinking a heap-organized table, you must enable row movement on that table. You can do this with Database Control from the Options tab on the Edit Table page.

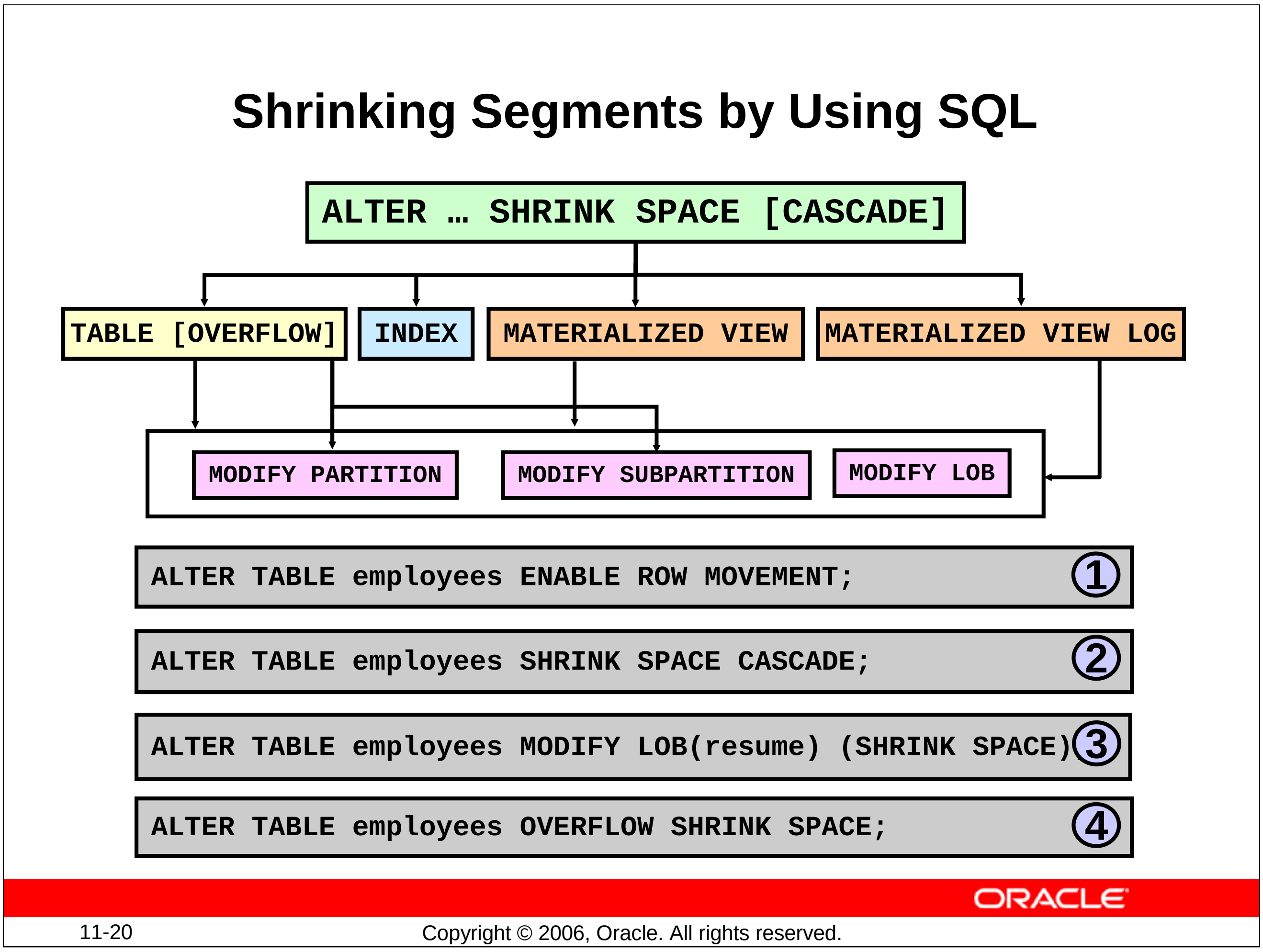
Database Control and Segment Shrink



Database Control and Segment Shrink

Alternatively (to implementing the Segment Advisor recommendations), you can shrink individual segments. For example, from the Database Control home page, click the Tables link in the Storage section. On the Tables page, select your table, and then select Shrink Segment in the Actions drop-down list. Then click the Go button. This brings you to the Shrink Segment page, where you can choose the dependent segments to shrink. You have the opportunity to compact only or to compact and release the space. You can also choose the CASCADE option.

When done, click the Continue link. This submits the shrink statements as a scheduled job.



Shrinking Segments by Using SQL

Because a shrink operation may cause `ROWID`s to change in heap-organized segments, you must enable row movement on the corresponding segment before executing a shrink operation on that segment. Row movement by default is disabled at segment level. To enable row movement, the `ENABLE ROW MOVEMENT` clause of the `CREATE TABLE` or `ALTER TABLE` command is used. This is illustrated in the first example in the slide.

Use the `ALTER` command to invoke segment shrink on an object. The object's type can be one of the following: table (heap- or index-organized), partition, subpartition, LOB (data and index segment), index, materialized view, or materialized view log.
Use the `SHRINK SPACE` clause to shrink space in a segment. If `CASCADE` is specified, the shrink behavior is cascaded to all the dependent segments that support a shrink operation, except materialized views, LOB indexes, and IOT (index-organized tables) mapping tables. The `SHRINK SPACE` clause is illustrated in the second example.
In an index segment, the shrink operation coalesces the index before compacting the data.
Example 3 shows a command that shrinks a LOB segment, given that the `RESUME` column is a `CLOB`.

Example 4 shows a command that shrinks an IOT overflow segment belonging to the `EMPLOYEES` table.

Note: For more information, refer to the *Oracle Database SQL Reference* guide.

Managing Resumable Space Allocation

A resumable statement:

- Enables you to suspend large operations instead of receiving an error
- Gives you a chance to fix the problem while the operation is suspended, rather than starting over
- Is suspended for the following conditions:
  – Out of space
  – Maximum extents reached
  – Space quota exceeded

ORACLE

11-21

Managing Resumable Space Allocation

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

A statement executes in resumable mode only when the resumable statement feature has been enabled for the system or session.

Suspending a statement automatically results in suspending the transaction. Thus all transactional resources are held through the suspension and resuming of a SQL statement. 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.

A suspension time-out interval is associated with resumable statements. A resumable statement that is suspended for the time-out interval (the default is 7,200 seconds (2 hours)) reactivates itself and returns the exception to the user. A resumable statement can be suspended and resumed multiple times during execution.

Using Resumable Space Allocation

- Queries, DML operations, and certain DDL operations can be resumed if they encounter an out-of-space error.
- A resumable statement can be issued through SQL, PL/SQL, SQL*Loader, or the Oracle Call Interface (OCI).
- To run a resumable statement, you must first enable resumable statements for your session.

```
ALTER SESSION ENABLE RESUMABLE;
INSERT INTO sales_new SELECT * FROM sh.sales;
ALTER SESSION DISABLE RESUMABLE;
```

11-22

Using Resumable Space Allocation

Resumable space allocation is possible only when statements are executed within a session that has resumable mode enabled. There are two means of enabling and disabling resumable space allocation:

- Issue the `ALTER SESSION ENABLE RESUMABLE` command.
- Set the `RESUMABLE_TIMEOUT` initialization parameter to a nonzero value with an `ALTER SESSION` or `ALTER SYSTEM` statement.

When enabling resumable mode for a session or the database, you can specify a time-out period, after which a suspended statement errors out if no intervention has taken place. The `RESUMABLE_TIMEOUT` initialization parameter indicates the number of seconds before a time-out occurs. You can also specify the time-out period with the following command:

```
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 time-out interval when using the `ENABLE RESUMABLE TIMEOUT` clause to enable resumable mode is 7,200 seconds, or 2 hours.

Using Resumable Space Allocation (continued)

You can also give a name to resumable statements. For example:

```
ALTER SESSION ENABLE RESUMABLE TIMEOUT 3600
NAME 'multitab insert';
```

The name of the statement is used to identify the resumable statement in the DBA_RESUMABLE and USER_RESUMABLE views.

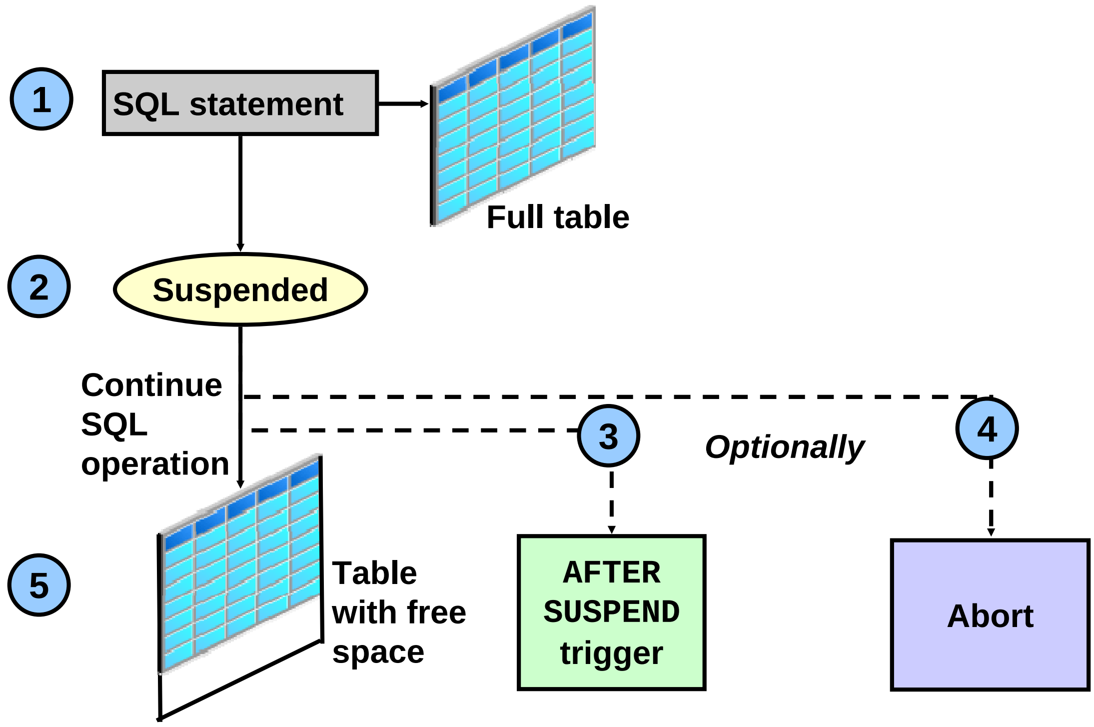
For example:

```
SELECT name, sql_text FROM user_resumable;

NAME            SQL_TEXT
--------------- ----------------------------------------------
multitab insert INSERT INTO oldsales SELECT * FROM sh.sales;
```

To automatically configure resumable statement settings for individual sessions, you can create and register a database-level LOGON trigger that alters a user's session. The trigger issues commands to enable resumable statements for the session, specifies a time-out period, and associates a name with the resumable statements issued by the session.

Because suspended statements can hold up some system resources, users must be granted the RESUMABLE system privilege before they are allowed to enable resumable space allocation and execute resumable statements.

Resuming Suspended Statements



Resuming Suspending Statements

Example:

1. An `INSERT` statement encounters an error saying the table is full.
2. The `INSERT` statement is suspended, and no error is passed to client.
3. Optionally, an `AFTER SUSPEND` trigger is executed.
4. Optionally, the `SQLERRROR` exception is activated to abort the statement.
5. If the statement is not aborted and free space is successfully added to the table, the `INSERT` statement resumes execution.

Detecting a Suspended Statement

When a resumable statement is suspended, the error is not raised to the client. In order for corrective action to be taken, the Oracle database provides alternative methods for notifying users of the error and for providing information about the circumstances.

Resuming Suspended Statements (continued)

Possible Actions During Suspension

When a resumable statement encounters 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 an `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.

Within the trigger code, you can use the `USER_RESUMABLE` or `DBA_RESUMABLE` views, or the `DBMS_RESUMABLE.SPACE_ERROR_INFO` function to get information about the resumable statements.

When a resumable statement is suspended:

- The session invoking the statement is put into a wait state. A row is inserted into `V$SESSION_WAIT` for the session with the `EVENT` column containing "`statement suspended, wait error to be cleared`".
- An operation-suspended alert is issued on the object that needs addition resources for the suspended statement to complete.

Ending a Suspended Statement

When the error condition is resolved (for example, as a result of DBA intervention or perhaps sort space released by other queries), the suspended statement automatically resumes execution and the "resumable session suspended" alert is cleared.

A suspended statement can be forced to activate the `SERVERERROR` exception by using the `DBMS_RESUMABLE.ABORT()` procedure. This procedure can be called by a DBA, or by the user who issued the statement. If the suspension time-out interval associated with the resumable statement is reached, the statement aborts automatically and an error is returned to the user.

Transporting Tablespaces

...
Resumable
Allocation
> Transportable TBS
Transportable DB

Concept: Cross-platform transportable tablespaces:

- **Simplify data distribution between data warehouse and data marts**
- **Allow database migration from one platform to another**
- **Supported platforms:**

Solaris[tm] OE (32-bit)	HP-UX (64-bit)	Microsoft Windows IA (64-bit)
Solaris[tm] OE (64-bit)	HP Tru64 UNIX	IBM zSeries Based Linux
Microsoft Windows IA (32-bit)	HP-UX IA (64-bit)	Linux 64-bit for AMD
Linux IA (32-bit)	Linux IA (64-bit)	Apple Mac OS
AIX-Based Systems (64-bit)	HP Open VMS	Microsoft Windows 64-bit for AMD
		Solaris Operating System (x86)

ORACLE

11-26

Transporting Tablespaces

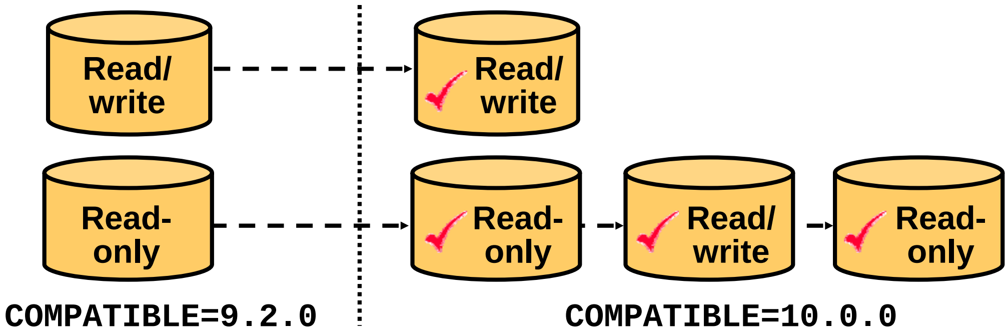
You can use the transportable tablespace feature to move data across platform boundaries. This simplifies the distribution of data from a data warehouse environment to data marts, which often run on smaller platforms. It also allows a database to be migrated from one platform to another by rebuilding the dictionary and transporting the user tablespaces.

To be able to transport data files from one platform to another, you must ensure that both the source system and the target system are running on one of the supported platforms (see slide).

Note: The cross-platform transportable tablespace feature requires both platforms to be using the same character sets.

Concept: Minimum Compatibility Level

- Both source and target databases must have `COMPATIBLE` set to `10.0.0` or higher.
- Data file headers are platform-aware.
- Before transporting, make sure that all read-only and offline files are platform-aware.

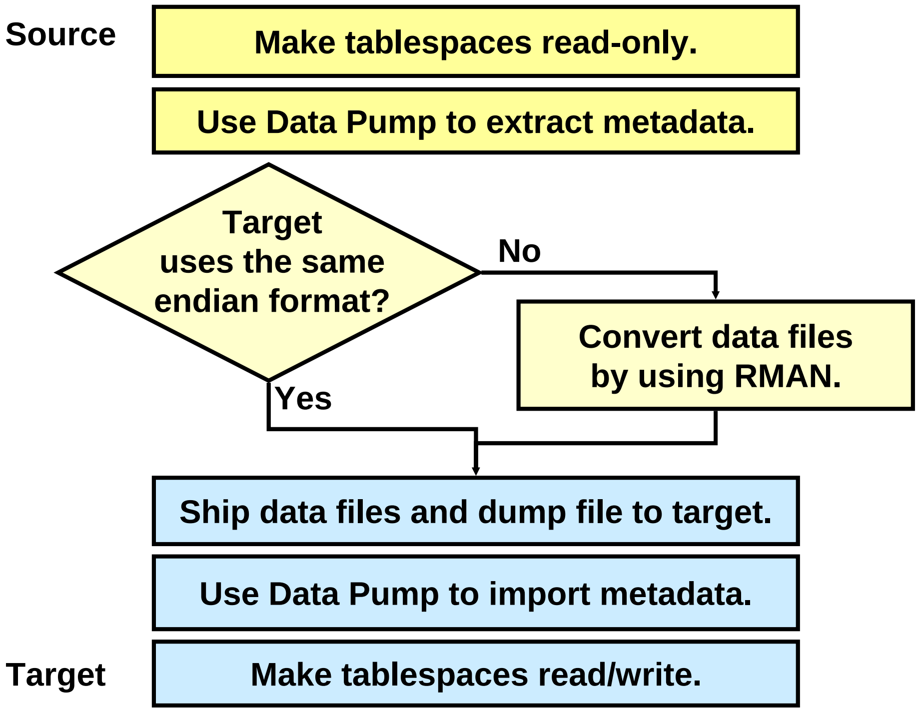


Concept: Minimum Compatibility Level

Both source and target databases need to advance their database `COMPATIBLE` initialization parameter to `10.0.0` or greater before they can use the cross-platform transportable tablespace feature.

When data files are first opened in Oracle Database 10*g* with `COMPATIBLE` set to `10.0.0` (or greater), the files are made platform-aware. This is represented by the check marks in the diagram. Each file identifies the platform that it belongs to. These files have identical on-disk formats for file header blocks that are used for file identification and verification. Read-only and offline files get the compatibility advanced only after they are made read/write or are brought online. This implies that tablespaces that are read-only in databases before Oracle Database 10*g* must be made read/write at least once before they can use the cross-platform transportable feature.

Transportable Tablespace Procedure



Transportable Tablespace Procedure

To transport a tablespace from one platform to another (source to target), data files belonging to the tablespace set must be converted to a format that can be understood by the target or destination database. Although with Oracle Database 10*g*, disk structures conform to a common format, it is possible for the source and target platforms to use different endian formats (byte ordering). When going to a different endian platform, you must use the `CONVERT` command of the RMAN utility to convert the byte ordering. This operation can be performed on either the source or the target platforms. For platforms that have the same endian format, no conversion is needed.

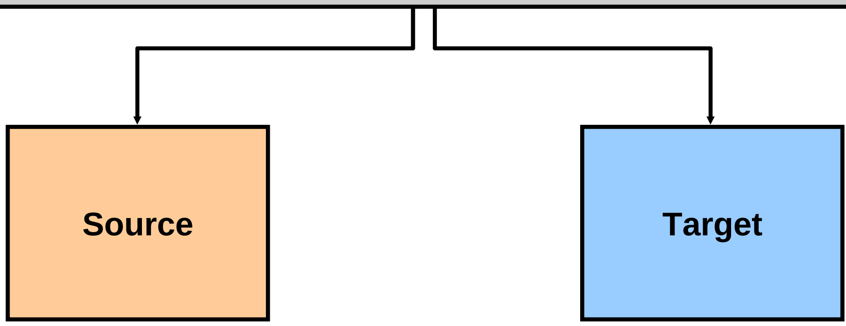
The slide graphic depicts the possible steps to transport tablespaces from a source platform to a target platform. However, it is possible to perform the conversion after shipping the files to the target platform. The last two steps must be executed on the target platform.

Basically, the procedure is the same as when using previous releases of the Oracle database except when both platforms use different endian formats. It is assumed that both platforms are cross-transportable compliant.

Note: Byte ordering can affect the results when data is written and read. For example, the 2-byte integer value `1` is written as `0x0001` on a big-endian system (such as Sun SPARC Solaris) and as `0x0100` on a little-endian system (such as an Intel-compatible PC).

Determining the Endian Format of a Platform

```
SELECT tp.endian_format
FROM   v$transportable_platform tp,
       v$database d
WHERE  tp.platform_name = d.platform_name;
```



ORACLE

Determining the Endian Format of a Platform

You can query `V$TRANSPORTABLE_PLATFORM` to determine whether the endian ordering is the same on both platforms. `V$DATABASE` has two columns that can be used to determine your own platform name and platform identifier.

Use the query in the slide on both platforms, and then compare the results. On a Sun SPARC Solaris system, the `SELECT` statement produces the following output:

```
ENDIAN_FORMAT
-------------
Big
```

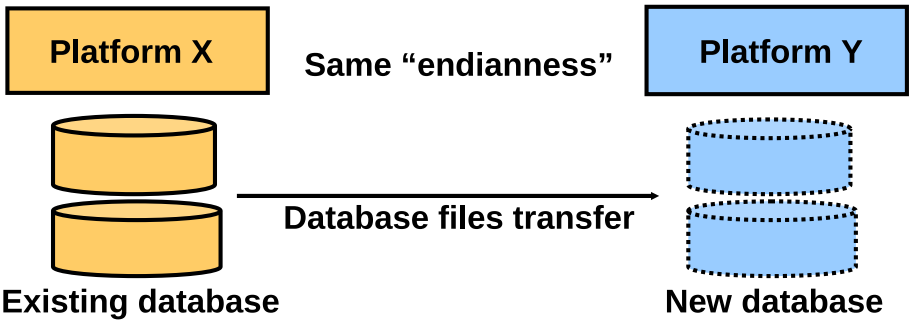
On a Microsoft Windows Intel-based platform, the `SELECT` statement produces the following output:

```
ENDIAN_FORMAT
-------------
Little
```

Transporting Databases

...
Resumable
Allocation
Transportable TBS
> Transportable DB

- Generalize the transportable tablespace feature.
- Data can easily be distributed from a data warehousing environment to data marts, which are usually on smaller platforms.
- A database can be migrated from one platform to another very quickly.



Transporting Databases

With the transportable tablespace feature, moving data across different platforms becomes much faster. However, metadata still needs to be unloaded, because the system tablespace cannot be transported.

The purpose of the database transport feature is to provide a fast and easy way to transport a database across different platforms with the same endian format. However, the source platform and the target platform can have different disk alignments. For example, HP-UX and Solaris both have big endian, but the disk alignment is eight on HP-UX and four on Solaris.

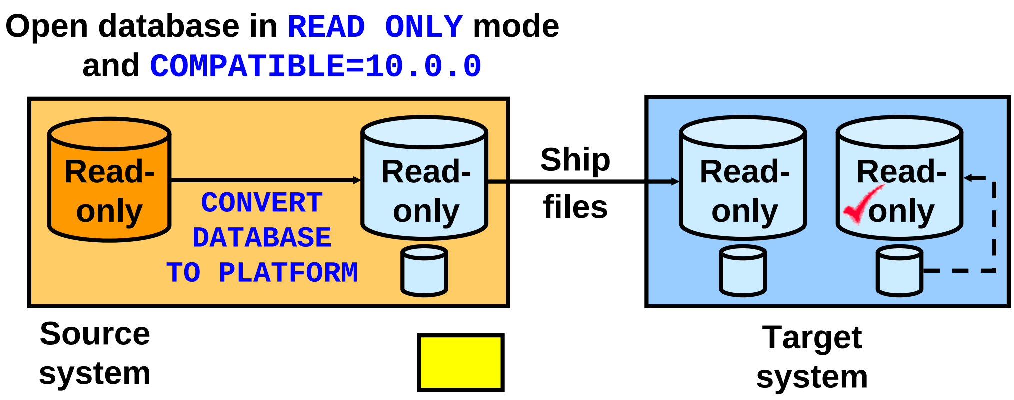
To transport databases from one platform to another, you must ensure that both the source system and the target system are running on one of the platforms that are listed in `V$TRANSPORTABLE_PLATFORM` and that both have the same endian format. For example, you can transport a database running on Linux IA (32-bit) to one of the Windows platforms.

If one or both of the databases uses Automatic Storage Management (ASM), you may need to use the `DBMS_FILE_TRANSFER` package to ftp the files.

Unlike transportable tablespace, where there is a target database to plug data into, this feature creates a new database on the target platform. The newly created database contains the same data as the source database. Except for things such as database name, instance name, and location of files, the new database also has the same settings as the source database.

Note: Transporting database is faster than using Data Pump to move data.

Database Transportation Procedure: Source System Conversion



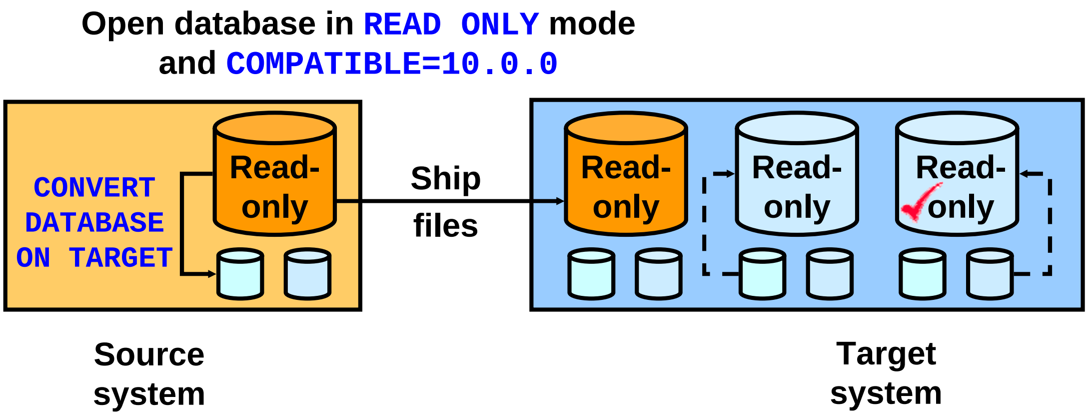
Database Transportation Procedure: Source System Conversion

Before you can transport your database, you must open it in `READ ONLY` mode. Then use RMAN to convert the necessary data files of the database.

When you do the conversion on the source platform, the new RMAN command `CONVERT DATABASE` generates a script containing the correct `CREATE CONTROLFILE RESETLOGS` command that is used on the target system to create the new database. The `CONVERT DATABASE` command then converts all identified data files so that they can be used on the target system. You then ship the converted data files and the generated script to the target platform. By executing the generated script on the target platform, you create a new copy of your database.

Note: The source database must be running with the `COMPATIBLE` initialization parameter set to `10.0.0` or higher. All identified tablespaces must have been `READ WRITE` at least once since `COMPATIBLE` was set to `10.0.0` or higher.

Database Transportation Procedure: Target System Conversion



Database Transportation Procedure: Target System Conversion

Before you can transport your database, you must open it in `READ ONLY` mode. Then use RMAN to convert the necessary data files of the database.

When you do the conversion on the target platform, the `CONVERT DATABASE` command (which is executed on the source system) generates only two scripts used on the target system to convert the data files, and to re-create the control files for the new database. Then, you ship the identified data files and both scripts to the target platform. After this is done, execute both scripts in the right order. The first one uses the existing `CONVERT DATAFILE` RMAN command to do the conversion, and the second issues the `CREATE CONTROLFILE RESETLOGS` SQL command with the converted data files to create the new database.

Note: The source database must be running with the `COMPATIBLE` initialization parameter set to `10.0.0` or higher. All identified tablespaces must have been `READ WRITE` at least once since `COMPATIBLE` was set to `10.0.0` or higher.

Database Transportation: Considerations

- Create the password file on the target platform.
- Transport the `BFILE`s used in the source database.
- The generated pfile and transport script use OMF.
- Use `DBNEWID` to change the `DBID`.

Database Transportation: Considerations

Redo logs, control files, and tempfiles are not transported. They are re-created for the new database on the target platform. As a result, the new database on the target platform must be opened with the `RESETLOGS` option.

If a password file is used, it is not transported and you need to create it on the target platform. This is because the types of file names allowed for the password file are OS specific. However, the output of the `CONVERT DATABASE` command lists all the usernames and their system privileges, and advises to re-create the password file and add entries for these users on the target platform.

The `CONVERT DATABASE` command lists all the directory objects and objects that use `BFILE` data types or external tables in the source database. You may need to update these objects with new directory and file names. If `BFILE`s are used in the database, you have to transport the `BFILE`s.

The generated pfile and transport script use Oracle Managed Files (OMF) for database files. If you do not want to use OMF, you must modify the pfile and transport script.

The transported database has the same `DBID` as the source database. You can use the `DBNEWID` utility to change the `DBID`. In the transport script as well as the output of the `CONVERT DATABASE` command, you are prompted to use the `DBNEWID` utility to change the database ID.

Summary

In this lesson, you should have learned how to:

- Use the Oracle database to automatically manage space
- Proactively monitor and manage tablespace space usage
- Use the Segment Advisor
- Reclaim wasted space from tables and indexes by using the segment shrink functionality
- Manage resumable space allocation
- Describe the concepts of transportable tablespaces and databases

ORACLE

11-34

Practice Overview: Managing Storage

This practice covers the following topics:

- Using threshold alerts to proactively manage tablespaces
- Using the Segment Advisor to shrink space
- Viewing alerts and alert history in SQL*Plus and Enterprise Manager

12

Automatic Storage Management

Objectives

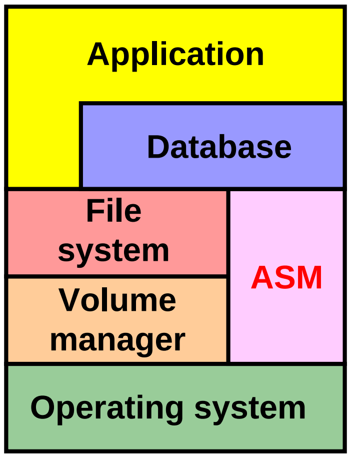
After completing this lesson, you should be able to:

- Identify the features of Automatic Storage Management (ASM)
- Set up initialization parameter files for ASM and database instances
- Execute SQL commands with ASM file names
- Start up and shut down ASM instances
- Administer ASM disk groups
- Use RMAN to migrate your database to ASM

ORACLE

Automatic Storage Management: Review

- Portable and high-performance cluster file system
- Manages Oracle database files
- Data spread across disks to balance load
- Integrated mirroring across disks
- Solves many storage management challenges



12-3

Automatic Storage Management: Review

Automatic Storage Management (ASM) provides a vertical integration of the file system and the volume manager that is specifically built for the Oracle database files. ASM can provide management for single SMP machines, or across multiple nodes of a cluster for Oracle Real Application Clusters (RAC) support.

ASM distributes I/O load across all available resources to optimize performance while removing the need for manual I/O tuning. ASM helps DBAs to manage a dynamic database environment by allowing them to increase the database size without having to shut down the database to adjust the storage allocation.

ASM can maintain redundant copies of data to provide fault tolerance, or it can be built on top of vendor-supplied reliable storage mechanisms. Data management is done by selecting the desired reliability and performance characteristics for classes of data rather than with human interaction on a per file basis.

ASM capabilities save DBAs' time by automating manual storage and thereby increasing their ability to manage larger databases and more of them with increased efficiency.

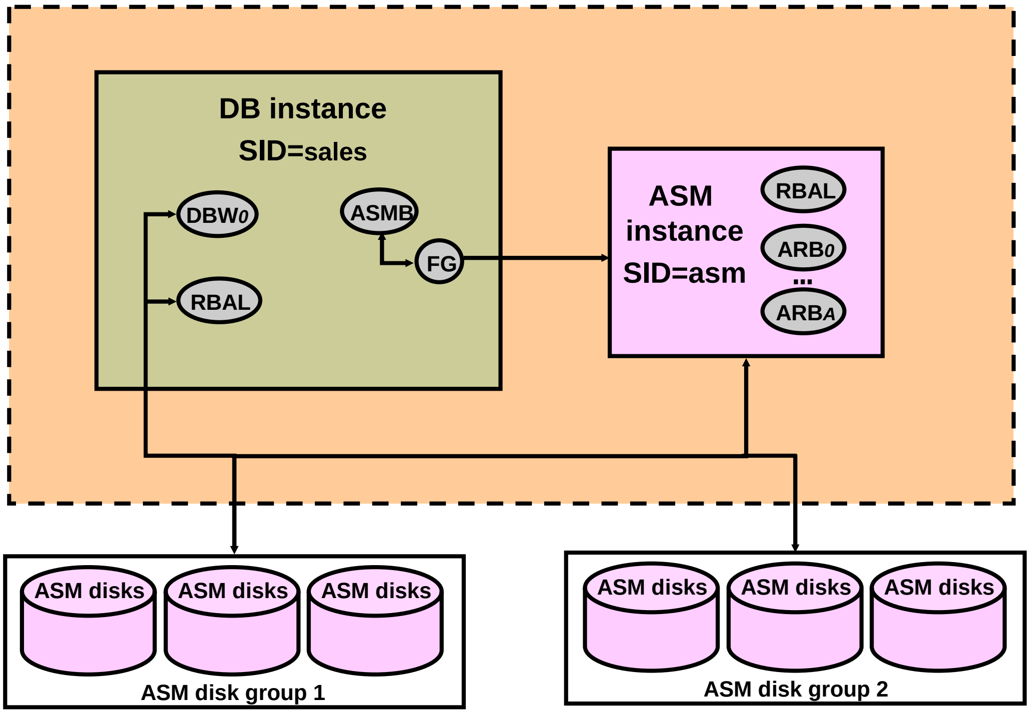
Automatic Storage Management: Review (continued)

ASM divides files into allocation units (AUs) and spreads the AUs for each file evenly across all the disks. ASM uses an index technique to track the placement of each AU. When your storage capacity changes, ASM does not restripe all of the data, but moves an amount of data proportional to the amount of storage added or removed to evenly redistribute the files and maintain a balanced load across the disks. This is done while the database is active.

You can increase the speed of a rebalance operation, or lower it to reduce the impact on the I/O subsystem. ASM provides mirroring protection without the need to purchase a third-party Logical Volume Manager. One unique advantage of ASM is that the mirroring is applied on a file basis, rather than on a volume basis. Therefore, the same disk group can contain a combination of files protected by mirroring, along with those that are not protected at all.

ASM supports data files, log files, control files, archive logs, RMAN backup sets, and other Oracle database file types. ASM supports Real Application Clusters and eliminates the need for a Cluster Logical Volume Manager or a Cluster File System.

ASM General Architecture



ASM General Architecture

To use ASM, you must start a special instance, called an ASM instance, before you start your database instance. ASM instances do not mount databases, instead they manage the metadata needed to make ASM files available to ordinary database instances. Both ASM instances and database instances have access to some common set of disks called disk groups. Database instances access the contents of ASM files directly, communicating with an ASM instance only to get information about the layout of these files.

An ASM instance contains two new background processes. One coordinates rebalance activity for disk groups. It is called `RBAL`. The second one performs the actual rebalance AU movements. There can be many of these at a time, and they are called `ARB0`, `ARB1`, and so forth. An ASM instance also has some of the same background processes as a database instance, including `SMON`, `PMON`, `LGWR`, `DBWR`, and `CKPT`.

ASM General Architecture (continued)

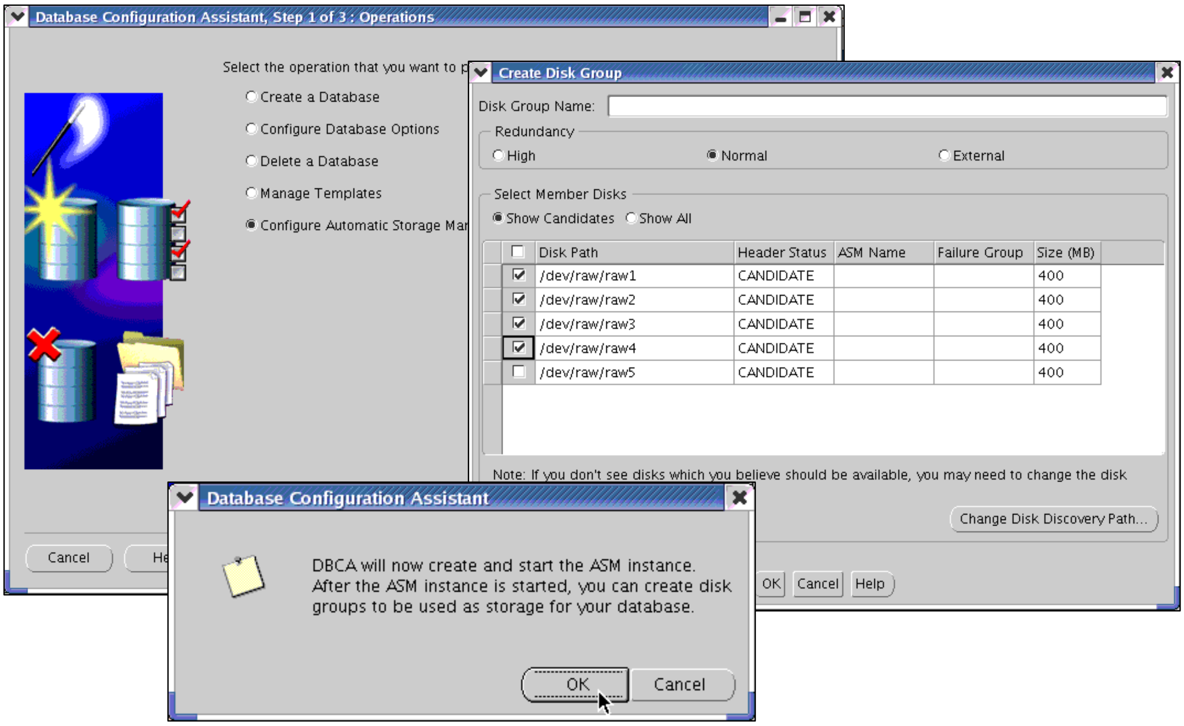
Each database instance using ASM has two new background processes called `ASMB` and `RBAL`. `RBAL` performs global opens of the disks in the disk groups. At database instance startup, `ASMB` connects as a foreground process into the ASM instance. Communication between the database and the ASM instance is performed via this bridge. This includes physical file changes such as data file creation and deletion. Over this connection, periodic messages are exchanged to update statistics and to verify that both instances are healthy.

ASM Instance Tasks

The following are tasks that you need to be able to perform in order to use an ASM instance:

- Create the ASM instance
- Set the initialization parameters
- Start the ASM instance
- Manage the ASM instance
- Shut down the ASM instance

Creating an ASM Instance



Creating an ASM Instance

You create an ASM instance by running the Database Configuration Assistant (DBCA). On the first screen, choose the option to Configure Automatic Storage Management, and follow the steps. The ASM instance is created and started for you. Then you are guided through the process of defining disk groups for the instance.

As part of the ASM instance creation process, the DBCA automatically creates an entry into the `oratab` file. This entry is used for discovery purposes. On the Windows platform where a services mechanism is used, the DBCA automatically creates an Oracle Service and the appropriate registry entry to facilitate the discovery of ASM instances.

When an ASM instance is configured, the DBCA creates an ASM instance parameter file and an ASM instance password file.

If you were to first create an ASM-enabled database, the DBCA determines whether an ASM instance already exists on your host. If ASM instance discovery returns an empty list, the DBCA creates a new ASM instance.

ASM Instance Initialization Parameters

```
INSTANCE_TYPE = ASM
DB_UNIQUE_NAME = +ASM
ASM_POWER_LIMIT = 1
ASM_DISKSTRING = '/dev/rdsk/*s2', '/dev/rdsk/c1*'
ASM_DISKGROUPS = dgroupA, dgroupB
LARGE_POOL_SIZE = 8MB
```


ASM Instance Initialization Parameters

- `INSTANCE_TYPE` should be set to ASM for ASM instances.
- `DB_UNIQUE_NAME` specifies the service provider name for which this ASM instance manages disk groups. The default value of `+ASM` must be modified only if you run multiple ASM instances on the same node.
- `ASM_POWER_LIMIT` controls the speed for a rebalance operation. Values range from 1 through 11, with 11 being the fastest. If omitted, this value defaults to 1. The number of slaves is derived from the parallelization level specified in a manual rebalance command (`POWER`), or by the `ASM_POWER_LIMIT` parameter.
- `ASM_DISKSTRING` is an operating system–dependent value used by ASM to limit the set of disks considered for discovery.
- `ASM_DISK_GROUPS` is the list of names of disk groups to be mounted by an ASM instance at startup, or when the `ALTER DISKGROUP ALL MOUNT` command is used.

The `INSTANCE_TYPE` parameter is the only parameter that you must define. All other ASM parameters have default values that are suitable for most environments.

Note: If the ASM environment has been created using the command line instead of EM, then the disk groups must be created before they can be mounted.

Database Instance Parameter Changes

```
…
INSTANCE_TYPE = RDBMS
LOG_ARCHIVE_FORMAT
DB_BLOCK_SIZE
DB_CREATE_ONLINE_LOG_DEST_n
DB_CREATE_FILE_DEST
DB_RECOVERY_FILE_DEST
CONTROL_FILES
LOG_ARCHIVE_DEST_n
LOG_ARCHIVE_DEST
STANDBY_ARCHIVE_DEST
LARGE_POOL_SIZE = 8MB
…
```

ORACLE

Database Instance Parameter Changes

INSTANCE_TYPE defaults to RDBMS and specifies that this instance is an RDBMS instance.

LOG_ARCHIVE_FORMAT is ignored if LOG_ARCHIVE_DEST is set to an incomplete ASM file name, such as +dGroupA. If LOG_ARCHIVE_DEST is set to an ASM directory (for example, +dGroupA/myarchlogdir/), then LOG_ARCHIVE_FORMAT is used and the files are non-OMF. Unique file names for archived logs are automatically created by the Oracle database.

The following parameters accept the multifile creation context form of ASM file names as a destination:

- DB_CREATE_ONLINE_LOG_DEST_n
- DB_CREATE_FILE_DEST
- DB_RECOVERY_FILE_DEST
- CONTROL_FILES
- LOG_ARCHIVE_DEST_n
- LOG_ARCHIVE_DEST
- STANDBY_ARCHIVE_DEST

Note: Because allocation unit maps for ASM files are allocated from the LARGE_POOL, you must set the LARGE_POOL_SIZE initialization parameter to at least 8 MB, preferably higher.

Starting Up an ASM Instance

```
$ export ORACLE_SID='+ASM'
$ sqlplus /nolog
SQL> CONNECT / AS sysdba
Connected to an idle instance.
SQL> STARTUP;
ASM instance started
Total System Global Area 147936196 bytes
Fixed Size                   324548 bytes
Variable Size              96468992 bytes
Database Buffers           50331648 bytes
Redo Buffers                 811008 bytes
ASM diskgroups mounted
```

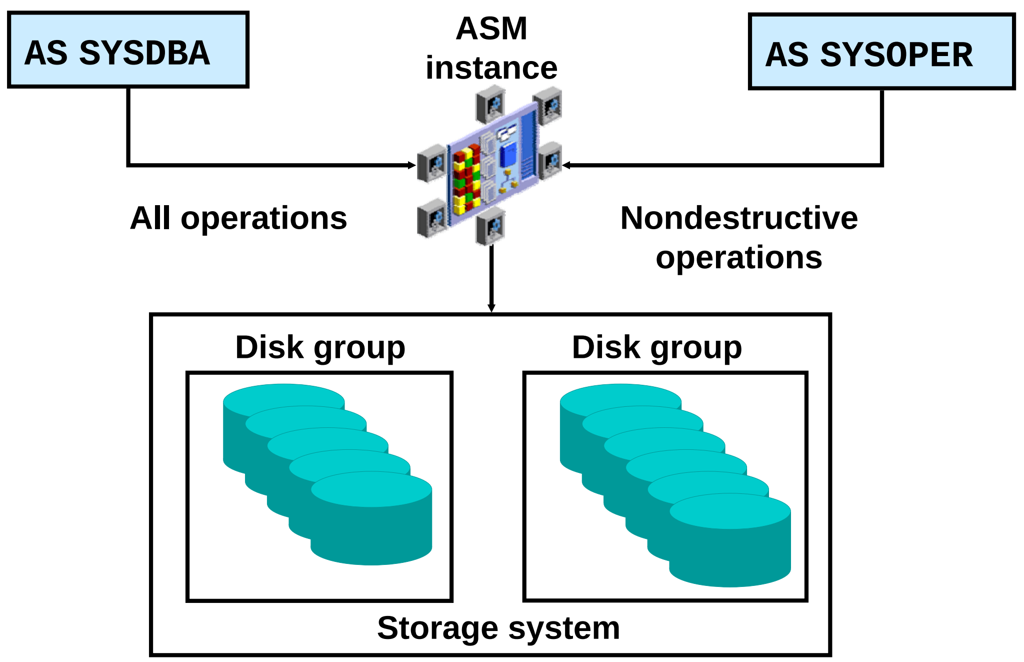
12-11

Starting Up an ASM Instance

ASM instances are started similarly to database instances except that the initialization parameter file contains an entry like `INSTANCE_TYPE=ASM`. When this parameter is set to the value `ASM`, it informs the Oracle executable that an ASM instance is starting, not a database instance. Also, the `ORACLE_SID` variable must be set to the ASM instance name. When the ASM instance starts up, the mount stage attempts to mount the disk groups specified by the `ASM_DISKGROUPS` initialization parameter rather than mounting a database, as is done with non-ASM instances.

Other `STARTUP` clauses have comparable interpretation for ASM instances as they do for database instances. `OPEN` is invalid for an ASM instance. `NOMOUNT` starts up the ASM instance without mounting any disk group.

Accessing an ASM Instance



Accessing an ASM Instance

ASM instances do not have a data dictionary, so the only way to connect to one is by using OS authentication, that is, SYSDBA or SYSOPER. To connect remotely, a password file must be used. Normally, the SYSDBA privilege is granted through the use of an operating system group. On UNIX, this is typically the dba group. By default, members of the dba group have SYSDBA privilege on all instances on the node, including the ASM instance. Users who connect to the ASM instance with the SYSDBA privilege have administrative access to all disk groups in the system. The SYSOPER privilege is supported in ASM instances and limits the set of allowable SQL commands to the minimum required for basic operation of an already configured system.

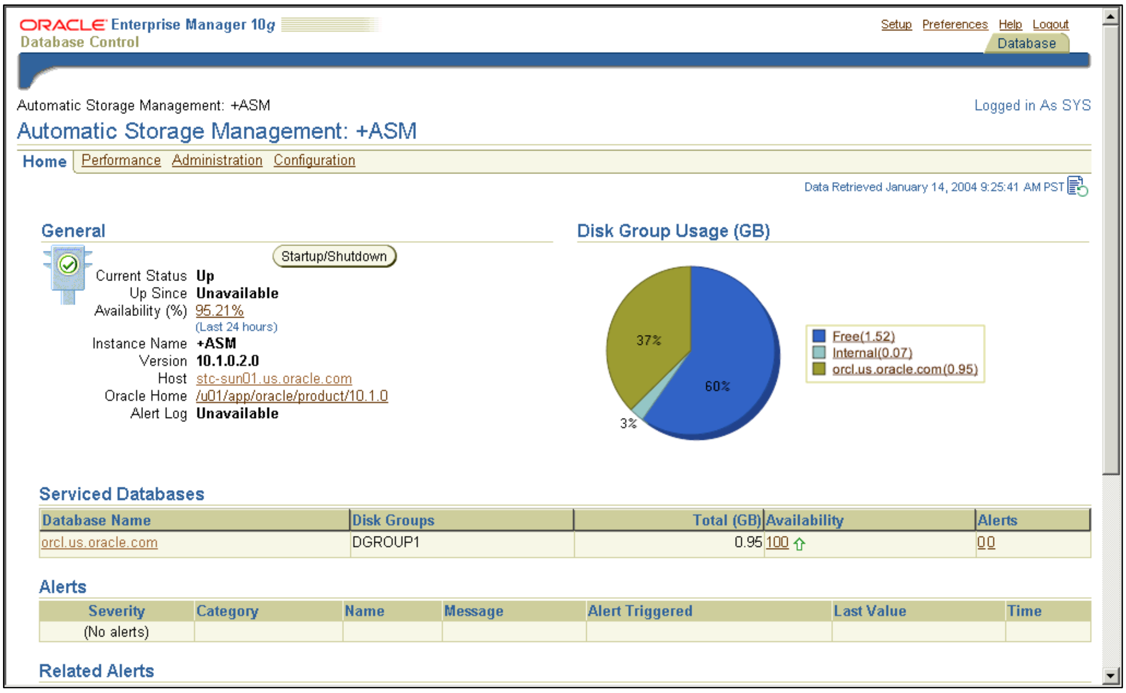
Accessing an ASM Instance (continued)

The following commands are available to SYSOPER users:

- STARTUP/SHUTDOWN
- ALTER DISKGROUP MOUNT/DISMOUNT
- ALTER DISKGROUP ONLINE/OFFLINE DISK
- ALTER DISKGROUP REBALANCE
- ALTER DISKGROUP CHECK
- SELECT all V$ASM_* views

All other commands, such as CREATE DISKGROUP, ADD/DROP/RESIZE DISK, and so on, require the SYSDBA privilege and are not allowed with the SYSOPER privilege.

ASM Home Page

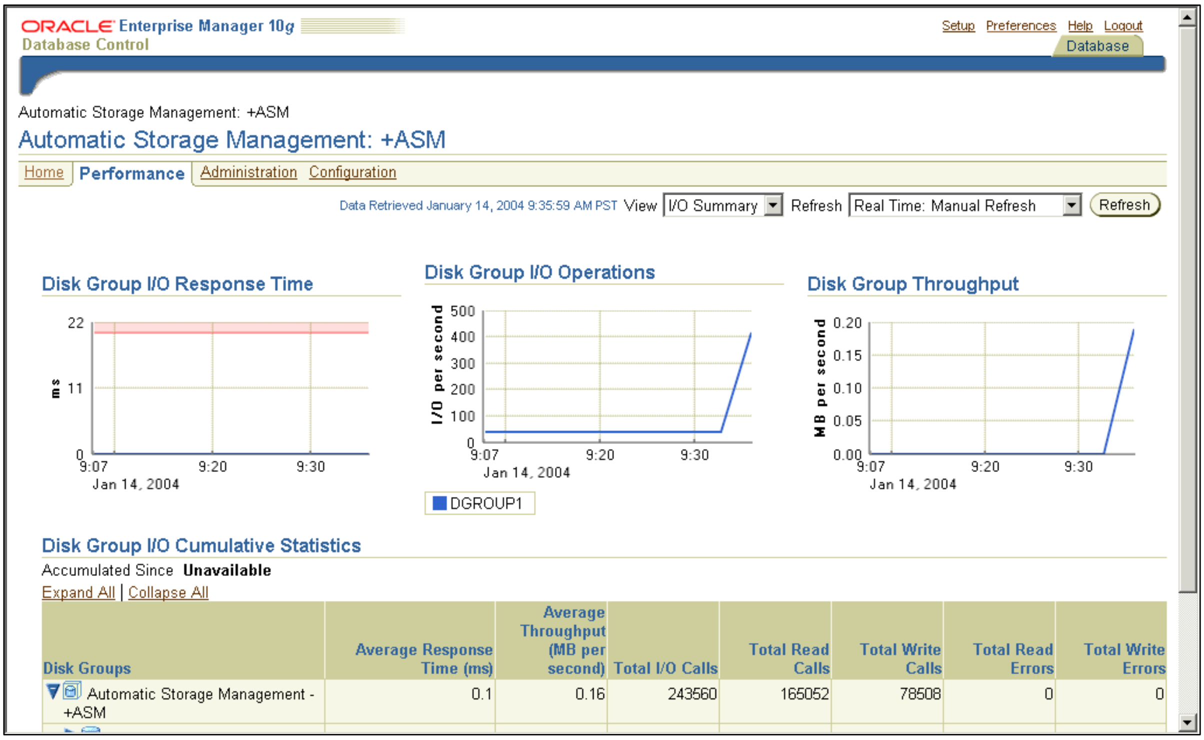


ASM Home Page

Enterprise Manager provides a user-friendly graphical interface to the Oracle database management, administration, and monitoring tasks. Oracle Database 10*g* extends the existing functionality to transparently support the management, administration, and monitoring of Oracle databases that use ASM storage. It also adds support for the new management tasks required for administration of ASM instance and ASM disk groups.

The ASM home page shows the status of the ASM instance along with the metrics and alerts generated by the collection mechanisms. It also provides the startup and shutdown functionality. Clicking the Alert link takes the user to an alert details page. The DiskGroup Usage chart shows space used by each client database along with free space.

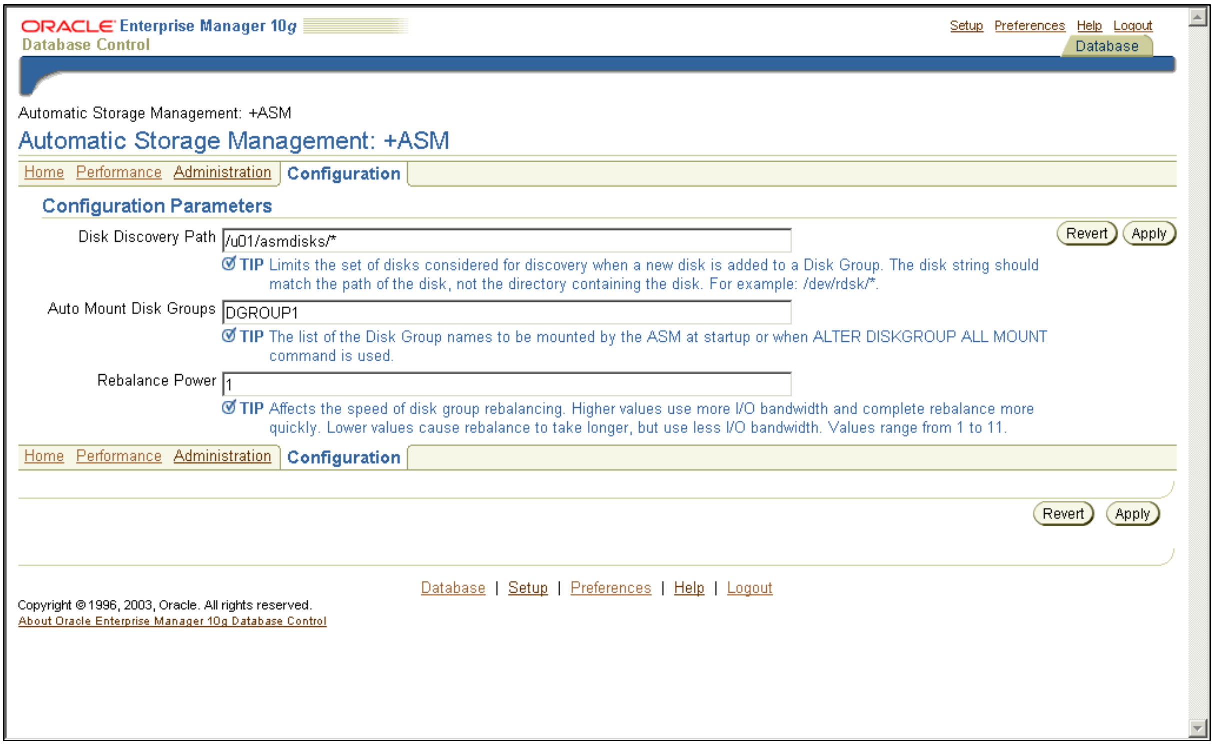
ASM Performance Page



ASM Performance Page

The Performance tab of the Automatic Storage Management page shows the I/O response time and throughput for each disk group. You can further drill down to view disk-level performance metrics.

ASM Configuration Page



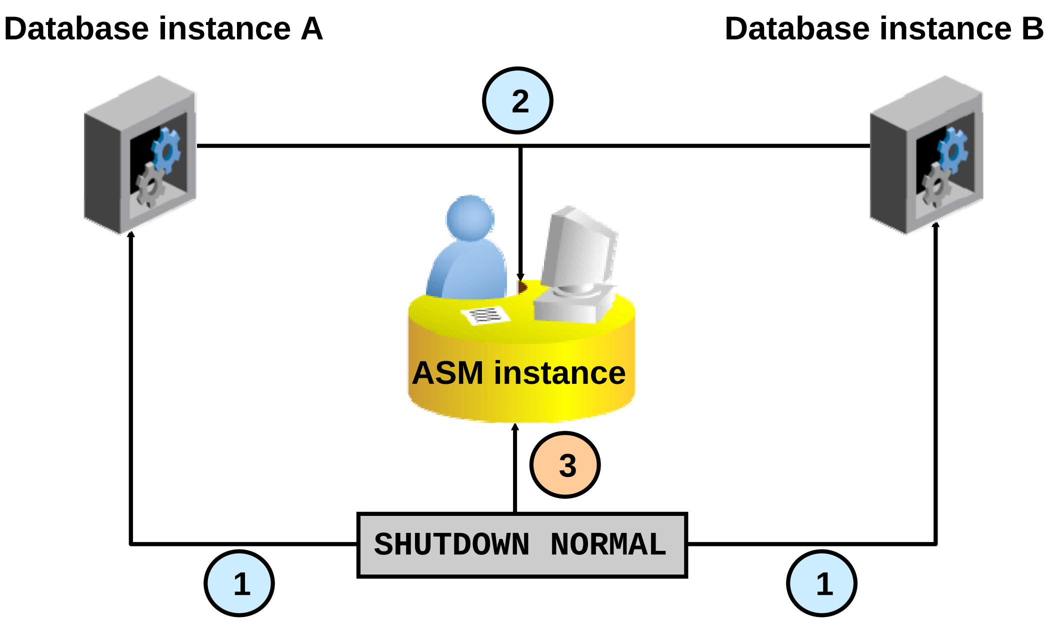
ORACLE

12-16

ASM Configuration Page

The Configuration tab of the Automatic Storage Management page enables you to view or modify the initialization parameters of the ASM instance.

Shutting Down an ASM Instance



Shutting Down an ASM Instance

When you attempt to shutdown an ASM instance in the `NORMAL`, `IMMEDIATE`, or `TRANSACTIONAL` modes, it will only succeed if there are no database instances connected to the ASM instance. If there is at least one connected instance, you will receive the following error:

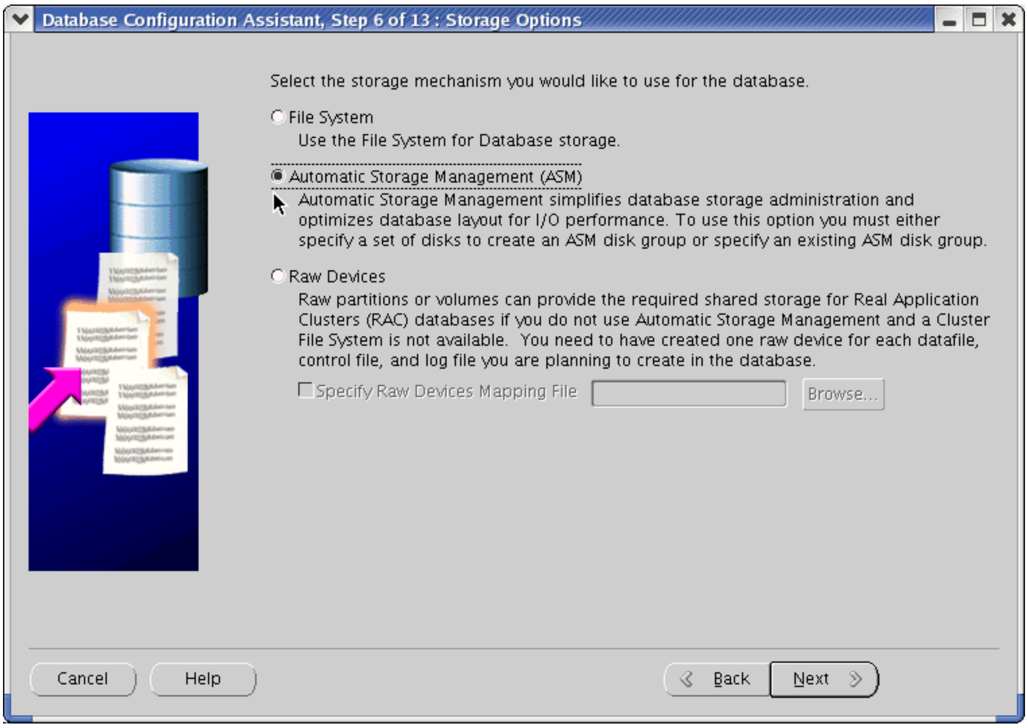
```
ORA-15097: cannot SHUTDOWN ASM instance with connected RDBMS
instance
```

If you perform a `SHUTDOWN ABORT` on the ASM instance, it will shutdown, and it will require recovery at the time of the next startup. Any connected database instances will also eventually shutdown, reporting the following error:

```
ORA-15064: communication failure with ASM instance
```

In a single ASM instance configuration, if the ASM instance fails while disk groups are open for update, then after the ASM instance reinitializes, it reads the disk group's log and recovers all transient changes. With multiple ASM instances sharing disk groups, if one ASM instance fails, another ASM instance automatically recovers transient ASM metadata changes caused by the failed instance. The failure of a database instance does not affect ASM instances. The ASM instance should be started automatically whenever the host is rebooted. ASM instance is expected to use the automatic startup mechanism supported by the underlying operating system. Note that file system failure usually crashes a node.

DBCA and Storage Options

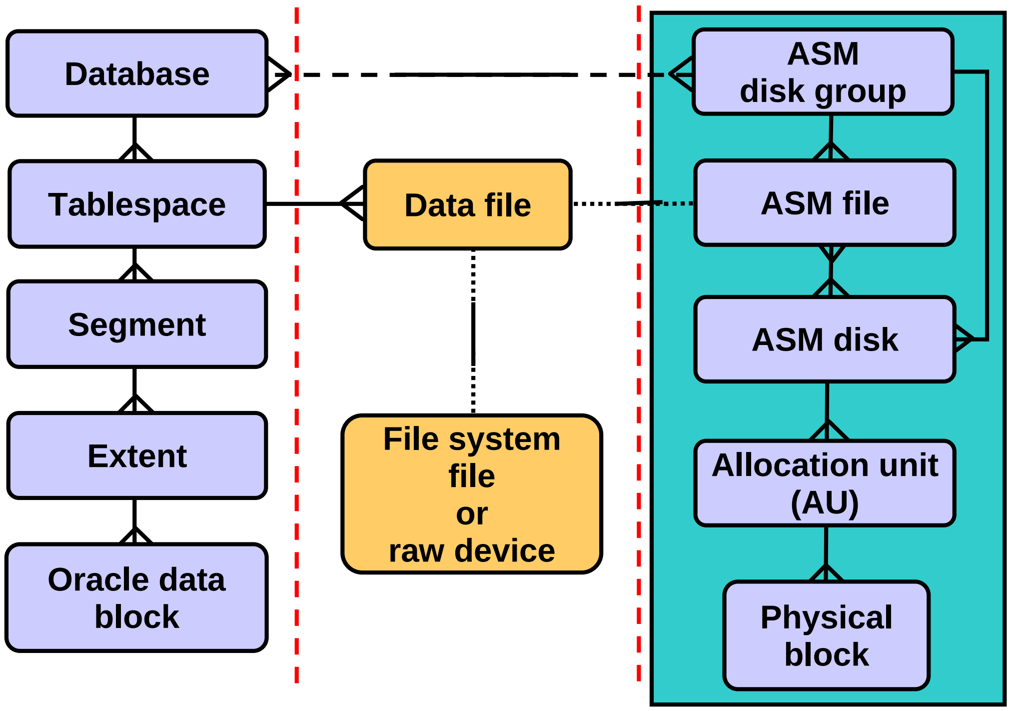


12-18

DBCA and Storage Options

In order to support ASM as a storage option, this screen appears in the Database Configuration Assistant (DBCA) when creating a database. This allows you to choose the storage options: file system, ASM, or raw devices.

ASM Storage: Concepts



ASM Storage: Concepts

ASM does not eliminate any preexisting database functionality. Existing databases are able to operate as they always have. You can create new files as ASM files and leave existing files to be administered in the old way, or you can eventually migrate them to ASM.

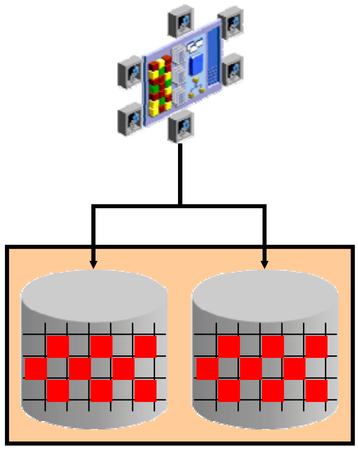
The diagram depicts the relationships that exist between the various storage components inside an Oracle database with ASM available. The left and middle parts of the diagram show the relationships that exist in previous releases. On the right are the new concepts introduced by ASM.

Database files can be stored as ASM files. At the top of the new hierarchy are ASM disk groups. Any single ASM file is contained in only one disk group. However, a disk group may contain files belonging to several databases, and a single database may use storage from multiple disk groups. As you can see, one disk group is made up of multiple ASM disks, and each ASM disk belongs to only one disk group. ASM files are always spread across all the ASM disks in the disk group. ASM disks are partitioned in allocation units (AU) of one megabyte each. An allocation unit is the smallest contiguous disk space that ASM allocates. ASM does not allow an Oracle block to be split across allocation units.

Note: This graphic deals with only one type of ASM file: data file. However, ASM can be used to store other database file types.

ASM Disk Groups

- A pool of disks managed as a logical unit
- Partitions total disk space into uniform sized units
- Spreads each file evenly across all disks
- Uses coarse- or fine-grain striping on the basis of file type
- Administers disk groups, not files



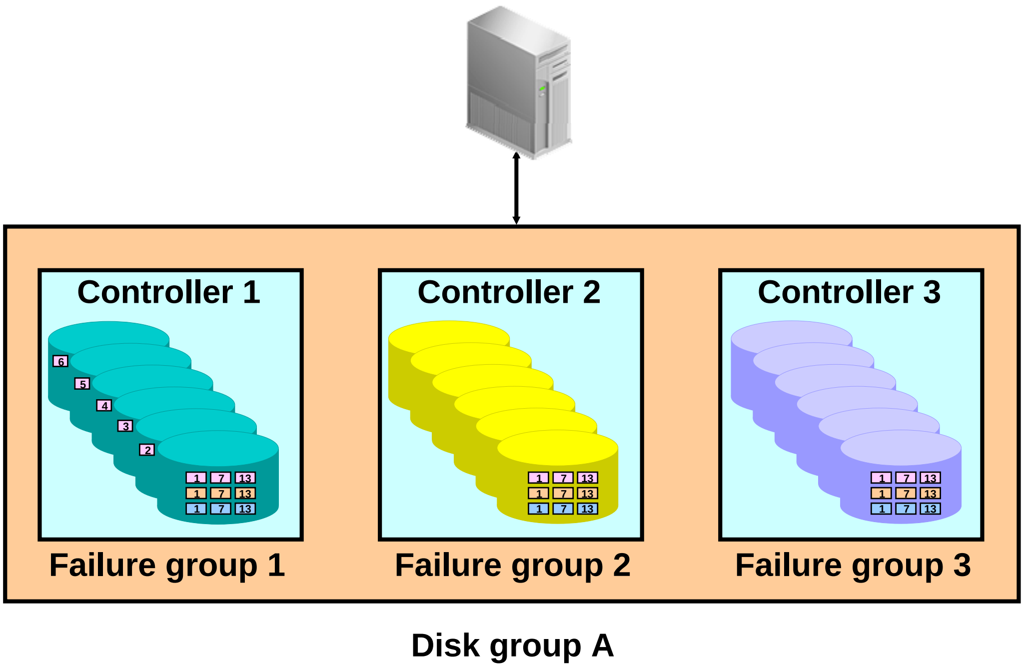
ASM Disk Groups

A disk group is a collection of disks managed as a logical unit. Storage is added and removed from disk groups in units of ASM disks. Every ASM disk has an ASM disk name, which is a name common to all nodes in a cluster. The ASM disk name abstraction is required because different hosts can use different names to refer to the same disk.

ASM always spreads files evenly in 1 MB allocation unit (AU) chunks across all the disks in a disk group. This is called *coarse* striping. That way, ASM eliminates the need for manual disk tuning. However, disks in a disk group should have similar size and performance characteristics to obtain optimal I/O. For most installations there is only a small number of disk groups. For instance, one disk group for a work area, and one for a recovery area. For files, such as log files, that require low latency, ASM provides fine-grained (128 KB) striping. *Fine* striping stripes each AU. Fine striping breaks up medium-sized I/O operations into multiple smaller I/O operations that execute in parallel. While the number of files and disks increase, you only have to manage a constant number of disk groups. From a database perspective, disk groups can be specified as the default location for files created in the database.

Note: Each disk group is self-describing, containing its own file directory and disk directory.

Failure Group



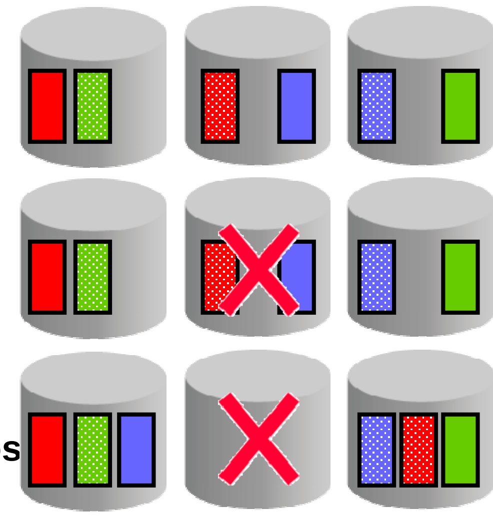
Failure Group

A failure group is a set of disks, inside one particular disk group, sharing a common resource whose failure needs to be tolerated. An example of a failure group is a string of SCSI disks connected to a common SCSI controller. A failure of the controller leads to all the disks on its SCSI bus becoming unavailable, although each of the individual disks is still functional.

What constitutes a failure group is site-specific. It is largely based upon failure modes that a site is willing to tolerate. By default, ASM assigns each disk to its own failure group. When creating a disk group or adding a disk to a disk group, administrators may specify their own grouping of disks into failure groups. After failure groups are identified, ASM can optimize file layout to reduce the unavailability of data due to the failure of a shared resource.

Disk Group Mirroring

- Mirror at AU level
- Mix primary and mirror AUs on each disk
- External redundancy: Defers to hardware mirroring
- Normal redundancy:
  - Two-way mirroring
  - At least two failure groups
- High redundancy:
  - Three-way mirroring
  - At least three failure groups



Disk Group Mirroring

ASM has three disk group types that support different types of mirroring:

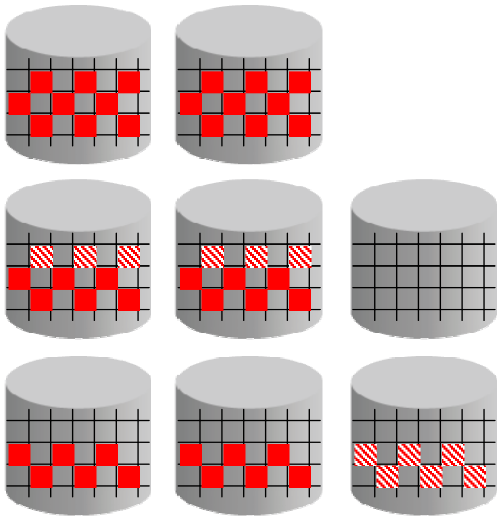
- **External redundancy:** Do not provide mirroring. Use an external-redundancy disk group if you use hardware mirroring or if you can tolerate data loss as the result of a disk failure. Failure groups are not used with these types of disk groups.
- **Normal-redundancy:** Support two-way mirroring
- **High-redundancy:** Provide triple mirroring

ASM does not mirror disks; rather, it mirrors allocation units. As a result, you need only spare capacity in your disk group. When a disk fails, ASM automatically reconstructs the contents of the failed disk on the surviving disks in the disk group by reading the mirrored contents from the surviving disks. This spreads the I/O hit from a disk failure across several disks.

When ASM allocates a primary AU of a file to one disk in a disk group, it allocates a mirror copy of that AU to another disk in the disk group. Primary AUs on a given disk can have their mirror copies on one of several partner disks in the disk group. ASM ensures that a primary AU and its mirror copy never reside in the same failure group. If you define failure groups for your disk group, ASM can tolerate the simultaneous failure of multiple disks in a single failure group.

Disk Group Dynamic Rebalancing

- **Automatic online rebalance whenever storage configuration changes**
- **Only move data proportional to storage added**
- **No need for manual I/O tuning**
- **Online migration to new storage**
- **Configurable load on system using `ASM_POWER_LIMIT`**

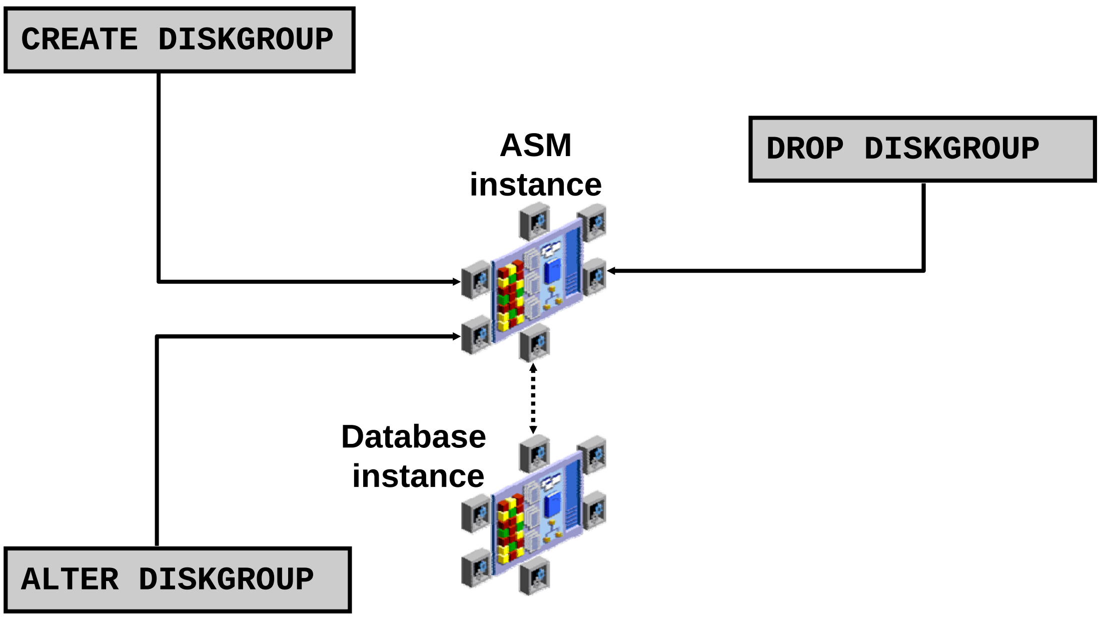


12-23

Disk Group Dynamic Rebalancing

- With ASM, the rebalance process is very easy and happens without any intervention from the DBA or system administrator. ASM automatically rebalances a disk group whenever disks are added or dropped.
- By using index techniques to spread AUs on the available disks, ASM does not need to restripe all of the data, but instead needs to only move an amount of data proportional to the amount of storage added or removed to evenly redistribute the files and maintain a balanced I/O load across the disks in a disk group.
- With the I/O balanced whenever files are allocated and whenever the storage configuration changes, the DBA never needs to search for hot spots in a disk group and manually move data to restore a balanced I/O load.
- It is more efficient to add or drop multiple disks at the same time so that they are rebalanced as a single operation. This avoids unnecessary movement of data. With this technique, it is easy to achieve online migration of your data. All you need to do is add the new disks in one operation and drop the old ones in one operation.
- You can control how much of a load the rebalance operation has on the system by setting the `ASM_POWER_LIMIT` initialization variable. Its range of values is `0` through `11`. The lower the number, the lighter the load, whereas a higher setting has more of a load, and finishes sooner. A setting of `0` places rebalance operations on hold. The default value is `1`.

Managing Disk Groups



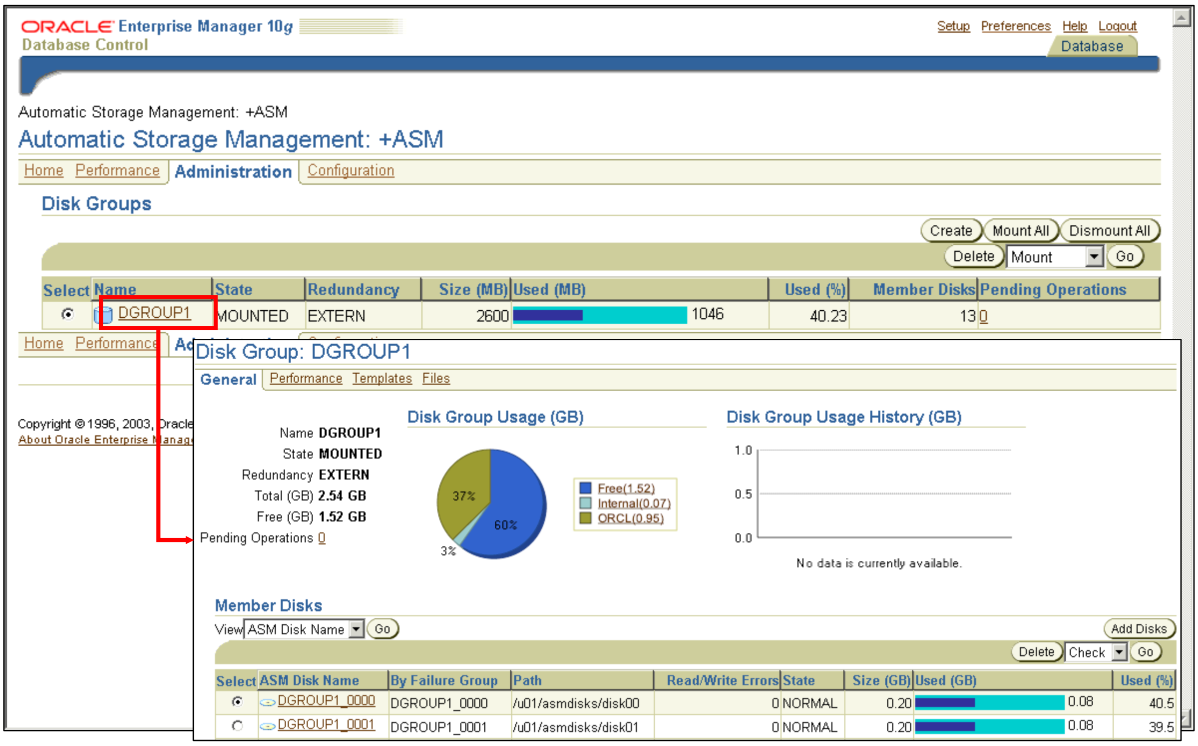
Managing Disk Groups

The main goal of an ASM instance is to manage disk groups and protect their data. ASM instances also communicate file layout to database instances. In this way, database instances can directly access files stored in disk groups.

There are several new disk group administrative commands. They all require the `SYSDBA` privilege and must be issued from an ASM instance.

You can add new disk groups. You can also modify existing disk groups to add new disks, remove existing ones, and perform many other operations. You can remove existing disk groups.

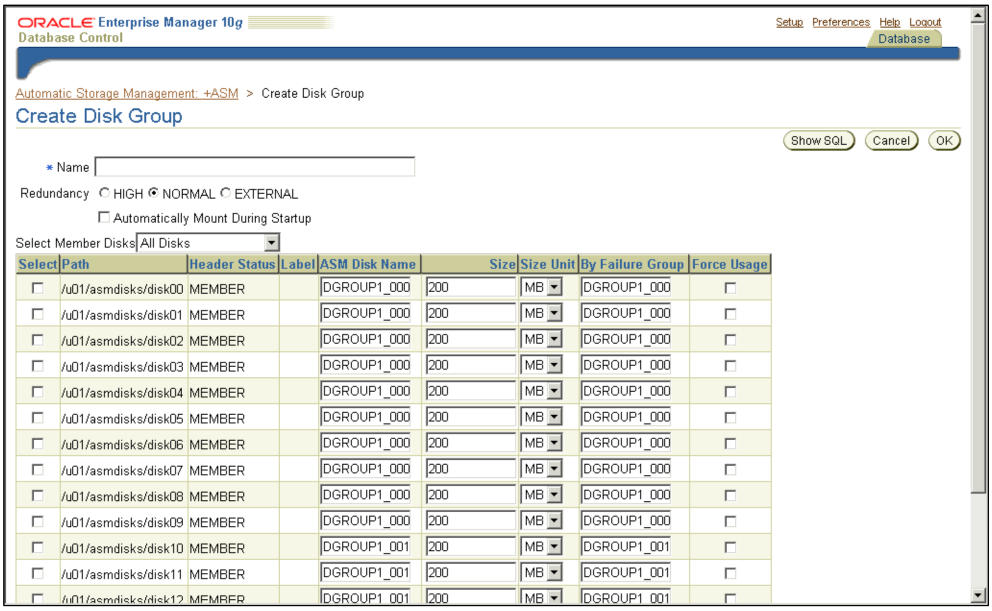
ASM Administration Page



ASM Administration Page

When you click the Administration tabbed page of the Automatic Storage Management page, you can see the disk groups listed in the `V$ASM_DISKGROUP` view. From here, you can create, edit, or drop a disk group. You can also perform disk group operations such as mount, dismount, rebalance, check, and repair on a selected disk group.

Create Disk Group Page



ORACLE

12-26

Create Disk Group Page

Clicking Create on the Disk Group Overview page displays the Create Disk Group page. You can enter the disk group name, redundancy mechanism, and the list of disks that you would like to include in the new disk group.

The list of disks is obtained from the `V$ASM_DISK` fixed view. By default, only the disks that can be assigned to a disk group show up. Those are the ones with a status of one of the following:

- **`CANDIDATE`:** The disk has never been assigned to an ASM disk group.
- **`FORMER`:** The disk was once assigned to an ASM disk group, but is not now.
- **`PROVISIONED`:** ASMLib is being used, and this disk is not yet assigned to a disk group.

Note: ASMLib is an API that interfaces with other vendors' storage arrays. See the *Database Administrator's Guide* documentation for more information about ASMLib.

Creating and Dropping Disk Groups

```
CREATE DISKGROUP dgroupA NORMAL REDUNDANCY
FAILGROUP controller1 DISK
   '/devices/A1' NAME diskA1 SIZE 120G FORCE,
   '/devices/A2',
   '/devices/A3'
FAILGROUP controller2 DISK
   '/devices/B1',
   '/devices/B2',
   '/devices/B3';
```

```
DROP DISKGROUP dgroupA INCLUDING CONTENTS;
```


Creating and Dropping Disk Groups

Assume that ASM disk discovery identified the following disks in the `/devices` directory: `A1`, `A2`, `A3`, `B1`, `B2`, and `B3`. Also, assume that disks `A1`, `A2`, and `A3` are on a separate SCSI controller from disks `B1`, `B2`, and `B3`. The first example in the slide illustrates how to configure a disk group called `DGROUPA` with two failure groups: `CONTROLLER1` and `CONTROLLER2`.

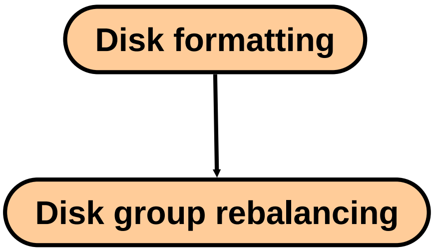
The example also uses the default redundancy characteristic, `NORMAL REDUNDANCY`, for the disk group. You can optionally provide a disk name and size for the disk. If you do not supply this information, ASM creates a default name and attempts to determine the size of the disk. If the size cannot be determined, an error is returned. `FORCE` indicates that a specified disk should be added to the specified disk group even though the disk is already formatted as a member of an ASM disk group. Using the `FORCE` option for a disk that is not formatted as a member of an ASM disk group returns an error.

As shown by the second statement in the slide, you can delete a disk group along with all its files. To avoid accidental deletions, the `INCLUDING CONTENTS` option must be specified if the disk group still contains any files besides internal ASM metadata. The disk group must be mounted in order for it to be dropped. After ensuring that none of the disk group files are open, the group and all its drives are removed from the disk group. Then the header of each disk is overwritten to eliminate the ASM formatting information.

Adding Disks to Disk Groups

```
ALTER DISKGROUP dgroupA ADD DISK
  '/dev/rdsk/c0t4d0s2' NAME A5,
  '/dev/rdsk/c0t5d0s2' NAME A6,
  '/dev/rdsk/c0t6d0s2' NAME A7,
  '/dev/rdsk/c0t7d0s2' NAME A8;
```

```
ALTER DISKGROUP dgroupA ADD DISK '/devices/A*';
```



Adding Disks to Disk Groups

This example shows how to add disks to a disk group. You execute an `ALTER DISKGROUP ADD DISK` command to add the disks. The first statement adds four new disks to the `DGROUPA` disk group.

The second statement demonstrates the interactions of discovery strings. Consider the following configuration:
`/devices/A1` is a member of disk group `DGROUPA`.
`/devices/A2` is a member of disk group `DGROUPA`.
`/devices/A3` is a member of disk group `DGROUPA`.
`/devices/A4` is a candidate disk.
The second command adds `A4` to the `DGROUPA` disk group. It ignores the other disks, even though they match the discovery string, because they are already part of the `DGROUPA` disk group. As shown by the diagram, when you add a disk to a disk group, the ASM instance ensures that the disk is addressable and usable. The disk is then formatted and rebalanced. The rebalance process is time consuming because it moves AUs from every file onto the new disk.

Adding Disks to Disk Groups (continued)

Note: Rebalancing does not block any database operations. The main impact that a rebalance process has is on the I/O load on the system. The higher the power of the rebalance, the more I/O load it puts on the system. Thus less I/O bandwidth is available for database I/Os.

Miscellaneous ALTER Commands

Remove a disk from dgroupA:

```
ALTER DISKGROUP dgroupA DROP DISK A5;
```

Add and drop a disk in a single command:

```
ALTER DISKGROUP dgroupA
 DROP DISK A6
 ADD FAILGROUP fred
         DISK '/dev/rdsk/c0t8d0s2' NAME A9;
```

Cancel a disk drop operation:

```
ALTER DISKGROUP dgroupA UNDROP DISKS;
```

ORACLE

12-30

Miscellaneous ALTER Commands

The first statement in the slide shows how to remove one of the disks from the DGROUPA disk group. The second statement shows how you can add and drop a disk in a single command. The big advantage in this case is that rebalancing is not started until the command completes. The third statement shows how to cancel a disk drop operation. The UNDROP command operates only on pending drops of disks; it has no effect on drops that have completed.

The following statement rebalances the DGROUPB disk group, if necessary:

```
ALTER DISKGROUP dgroupB REBALANCE POWER 5;
```

This command is generally not necessary because it is automatically done as disks are added, dropped, or resized. However, it is useful if you want to use the POWER clause to override the default speed defined by the initialization parameter ASM_POWER_LIMIT. You can change the power level of an ongoing rebalance operation by reentering the command with a new level. A power level of zero causes rebalancing to halt until the command is either implicitly or explicitly reinvoked.

The following statement dismounts DGROUPA:

```
ALTER DISKGROUP dgroupA DISMOUNT;
```

The MOUNT and DISMOUNT options allow you to make one or more disk groups available or unavailable to the database instances.

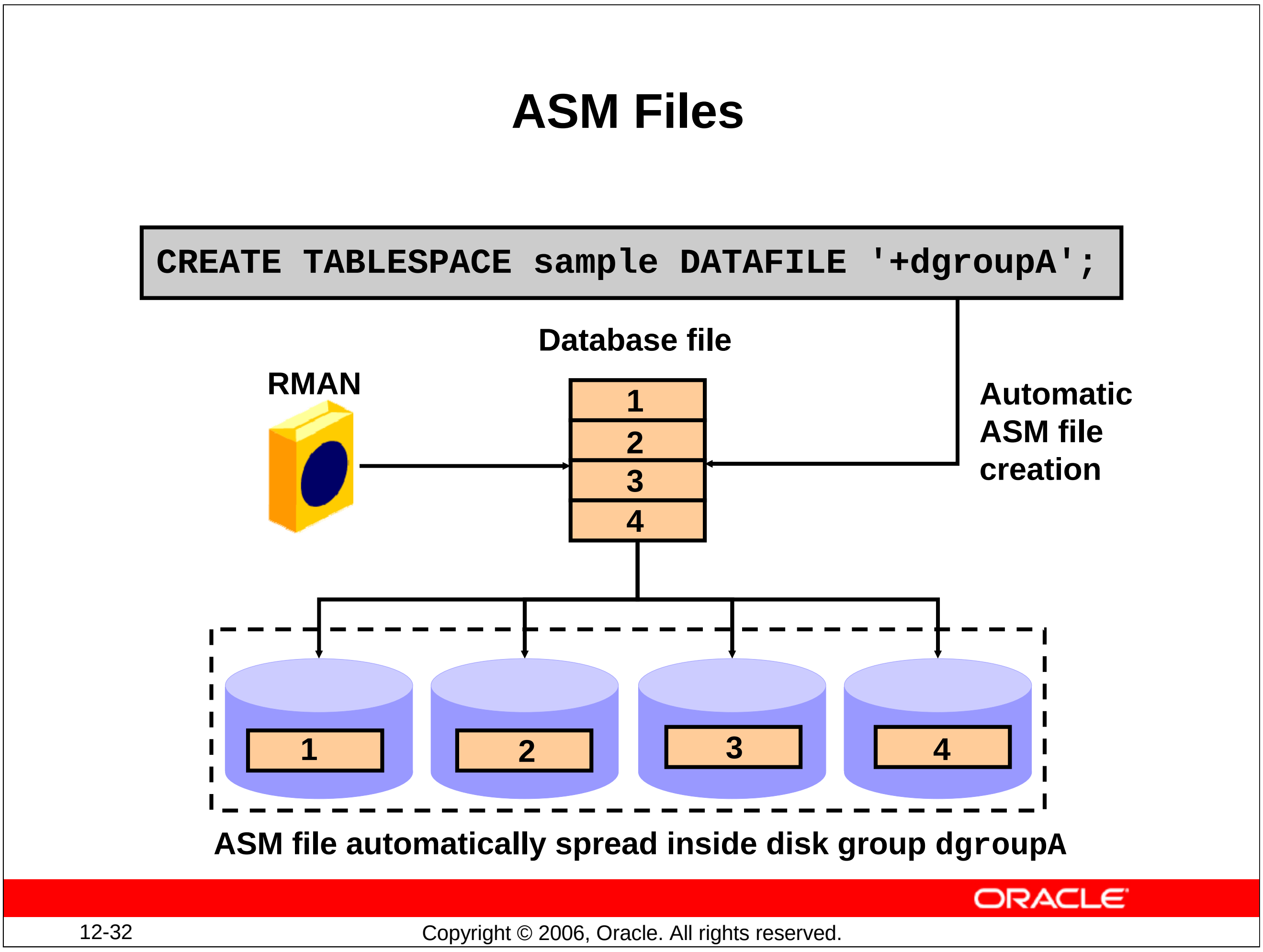
Miscellaneous ALTER Commands (continued)

Use the following statement to verify the internal consistency of disk group metadata and to repair any error found:

```
ALTER DISKGROUP dgroupA CHECK ALL;
```

It is also possible to use the `NOREPAIR` clause if you just want to be alerted about errors. While the example requests a check across all disks in the disk group, checking can be specified on a file or an individual disk. This command requires that the disk group be mounted. If any error is found, a summary error message is displayed and the details of the detected error are reported in the alert log.

Note: Of these six examples, the first four trigger a disk group rebalancing, and the last two do not.



ASM Files

When you specify an ASM disk group as the data file name for a tablespace, ASM files are created in the disk group to provide storage for the tablespace.

When an ASM file is created, certain file attributes are permanently set. Among these are its protection policy, and its striping policy. ASM files are Oracle Managed Files. Any file that is created by ASM is automatically deleted when it is no longer needed.

With ASM, file operations are specified in terms of database objects. Administration of databases never requires knowing the name of a file, though the name of the file is exposed through some data dictionary views, or the `ALTER DATABASE BACKUP CONTROLFILE TO TRACE` command. Because each file in a disk group is physically spread across all disks in the disk group, a backup of a single disk is not useful. Database backups of ASM files must be made with RMAN.

Note: ASM does not manage binaries, alert logs, trace files, or password files.

ASMCMD Utility

```
SQL> CREATE TABLESPACE tbsasm DATAFILE '+DGROUP1' SIZE 100M;
Tablespace created.

SQL> CREATE TABLESPACE hrapps DATAFILE '+DGROUP1' SIZE 10M;
Tablespace created.
```

```
$ asmcmd
ASMCMD> ls -l DGROUP1/ORCL/DATAFILE
Type      Redund  Striped  Time             Sys  Name
DATAFILE  MIRROR  COARSE   OCT 05 21:00:00  Y    HRAPPS.257.570923611
DATAFILE  MIRROR  COARSE   OCT 05 21:00:00  Y    TBSASM.256.570922917
ASMCMD>
```

12-33

ASMCMD Utility

ASMCMD is a command-line utility that you can use to easily view and manipulate files and directories within ASM disk groups. It can list the contents of disk groups, perform searches, create and remove directories, and display space utilization, among other things.

Note: For more information about ASMCMD, see the *Oracle Database Utilities* documentation.

Migrating Your Database to ASM Storage

1. **Shut down your database cleanly.**
2. **Shut down the database and modify your server parameter file to use Oracle Managed Files (OMF).**
3. **Edit and execute the following RMAN script:**

```
STARTUP NOMOUNT;
RESTORE CONTROLFILE FROM '/u1/c1.ctl';
ALTER DATABASE MOUNT;
BACKUP AS COPY DATABASE FORMAT '+dgroup1';
SWITCH DATABASE TO COPY;
SQL "ALTER DATABASE RENAME '/u1/log1' TO '+dgroup1' ";
# Repeat RENAME command for all online redo log
members ...
ALTER DATABASE OPEN RESETLOGS;
SQL "ALTER DATABASE TEMPFILE '/u1/temp1' DROP";
```

12-34

Migrating Your Database to ASM Storage

Because ASM files cannot be accessed through normal operating system interfaces, RMAN is the only means for copying ASM files. Although files in a tablespace may be both ASM files and non-ASM files as a result of the tablespace history, RMAN commands enable non-ASM files to be relocated to an ASM disk group. You can use the following procedure to relocate your entire database to an ASM disk group: (It is assumed that you are using a server parameter file.)

1. Obtain the file names of the current control files and online redo logs by using `V$CONTROLFILE` and `V$LOGFILE`.
2. Shut down the database consistently. Modify the server parameter file of your database as follows:
   - Set the necessary OMF destination parameters to the desired ASM disk group.
   - Remove the `CONTROL_FILES` parameter.

Migrating Your Database to ASM Storage (continued)

3. Edit and run the RMAN command file, which backs up the database, switches the current data files to the backups, and renames the online redo logs. You can move only tablespaces or data files by using the `BACKUP AS COPY` command.
4. Delete the old database files.

Note: If you create an OMF control file, and if there is a server parameter file, then a `CONTROL_FILES` initialization parameter entry is created in the server parameter file.

See the *Oracle Database Backup and Recovery Advanced User's Guide* for details about how to migrate a database to ASM.

Summary

In this lesson, you should have learned how to:

- Describe the concepts of Automatic Storage Management (ASM)
- Set up initialization parameter files for ASM and database instances
- Execute SQL commands with ASM file names
- Start up and shut down ASM instances
- Administer ASM disk groups
- Use RMAN to migrate your database to ASM

Practice Overview:
Using Automatic Storage Management

This practice covers the following topics:

- Creating and starting an ASM instance
- Creating and using ASM disk groups
- Migrating a tablespace to ASM storage

13

Managing Resources

Objectives

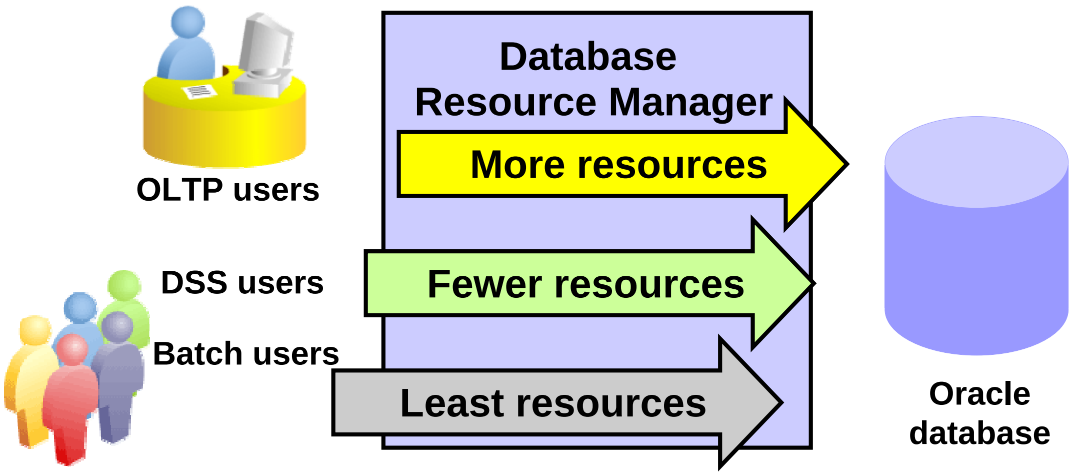
After completing this lesson, you should be able to do the following:

- Configure the Database Resource Manager
- Access and create resource plans
- Create consumer groups
- Specify directives for allocating resources to consumer groups
- Map consumer groups to plans
- Activate a resource plan
- Monitor the Resource Manager

ORACLE

Database Resource Manager: Overview

Use the Resource Manager to:
- Manage mixed workload
- Control system performance



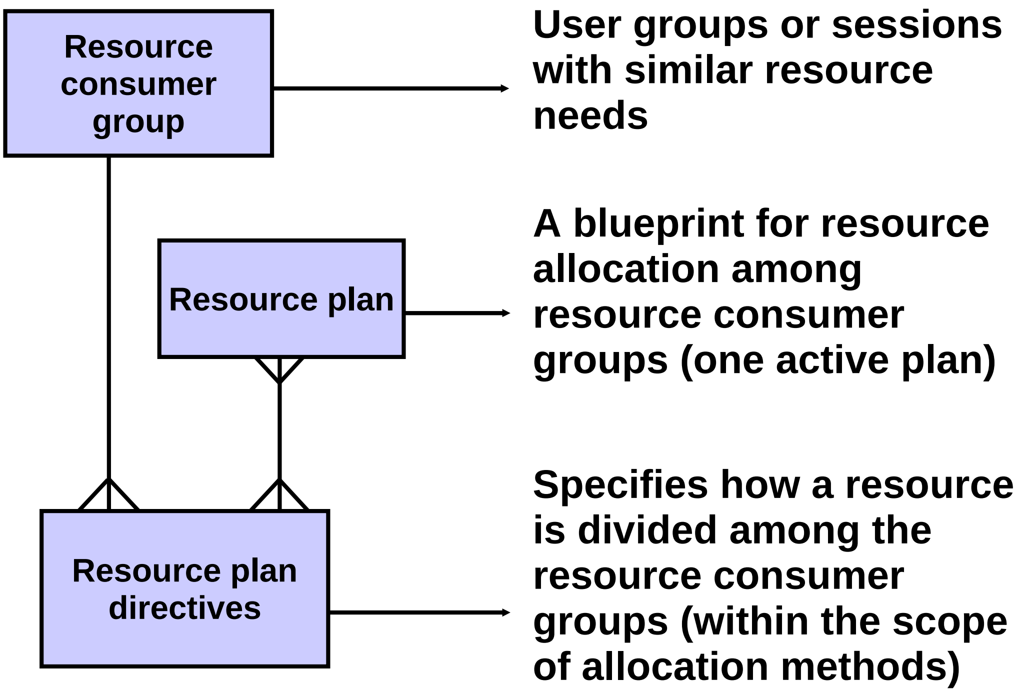
Database Resource Manager: Overview

By using the Database Resource Manager (also called the Resource Manager), you have more control over the allocation of machine resources than is normally possible through operating system resource management alone. If resource management decisions are made by operating system, it can lead to problems such as:

- Excessive overhead resulting from operating system context switching of Oracle database server processes when the number of server processes is high
- Suspension of a database server processes that is holding a latch
- Unequal distribution of resources among all Oracle database processes, and an inability to prioritize one task over another
- Inability to manage database-specific resources, such as parallel execution servers and active sessions

The Database Resource Manager controls the distribution of resources among various sessions by controlling the execution schedule inside the database. By controlling which sessions run and for how long, the Database Resource Manager can ensure that resource distribution matches the plan directive and, therefore, the business objectives. With the Database Resource Manager, you can guarantee groups of users a minimum amount of processing resources regardless of the load on the system and the number of users.

Database Resource Manager Concepts



Database Resource Manager Concepts

Administering systems by using the Database Resource Manager involves the use of resource plans, resource consumer groups, and resource plan directives.

A **resource consumer group** defines a set of users or sessions that have similar requirements for using system and database resources.

A **resource plan** specifies how the resources are distributed among various resource consumer groups. The Database Resource Manager also allows for creation of plans within plans, called **subplans**.

Resource plan directives specify how a particular resource is shared among consumer groups or subplans. You associate resource consumer groups and subplans with a particular resource plan through plan directives.

Resource allocation methods determine what policy to use when allocating for any particular resource. Resource allocation methods are used by resource plans and resource consumer groups.

Why Use Resource Manager

- You can manage database and operating system resources, such as:
  - CPU usage
  - Degree of parallelism
  - Number of active sessions
  - Undo generation
  - Operation execution time
  - Idle time
- You can also specify criteria that, if met, cause the automatic switching of sessions to another consumer group.

13-5

Why Use Resource Manager

The Database Resource Manager provides several means of allocating resources:

- **CPU Method:** Enables you to specify how CPU resources are allocated among consumer groups and subplans
- **Degree of Parallelism Limit:** Enables you to control the maximum degree of parallelism for any operation within a consumer group
- **Active Session Pool with Queuing:** Allows you to limit the number of concurrent active sessions for a consumer group or subplan. If a group exceeds the maximum allowed number of sessions, new sessions are placed in a queue where they wait for an active session to complete. You can also specify a time limit on how long a session will wait before exiting with an error.
- **Undo Pool:** Enables you to control the total amount of undo that can be generated by a consumer group or subplan. Whenever the total undo space exceeds the amount specified by `UNDO_POOL`, no further `INSERT`, `UPDATE`, or `DELETE` commands are allowed until undo space is freed by another session in the same group or the undo pool is increased for the consumer group. If the consumer group's quota is exceeded during the execution of a DML statement, the operation aborts and returns an error. Queries are still allowed, even if a consumer group has exceeded its undo threshold.

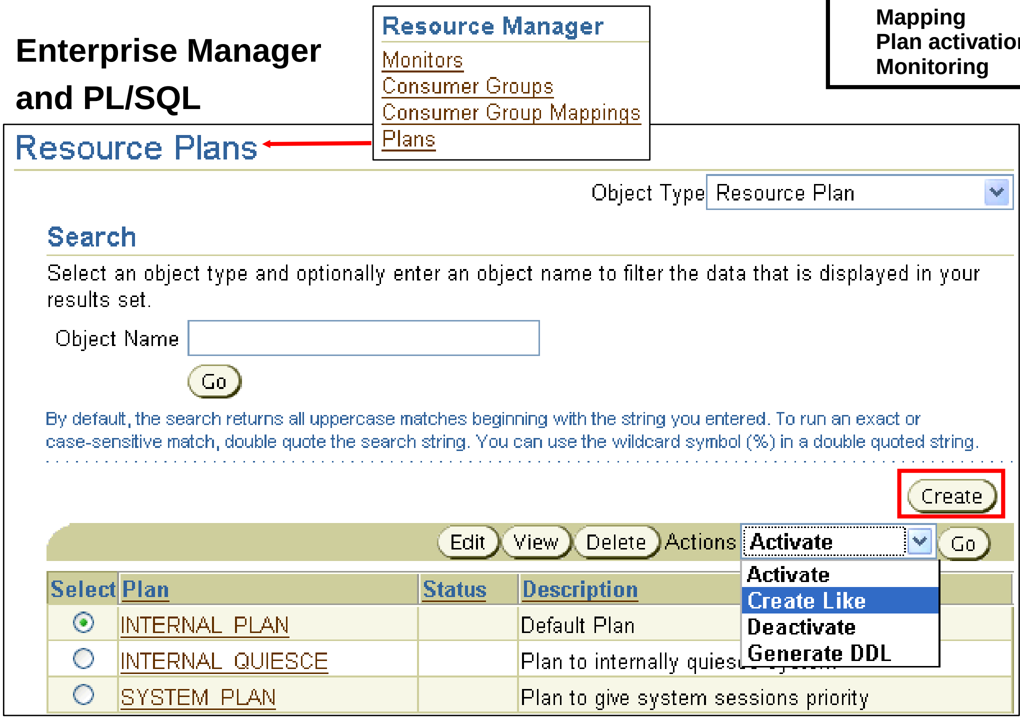
Why Use Resource Manager (continued)

- **Execution Time Limit:** Allows you to specify a maximum execution time allowed for an operation. The Oracle database uses cost-based optimizer statistics to estimate how long an operation will take. If it is longer than the maximum time allowed (`MAX_EST_EXEC_TIME`), the operation returns an error and is not started. If a resource consumer group has more than one plan directive with `MAX_EST_EXEC_TIME` specified, the Resource Manager chooses the most restrictive of all incoming values.
- **Idle Time Limit:** Enables you to specify an amount of time for which a session can be idle, after which it will be terminated (`MAX_IDLE_TIME`). You can further restrict the Resource Manager to only terminate sessions that are blocking other sessions (`MAX_IDLE_TIME_BLOCKER`).

Accessing Resource Plans

Concepts
> Resource Plan
Consumer Group
Plan Directives
Mapping
Plan activation
Monitoring

Enterprise Manager and PL/SQL



ORACLE

Accessing Resource Plans

Using Enterprise Manager

The Enterprise Manager Database Control Console provides an easy-to-use graphical interface for configuring resource plans, consumer groups, and so on.

Using the `DBMS_RESOURCE_MANAGER` Package

This PL/SQL package comprises many procedures, including the following:

- **`CREATE_PLAN`:** Names a resource plan and specifies its allocation methods
- **`UPDATE_PLAN`:** Updates a resource plan's comment
- **`DELETE_PLAN`:** Deletes a resource plan and its directives

Example: SYSTEM_PLAN

Resource Consumer Group	Allocation Methods		
	CPU_P1	CPU_P2	CPU_P3
SYS_GROUP	100%	0%	0%
OTHER_GROUPS	0%	100%	0%
LOW_GROUP	0%	0%	100%

Example: SYSTEM_PLAN

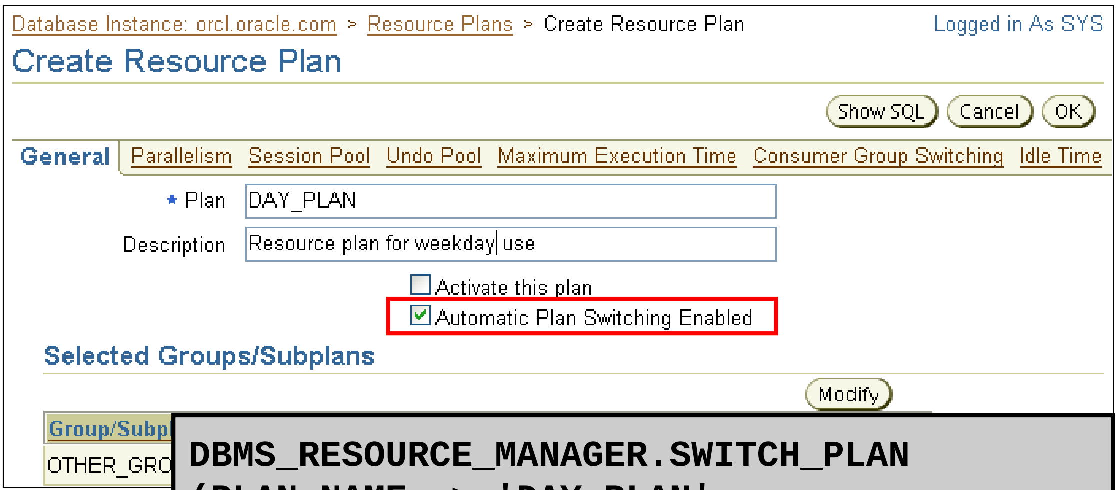
The SYSTEM_PLAN resource plan is one of the default plans provided for you. It contains directives for the following provided consumer groups:

- **SYS_GROUP:** The initial consumer group for the SYS and SYSTEM users
- **OTHER_GROUPS:** Used for all sessions that belong to consumer groups that are not part of the active resource plan. There must be a plan directive for OTHER_GROUPS in any active plan.
- **LOW_GROUP:** A group with lower priority than SYS_GROUP and OTHER_GROUPS in this plan. You must decide which user sessions will be part of LOW_GROUP. Initially, no user is associated with this consumer group. The switch privilege is granted to PUBLIC for this group.

The initial consumer group of a user is the consumer group to which any session created by that user initially belongs. If you have not set the initial consumer group for a user, the user's initial consumer group will automatically be DEFAULT_CONSUMER_GROUP.

The SYSTEM_PLAN and associated resource consumer groups can be used or not used. It can be a template for new resource plans; it can be modified or deleted. Use it as appropriate for your environment.

Creating a New Resource Plan




```
DBMS_RESOURCE_MANAGER.SWITCH_PLAN
(PLAN_NAME => 'DAY_PLAN',
 SID => 'ORCL',
 ALLOW_SCHEDULER_PLAN_SWITCHES => true );
```


Creating a New Resource Plan

To create a new plan, you need to configure several Resource Manager objects.

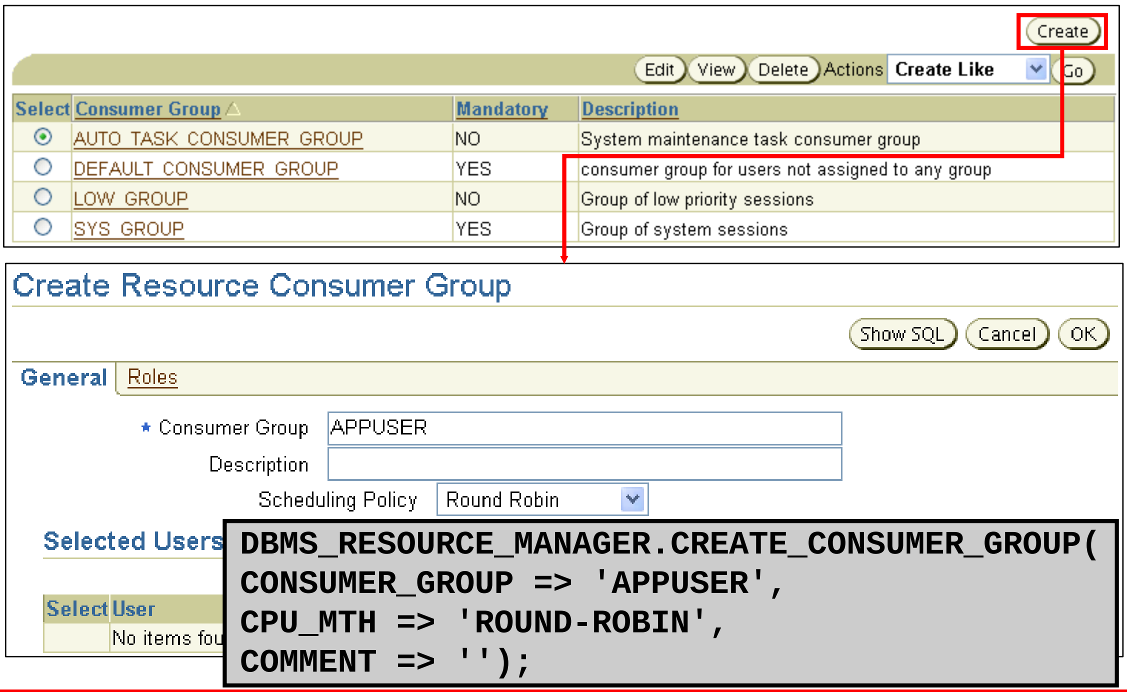
Select Administration > Plans, and then click Create or choose “Create Like” and click Go.

The Scheduler can automatically change the Resource Manager plan at the Scheduler window boundaries. Deselect the default “Automatic Plan Switching Enabled,” if this is unacceptable.

For more information about the Scheduler, see the lesson titled “Automating Tasks with the Scheduler.”

Creating Consumer Groups

Concepts
Resource Plan
> Consumer Group
Plan Directives
Mapping
Plan activation
Monitoring



ORACLE

Creating Consumer Groups

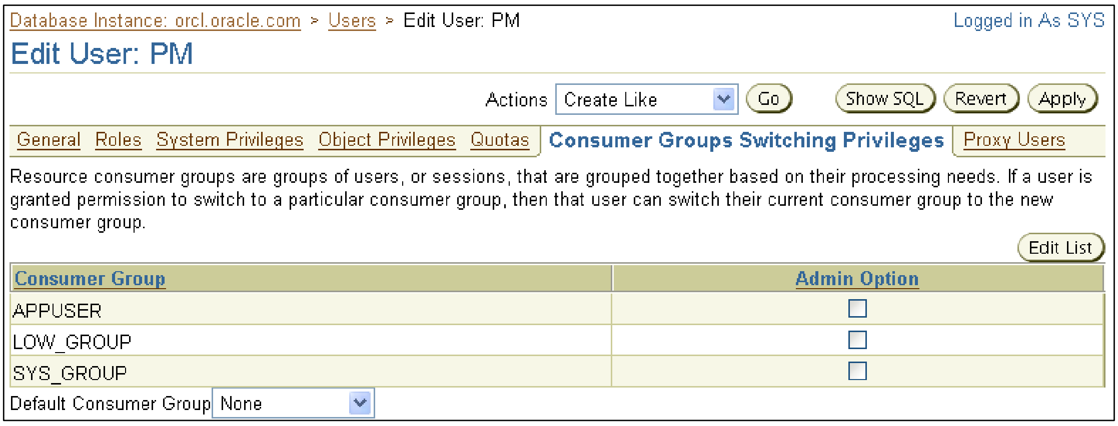
To manage a resource consumer group, select Administration > Resource Consumer Groups. Choose the action that you want to perform. You can create a new resource consumer group or you can select a resource consumer group from the results list and choose one of the actions from the Actions drop-down list.

Use the Resource Consumer Groups page to create or edit the consumer group and description, and to select users assigned to the group. You can add or delete members to the Selected Users table.

The General property sheet (shown in the slide) is one of the two pages that make up the Create Resource Consumer Group and Edit Resource Consumer Group pages. You can define or edit which database roles are associated with the specified resource consumer group by moving to the other property sheet (Roles).

You specify a resource allocation method for the distribution of CPU among sessions in the consumer group. “Round Robin” scheduling ensures that sessions are fairly executed. Therefore, the default allocation method is Round Robin. The “Run to Completion” allocation method specifies that sessions with the largest active time are scheduled ahead of other sessions. The equivalent functionality is achieved by the `DBMS_RESOURCE_MANAGER.CREATE_CONSUMER_GROUP` procedure with the `CPU_MTH` option.

Assigning Users to Consumer Groups



Assigning Users to Groups

Before enabling the Database Resource Manager, users must be assigned to resource consumer groups. The user's default consumer group is the one to which any session created by that user initially belongs. If it is not set for a user, the user's initial consumer group defaults to `DEFAULT_CONSUMER_GROUP`.

You must directly grant to the user, or to `PUBLIC`, the switch privilege to a consumer group before it can be the user's default consumer group. The switch privilege cannot come from a role granted to that user.

```
DBMS_RESOURCE_MANAGER.SET_INITIAL_CONSUMER_GROUP (
user => 'PM', consumer_group => 'APPUSER' );
```

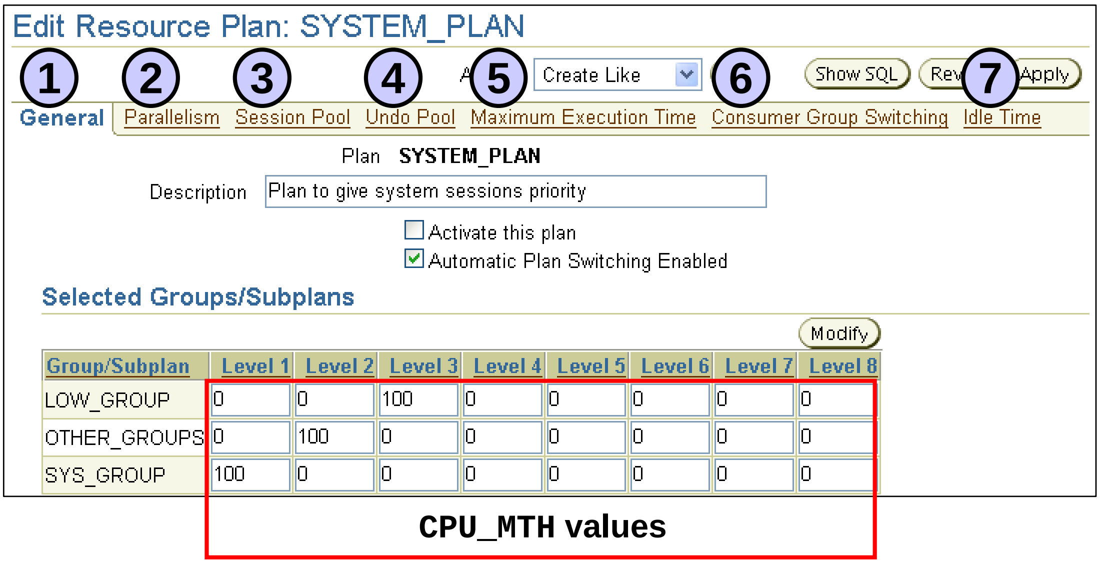
The `DBMS_RESOURCE_MANAGER_PRIVS` package contains the procedure to assign resource consumer groups to users. Granting the switch privilege to a user enables the user to switch to a different consumer group.

```
DBMS_RESOURCE_MANAGER_PRIVS.GRANT_SWITCH_CONSUMER_GROUP (
grantee_name => 'PM',
consumer_group => 'APPUSER',
grant_option => FALSE );
```

You do not use a pending area for any of these procedures.

Specifying Resource Plan Directives

Concepts
Resource Plan
Consumer Group
> Plan Directives
Mapping
Plan activation
Monitoring



Specifying Resource Plan Directives

If you do not use Enterprise Manager to create the resource plan or resource consumer groups, you must first create a *pending area*. This is a scratch area that enables you to stage your changes and to validate them before they are made active.

In Enterprise Manager, there are several property pages, which you can use for specifying plan directives:

1. On the General page, associate consumer groups with plans and specify how much CPU each consumer group or subplan gets with the `CPU_MTH` value.
2. Specify a parallel degree limit to control the maximum degree of parallelism for any operation within a consumer group.
3. You can control the maximum number of concurrently active sessions allowed within a consumer group. An entire parallel execution session is counted as one active session.
4. You can control the amount of total undo that can be generated by a consumer group.
5. You can specify a maximum execution time allowed for an operation.
6. You can control resources by specifying criteria that, if met, cause the automatic switching of sessions to another consumer group.
7. You can specify an amount of time that a session can be idle, after which it will be terminated. You can further restrict such termination to only sessions that are blocking other sessions.

Note: The following slides provide further details about directives using the tab numbers indicated in this slide. Refer to this slide when you see "Directive Tab *n*" on subsequent slides.

Resource Allocation Methods for Resource Plans

Parameter	Possible Values
CPU_MTH	EMPHASIS
	RATIO
PARALLEL_DEGREE_LIMIT_MTH	PARALLEL_DEGREE_LIMIT_ABSOLUTE
ACTIVE_SESS_POOL_MTH	ACTIVE_SESS_POOL_ABSOLUTE
QUEUING_MTH	FIFO_TIMEOUT

Resource Allocation Methods for Resource Plans

Resource allocation methods determine how the Resource Manager allocates a particular resource to a resource consumer group or resource plan. You specify values for the following resource allocation methods when creating the resource plan.

There are two ways of specifying the CPU distribution with the **CPU_MTH** parameter:

- EMPHASIS, the default method, is for multilevel plans that use percentages to specify how CPU is distributed among consumer groups.
- RATIO is for single-level plans that use ratios to specify how CPU is distributed.

PARALLEL_DEGREE_LIMIT_MTH limits the maximum degree of parallelism of any operation. This method can be specified only for resource consumer groups, not subplans. The ABSOLUTE method is the possible value, specifying how many processes may be assigned to an operation. If there are multiple plan directives referring to the same subplan or consumer group, the minimum of all the possible values is used as the parallel degree limit for that subplan or consumer group.

ACTIVE_SESS_POOL_MTH limits the number of active sessions. All other sessions are inactive and wait in a queue to be activated. ACTIVE_SESS_POOL_ABSOLUTE is the default and only method available.

QUEUING_MTH controls the order in which queued inactive sessions execute. FIFO_TIMEOUT is the default and only method available.

Comparison of EMPHASIS and RATIO

EMPHASIS	RATIO
The value specifies the maximum percentage of CPU resources a consumer group can use.	The value specifies a number that indicates the ratio of CPU resources to be allocated to the consumer group.
You can allocate resources for up to 8 different levels.	You can specify values for only one level.
The sum of percentages at any given level must be less than or equal to 100.	You must use integer values, but there is no limit on the sum of values.
Default value is NULL.	Default value is NULL.

ORACLE

13-14

Comparison of EMPHASIS and RATIO

The `EMPHASIS` CPU allocation method determines how much emphasis is given to sessions in different consumer groups in a resource plan. CPU usage is assigned levels from 1 through 8, with level 1 having the highest priority. Percentages specify how to allocate CPU to each consumer group at each level.

The following rules apply for the `EMPHASIS` resource allocation method:

- CPU resources are distributed at a given level on the basis of the specified percentages. The percentage of CPU specified for a resource consumer group is a maximum for how much that consumer group can use at a given level.
- Consumer resources that are not used at a given level are made available to consumer groups at next level. For example, if the consumer groups at Level 1 use only 60% of the available resources, the additional 40% is made available to consumer groups at Level 2.
- The sum of percentages at any given level must be less than or equal to 100.
- Any levels that have no plan directives explicitly specified have a default of 0% for all subplans or consumer groups.
- The `EMPHASIS` resource allocation method avoids starvation problems, where consumers with lower priorities are not given the opportunity to run.

Comparison of EMPHASIS and RATIO (continued)

The RATIO policy is a single-level CPU allocation method. Instead of percentages, you specify numbers corresponding to the ratio of CPU you want to give to the consumer group. For example, given three consumer groups OLTP_USERS, DSS_USERS, and BATCH_USERS, you can specify the following ratios:

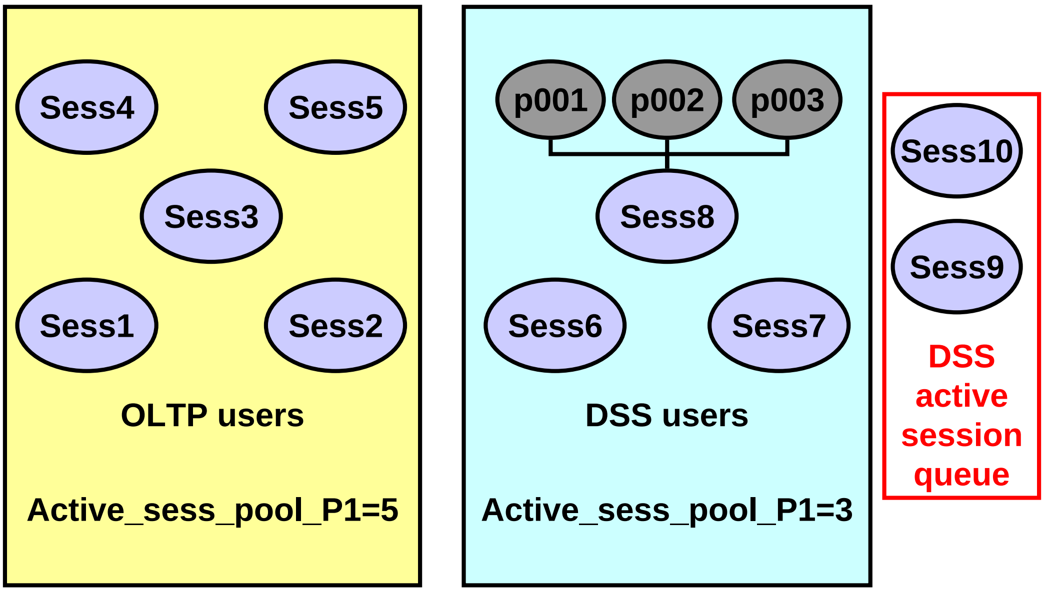
- **OLTP_USERS:** 4
- **DSS_USERS:** 3
- **BATCH_USERS:** 2
- **OTHER:** 1

This is similar to saying that OLTP users should get 40% of the resources, DSS users should get 30% of the resources, BATCH users should get 20% of the resources, and all other consumer groups should get 10% of the available resources.

If there are no consumers in the OTHER or DSS_USERS consumer groups currently utilizing CPU resources, then the OLTP_USERS consumer group would get two-thirds of the available resources and the BATCH_USERS consumer group would get the other third.

Directive Tab 3

Active Session Pool Mechanism



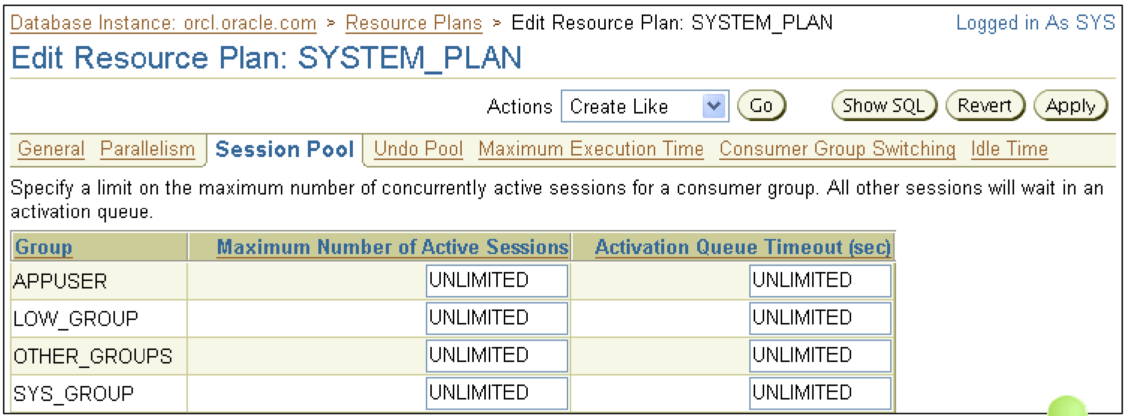
Active Session Pool Mechanism

Using the active session pool feature, you can control the maximum number of concurrently active sessions per resource consumer group. With this functionality, a DBA can indirectly control the amount of resources that any resource consumer group uses because resource consumption is proportional to the number of active sessions. Using an active session pool can help to reduce the number of servers taking resources in the system, thus avoiding inefficient paging, swapping, and other resource depletion (such as memory) resulting from attempting to run too many jobs simultaneously.

After the active session pool is filled with active sessions, the Resource Manager queues all subsequent sessions attempting to become active until other active sessions complete or become inactive. An active session is one currently involved in a transaction, query, or parallel operation. Individual parallel slaves are not counted as sessions; the entire parallel operation counts as one active session.

There is only one queue per resource consumer group and the queuing method is first in, first out (FIFO) with a timeout. The queue is implemented as a memory structure and cannot be queried directly.

Setting the Active Session Pool



ORACLE

13-17

Setting the Active Session Pool

You can easily configure the Active Session Pool settings for a resource plan by using Enterprise Manager.

Directive Tab 5

Maximum Estimated Execution Time

- The Database Resource Manager can estimate the execution time of an operation proactively.
- You can specify a maximum estimated execution time for an operation at the resource consumer group level.
- Operation does not start if the estimate is longer than `MAX_EST_EXEC_TIME`. (`ORA-07455`)
- The benefit of this feature is the elimination of the exceptionally large job that uses too many system resources.
- The default is `UNLIMITED`.

ORACLE

13-18

Maximum Estimated Execution Time

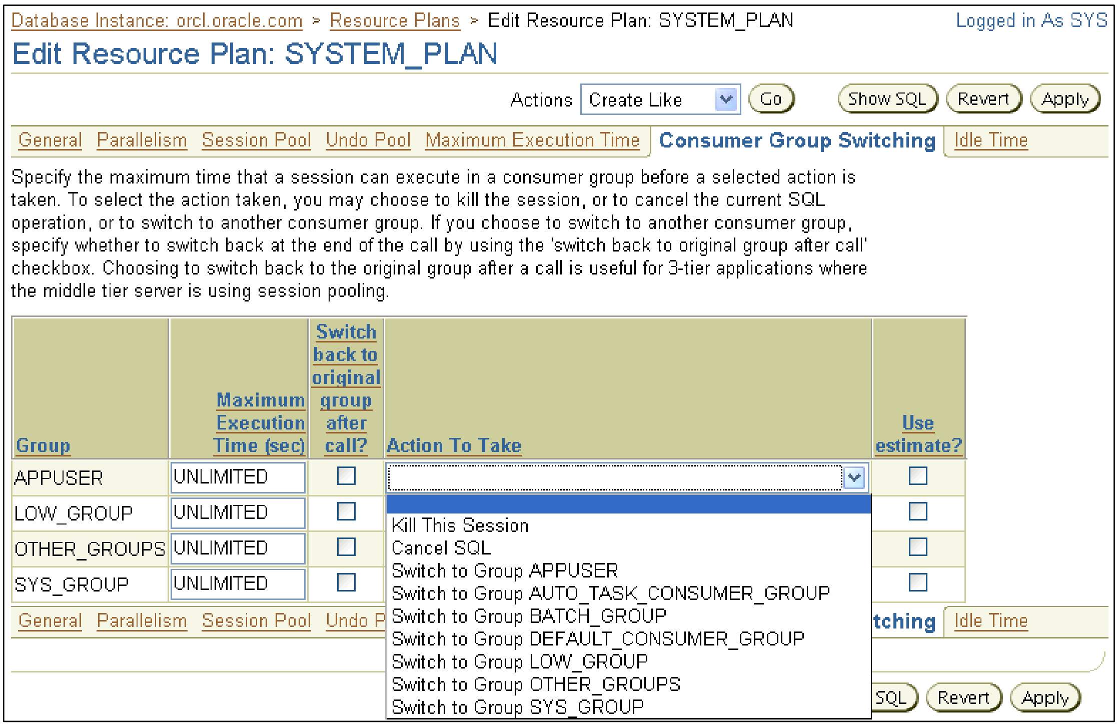
You can define the maximum estimated execution time any operation can take at any given time by setting the resource plan directive's `MAX_EST_EXEC_TIME` parameter. When this parameter is set, the Database Resource Manager estimates the time a specific job will take. If the operation's estimate is more than `MAX_EST_EXEC_TIME`, then the operation does not start and the `ORA-07455` error is issued. This eliminates any exceptionally large jobs that would utilize too many system resources.

If a resource consumer group has more than one plan directive referring to it, it may have more than one `MAX_EST_EXEC_TIME`. The Database Resource Manager then chooses the most restrictive of all incoming values.

The estimated execution time for a given statement is calculated using the statistics from the cost-based optimizer.

Directive
Tab 6

Consumer Group Switching



ORACLE

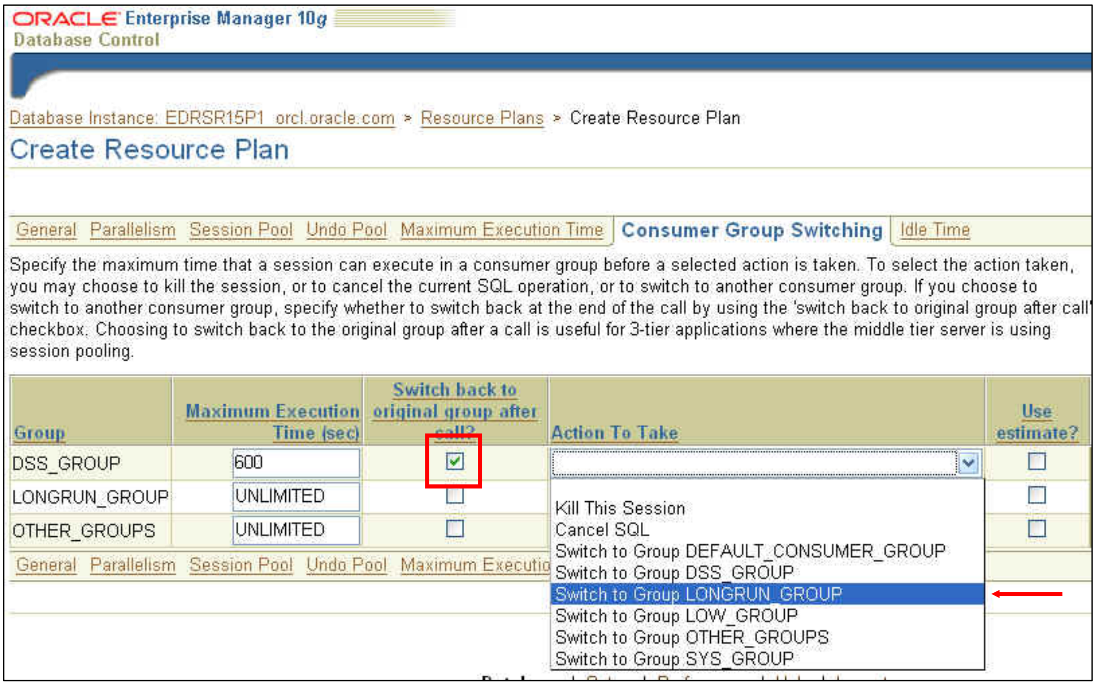
Consumer Group Switching

The EM Database Control Console provides a graphical interface for configuring automatic consumer group switching. You can configure this option when creating a new resource plan, or by editing an existing plan.

Note

- You cannot set the `SWITCH_GROUP` to either `CANCEL_SQL` or `KILL_SESSION` using the Enterprise Manager Database Control Console.
- You cannot set `SWITCH_TIME_IN_CALL` when using the Enterprise Manager interface. You can set `SWITCH_TIME`, which is displayed as the Execution Time in the screenshot in the slide.

Switching Back to the Initial Consumer Group at the End of Call



Switching Back to the Initial Consumer Group at the End of Call

You can specify that at the end of every top call, a session is returned back to its initial consumer group by selecting the “Switch back to original group after call?” check box in the Create Resource Plan window. The initial consumer group is the group that a session would be in had it just logged in. The top call is defined as treating an entire PL/SQL block as one call or, similarly, treating SQL statements that are issued separately by the client as separate calls.

This functionality is mostly beneficial for three-tier applications where the middle-tier server implements session pooling. In this case, the middle tier tends to do one call for an end user and then use the same session for a call for a different end user. Therefore, the boundaries of work are really calls, and the actions of a prior end user should not affect the next end user.

Switching Back to the Initial Consumer Group at the End of Call

Call 1

```
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE
  (PLAN => 'Day_Plan',
   GROUP_OR_SUBPLAN => 'DSS_GROUP',
   CPU_P1   => 100,  CPU_P2   =>   0,
   SWITCH_GROUP => 'LONGRUN_GROUP',
   SWITCH_TIME_IN_CALL => 600);
```

Call 2

```
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE
  (PLAN => 'Day_Plan',
   GROUP_OR_SUBPLAN => 'LONGRUN_GROUP',
   CPU_P1   =>   0,  CPU_P2   => 100);
```

At call end

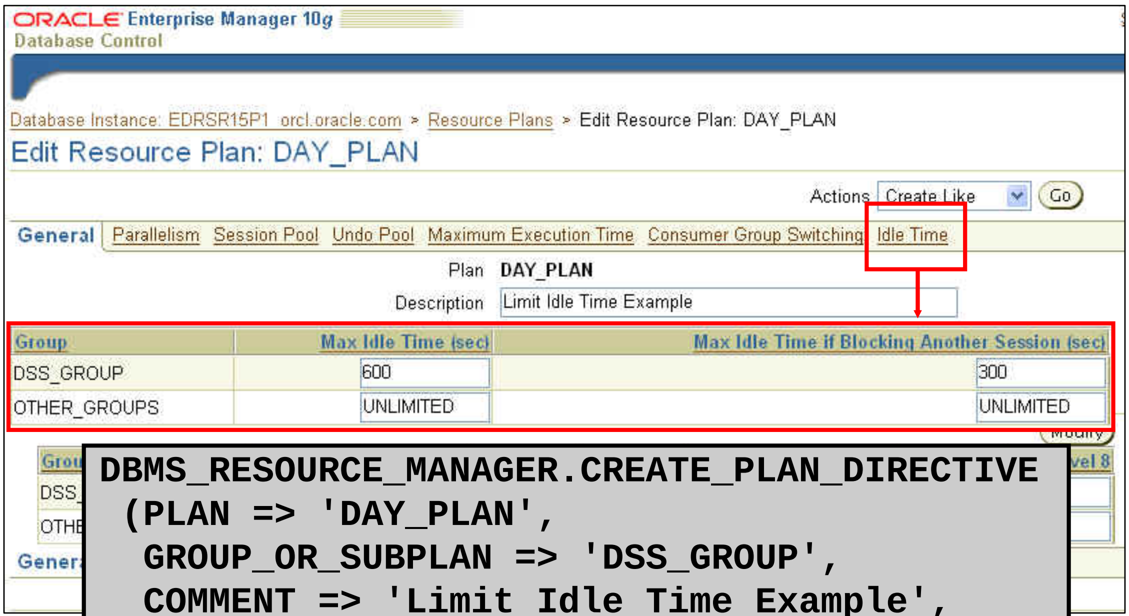
Switching Back to the Initial Consumer Group at the End of Call (continued)

Using the previous Enterprise Manager scenario example, but with the `DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE` procedure, when a user logs in, the Resource Manager places the session in the `DSS_GROUP` consumer group because of its initial consumer group mapping. The user then executes a query. When you set a value (in seconds) for the `SWITCH_TIME_IN_CALL` parameter, you are setting a timer on the call before an action is taken, dictated by the `SWITCH_GROUP` parameter. At the end of the top call, the Resource Manager automatically switches the user back to the initial consumer group.

Note: You cannot specify both the `SWITCH_TIME_IN_CALL` and `SWITCH_TIME` parameters within the same directive. The `SWITCH_TIME` parameter is primarily intended for client/server applications.

Directive Tab 7

Setting Idle Timeouts




```
DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE
 (PLAN => 'DAY_PLAN',
  GROUP_OR_SUBPLAN => 'DSS_GROUP',
  COMMENT => 'Limit Idle Time Example',
  MAX_IDLE_TIME => 600,
  MAX_IDLE_BLOCKER_TIME => 300);
```

13-22

Setting Idle Timeouts

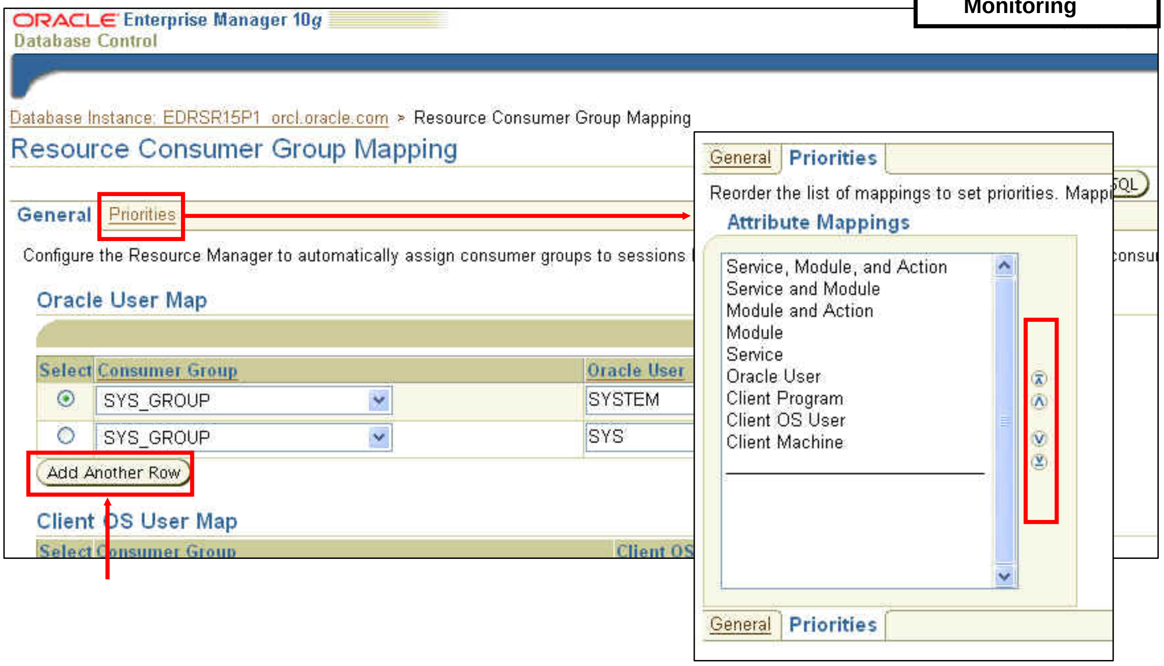
You use the resource plan’s Idle Time tab to set the maximum idle timeouts for a resource plan. “Max Idle Time (sec)” and “Max Idle Time if Blocking Another Session (sec)” are the respective equivalents of the MAX_IDLE_TIME and MAX_IDLE_BLOCKER_TIME resource directives in the DBMS_RESOURCE_MANAGER.CREATE_PLAN_DIRECTIVE procedure. They are both specified in seconds.

MAX_IDLE_TIME specifies the time that a session is neither executing nor waiting for I/O. When the session exceeds the specified limit, the PMON process forcibly kills the session and cleans up its state. In addition to limiting the maximum idle time for a session, you can also limit the amount of time that an idle session can block another session. You impose this limit by setting the MAX_IDLE_BLOCKER_TIME resource directive to the number of seconds to allow a session to be idle while blocking another session. You can also specify a value of UNLIMITED to indicate that no maximum time has been set. The default is NULL, which means unlimited. These settings give you a more granular control than profiles, whose single value cannot distinguish between blocking and nonblocking sessions.

In the slide example, the PMON process kills sessions that are idle for longer than 600 seconds. The PMON process also kills sessions that are idle for more than 300 seconds and are blocking other sessions. PMON checks these limits once every minute and if it finds a session that has exceeded one of the limits, it forcibly kills the session and cleans up all its resources.

Resource Consumer Group Mapping

Concepts
Resource Plan
Consumer Group
Plan Directives
> **Mapping**
Plan activation
Monitoring



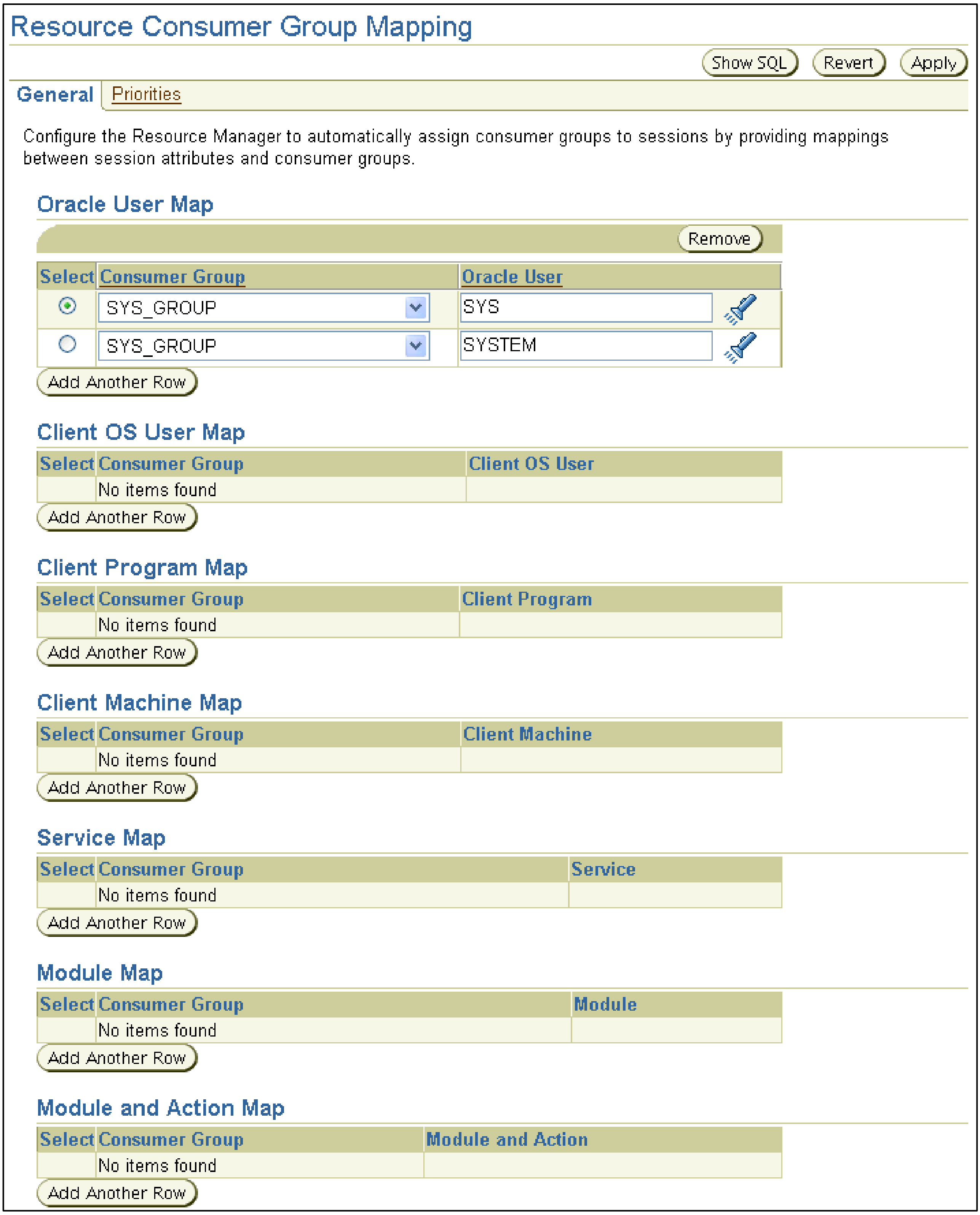
Resource Consumer Group Mapping

You can configure the Database Resource Manager to automatically assign consumer groups to sessions by providing mappings between session attributes and consumer groups. Further, you can prioritize the mappings so as to indicate which mapping has precedence in case of conflicts. There are two types of session attributes: login attributes and run-time attributes. The login attributes (the last five in the Attribute Mappings list shown in the slide) are meaningful only at session login time, when the Database Resource Manager determines the initial consumer group of the session. In contrast, a session that has already logged in can later be reassigned to another consumer group on the basis of its run-time attributes.

From the Database Control home page, navigate to the Administration tabbed page, and then click the Resource Consumer Group Mappings link in the Resource Manager section. For each of the attributes, set up a mapping that consists of a way to identify a session (for example, user name), and a consumer group. Add or remove rows for each of the resource consumer group categories, as required, and enter text identifying the user, client, module, or service in the corresponding group. You can establish a priority ordering between conflicting mappings of the attributes by using the Priorities tab. You can set the priority from the most important to the least important by using the navigational arrows (as highlighted). The mappings at the top of the list have the highest priority.

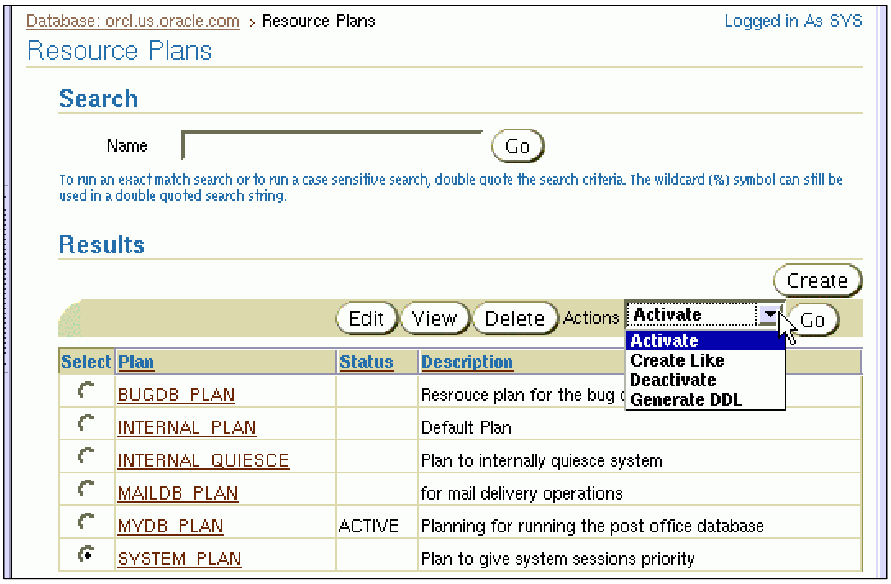
Using EM Database Control, you can easily view the SQL generated from your actions by clicking the Show SQL button.

Resource Consumer Group Mapping (continued)



Activating a Resource Plan for an Instance

Concepts
Resource Plan
Consumer Group
Plan Directives
Mapping
> **Plan activation**
Monitoring



ORACLE

Activating a Resource Plan for an Instance

You can use the “Resource Plans” page of Enterprise Manager to manage resource plans. To activate a plan, select the plan you want to make active, choose “Activate” from the Actions drop-down list, and then click Go. The plan you selected is then made the current top plan for the instance.

Using the `RESOURCE_MANAGER_PLAN` Initialization Parameter

The plan for an instance is defined using the `RESOURCE_MANAGER_PLAN` database initialization parameter. This parameter specifies the top plan to be used for this instance. If no plan is specified, the Resource Manager is not activated for the instance.

You can activate, deactivate, or change the current top plan by using an `ALTER SYSTEM` statement. When a resource plan is changed using this command, the change takes effect instantly.

If the parameter is set in a parameter file, and the plan specified is not defined in the database, then the database cannot be opened with that parameter file. The following error is returned:

```
ORA-07452: specified resource manager plan does not exist in
the data dictionary
```

If this error is encountered, the parameter must be modified to show a correct value before the instance can be restarted.

Database Resource Manager Information

View Name	Information
DBA_RSRC_PLANS	Plans and status
DBA_RSRC_PLAN_DIRECTIVES	Plan directives
DBA_RSRC_CONSUMER_GROUPS	Consumer groups
DBA_RSRC_CONSUMER_GROUP_PRIVS	Users/roles
DBA_RSRC_GROUP_MAPPINGS	Consumer group mapping
DBA_RSRC_MAPPING_PRIORITY	Mapping priority
DBA_USERS	Column initial_rsrc_ consumer_group
DBA_RSRC_MANAGER_SYSTEM_PRIVS	Users/roles

Database Resource Manager Information

Several data dictionary views are available to check the resource plans, consumer groups, and plan directives that are declared in the instance. This section discusses some useful information that can be obtained from these views. For more detailed information about the contents of each of these views, refer to the *Oracle Database Reference* manual.

Use the following query to obtain information about resource plans defined in the database:

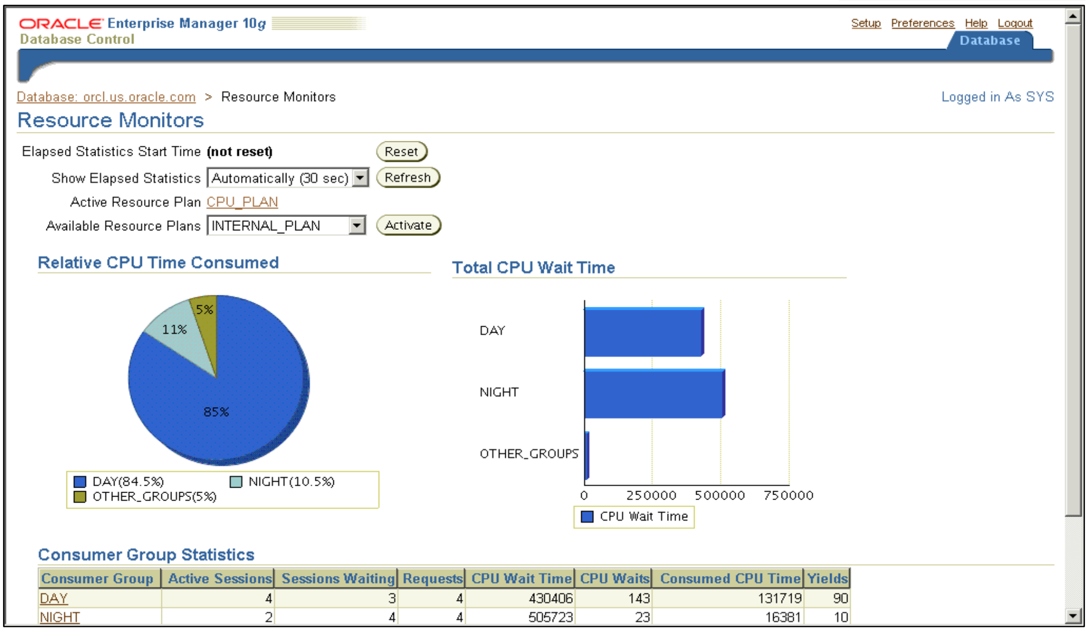
```
SQL> SELECT plan, num_plan_directives, status, mandatory
  2  FROM dba_rsrc_plans;
PLAN           NUM_PLAN_DIRECTIVES STATUS    MAN
-------------- ------------------- --------- ---
SYSTEM_PLAN                      3 ACTIVE    NO
INTERNAL_QUIESCE                 2 ACTIVE    YES
INTERNAL_PLAN                    1 ACTIVE    YES
BUGDB_PLAN                       4 ACTIVE    NO
MAILDB_PLAN                      3 ACTIVE    NO
MYDB_PLAN                        3 ACTIVE    NO
```

A status of `ACTIVE` indicates that the plan has been submitted and can be used, whereas a status of `PENDING` shows that the plan has been created, but is still in the pending area.

If the `mandatory` column is assigned a value of `YES`, then the plan cannot be deleted.

Monitoring the Resource Manager

- Concepts
- Resource Plan
- Consumer Group
- Plan Directives
- Mapping
- Plan activation
- > **Monitoring**



Monitoring the Resource Manager

You can monitor the functioning of the Database Resource Manager at the session level. It is integrated with Automatic Database Diagnostic Monitor (ADDM).

There are different ways to manage and monitor the Resource Manager by using EM Database Control. On the Administration tabbed page, click the Monitors link in the Resource Manager section.

The Resource Monitors page displays a grouping of statistics and charts that depict the current state of the active resource plan. You can view the statistics for the currently active plan, and you can select a plan from the list and activate that plan.

The Consumer Group Statistics table lists a series of statistics for the consumer groups that are part of the current resource plan.

Note: When you activate a plan by using the Resource Monitors page, you must exit the page and then choose Resource Monitors again to update the page and view the statistics for the newly activated plan.

Monitoring the Resource Manager

- **`V$SESSION`: Contains the `resource_consumer_group` column that shows the current group for a session**
- **`V$RSRC_PLAN`: A view that shows the active resource plan**
- **`V$RSRC_CONSUMER_GROUP`: A view that contains statistics for all active groups**

ORACLE

Monitoring the Resource Manager (continued)

CPU Utilization

There are at least three different views in the system that can provide you with information about the CPU utilization inside the Oracle database:

- `V$RSRC_CONSUMER_GROUP` shows CPU utilization statistics on a per consumer group basis, if you are running the Oracle Database Resource Manager. This view displays data related to currently active resource consumer groups.
- `V$SYSSTAT` shows the Oracle database CPU usage for all sessions. The statistic "CPU used by this session" shows the aggregate CPU used by all sessions.
- `V$SESSTAT` shows the Oracle database CPU usage per session. You can use this view to determine which particular session is using the most CPU.

The `V$RSRC_CONSUMER_GROUP` View

The following is a quick description of some of the columns in this view:

- **`name`:** Name of the consumer group
- **`active_sessions`:** Number of currently active sessions in this consumer group
- **`execution_waiters`:** Number of active sessions waiting for a time slice
- **`requests`:** Cumulative number of requests executed in this consumer group
- **`cpu_wait_time`:** Cumulative amount of time that sessions waited for CPU
- **`consumed_cpu_time`:** Cumulative amount of CPU time consumed by all sessions

Monitoring the Resource Manager (continued)

There is no view that shows the active session pool queue directly, but you can get some information from:

- **`V$SESSION`:** The `current_queue_duration` column shows how long a session has been queued, or 0 (zero) if the session is not currently queued.
- **`V$RSRC_CONSUMER_GROUP`:** The `queue_length` column shows the number of sessions currently queued per consumer group.

Summary

In this lesson, you should have learned how to do the following:

- Configure the Database Resource Manager
- Access and create resource plans
- Create consumer groups
- Specify directives for allocating resources to consumer groups
- Map consumer groups to plans
- Activate a resource plan
- Monitor the Resource Manager

ORACLE

Practice Overview: Using the Resource Manager

This practice covers the following topics:

- Creating a resource consumer group
- Specifying CPU resource allocation directives for consumer groups
- Associating users with a resource consumer group
- Activating a resource plan
- Testing in SQL*Plus
- Deactivating a resource plan

ORACLE

14

Automating Tasks with the Scheduler

Objectives

Key Comp.
& Steps
Schedules
Job Chains
Adv.Concepts

After completing this lesson, you should be able to:

- Simplify management tasks by using the Scheduler
- Create a job, program, and schedule
- Monitor job execution
- Use a time-based or event-based schedule for executing Scheduler jobs
- Use job chains to perform a series of related tasks
- Use advanced Scheduler concepts to prioritize jobs

ORACLE

14-2

Objectives

For information about the various Scheduler components and their interaction, see the *Oracle Database Administrator's Guide.*

For detailed information about the DBMS_SCHEDULER package, see the *Oracle Database PL/SQL Packages and Types Reference.*

Simplifying Management Tasks

- Performing a series of month-end tasks on the last day of each month
- Running a dequeue procedure as soon as a message is enqueued
- Replicating table data via materialized view refreshes
- Running a daily job to back up database
- Computing table and index statistics twice a day
- Starting the batch load as soon as the file arrives on the file system
- Generating an hourly report on invalid server access attempts
- Rebuilding an index when finished rebuilding the current index

14-3

Simplifying Management Tasks

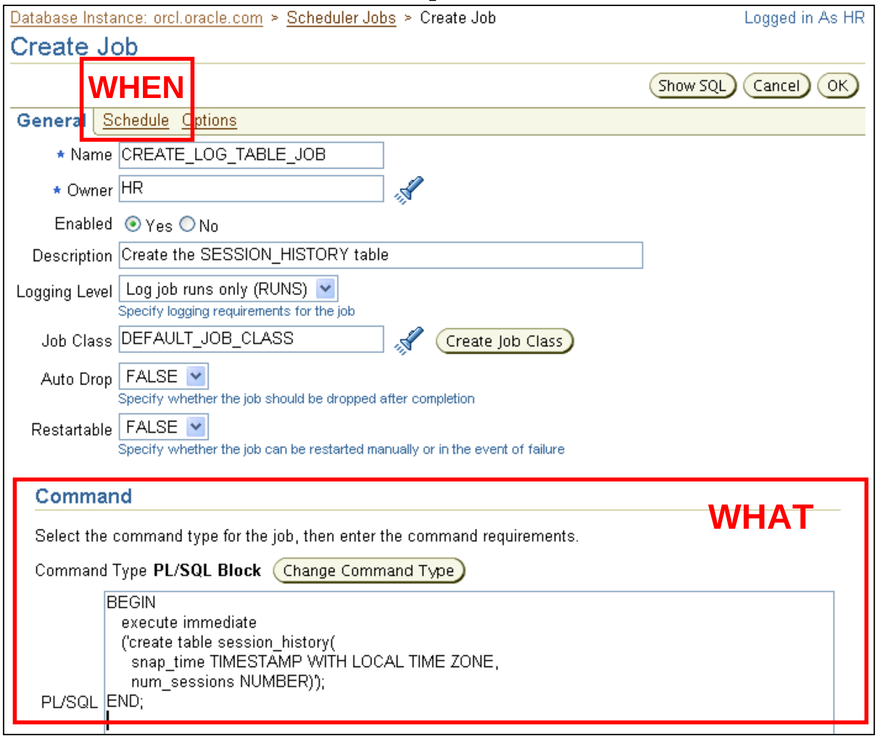
Many tasks in the Oracle environment need job-scheduling capabilities. Routine database maintenance and application logic require jobs to be scheduled and run periodically. Business-to-business (B2B) applications require scheduling for their business events. DBAs need to schedule regular maintenance jobs in specified time windows.

Oracle Database 10*g* provides advanced scheduling capabilities through the database Scheduler, which is a collection of functions and procedures in the `DBMS_SCHEDULER` package. The Scheduler can be invoked in any SQL environment, or through Enterprise Manager.

The Scheduler enables database administrators and application developers to control when and where various tasks take place in the database environment. These tasks can be time consuming and complicated; using the Scheduler, you can manage and plan these tasks.

Scheduler jobs can be started based on time or when a specified event occurs, and the Scheduler can raise events when a job's state changes (for example, from `RUNNING` to `COMPLETE`). You can also use a named series of programs that are linked together for a combined objective.

A Simple Job



A Simple Job

A job has two key components: action, “what” needs to be done and schedule, “when” action occurs. The “what” is expressed in the Command region of the screenshot shown in the slide and the `job_type` and `job_action` parameters.

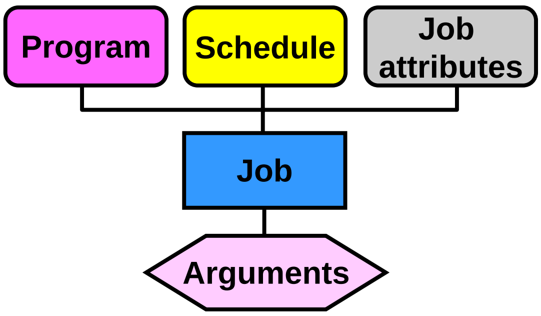
```
BEGIN
sys.dbms_scheduler.create_job(
job_name => '"HR"."CREATE_LOG_TABLE_JOB"',
job_type => 'PLSQL_BLOCK', job_action => 'begin
   execute immediate (''create table session_history(
   snap_time TIMESTAMP WITH LOCAL TIME ZONE,
   num_sessions NUMBER)'');  end;',
start_date => systimestamp at time zone 'America/New_York',
job_class => 'DEFAULT_JOB_CLASS',
comments => 'Create the SESSION_HISTORY table',
auto_drop => FALSE, enabled => TRUE);
END;
```

A job is also defined by “when” the desired action needs to take place. The “when” is expressed in a “schedule,” which can be based on time (see the `start_date` parameter) or events, or be dependent on the outcome of other jobs. These options are discussed in this lesson.

Key Components and Steps

To simplify management tasks with the Scheduler, perform the following steps:

1. **Create a program.**
2. **Create and use a schedule.**
3. **Create and submit a job.**
4. **Monitor a job.**

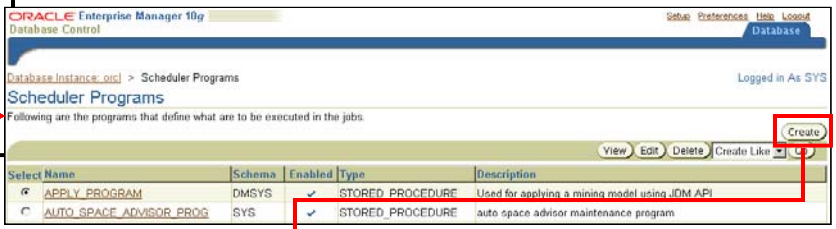


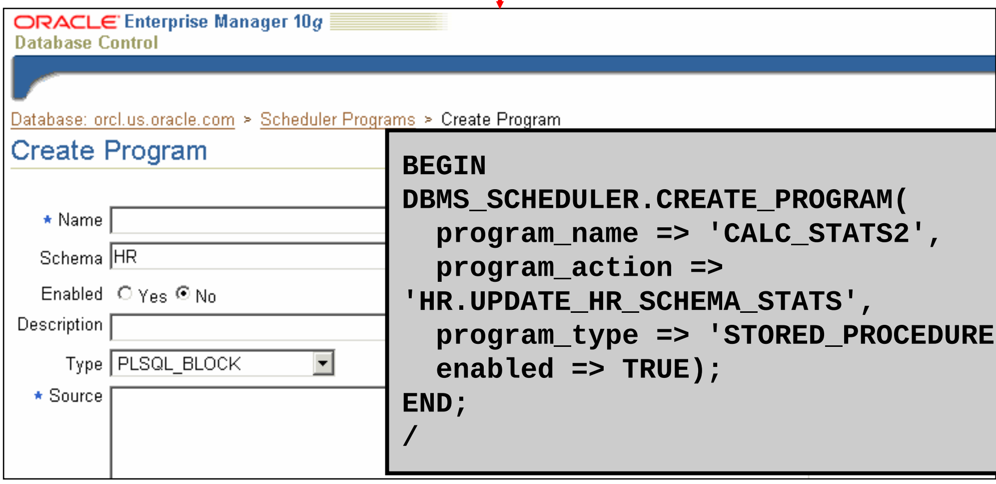
Key Components and Key Steps

The Scheduler offers a modularized approach for managing tasks within the Oracle database. By breaking down a task into its components, such as time, location, and database object, the Scheduler offers you an easier way to manage your database environment. The Scheduler uses three basic components:

- A **job** specifies what needs to be executed and when. For example, the “what” could be a PL/SQL procedure, a native binary executable, a Java application, or a shell script. You can specify the program (what) and schedule (when) as part of the job definition, or you can use an existing program or schedule instead. You can use arguments for a job to customize its run-time behavior.
- A **schedule** specifies when and how many times a job is executed. A schedule can be based on time or an event. You can define a schedule for a job by using a series of dates, an event, or a combination of the two, along with additional specifications to denote repeating intervals. You can store the schedule for a job separately and then use the same schedule for multiple jobs.
- A **program** is a collection of metadata about a particular executable, script, or procedure. An automated job executes some task. Using a program enables you to modify the job task, or the “what,” without modifying the job itself. You can define arguments for a program, enabling users to modify the run-time behavior of the task.

1. Creating a Program






```
BEGIN
DBMS_SCHEDULER.CREATE_PROGRAM(
  program_name => 'CALC_STATS2',
  program_action =>
'HR.UPDATE_HR_SCHEMA_STATS',
  program_type => 'STORED_PROCEDURE',
  enabled => TRUE);
END;
/
```

14-6

1. Creating a Program

Use the `CREATE_PROGRAM` procedure to create a program. Creating a program is an optional part of using the Scheduler. You can also encode the action to be performed within an anonymous PL/SQL block in the `CREATE_JOB` procedure. By creating the program separately, you can define the action once, and then reuse this action within multiple jobs. This enables you to change the schedule for a job without having to re-create the PL/SQL block. You can also customize the job by specifying argument values.

To create a program in your own schema, you need the `CREATE JOB` privilege. A user with the `CREATE ANY JOB` privilege can create a program in any schema.

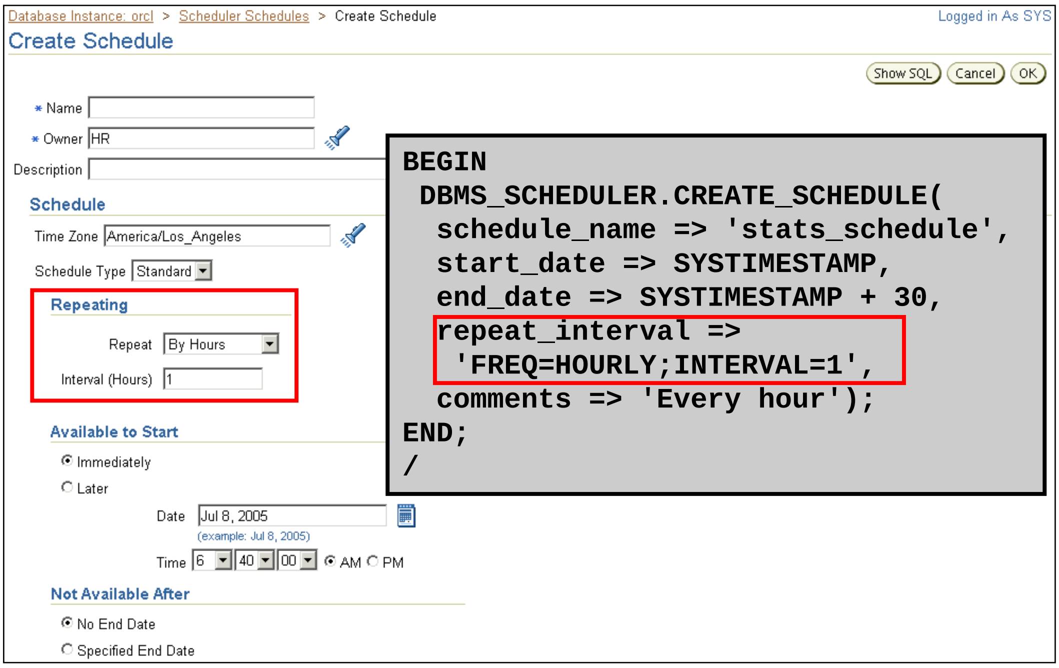
A program is created in a disabled state by default (unless the `enabled` parameter is set to `TRUE`). A disabled program cannot be executed by a job until it is enabled. You can specify that a program should be created in the enabled state by specifying a value of `TRUE` for `enabled`.

The program action is a string specifying a procedure, executable name, or a PL/SQL anonymous block, depending on what `program_type` is set to.

If you have a procedure called `UPDATE_HR_SCHEMA_STATS` that collects the statistics for the `hr` schema, then you can create a program to call this procedure.

In Enterprise Manager, select Administration > Programs and click the Create button.

2. Creating and Using Schedules




```
BEGIN
 DBMS_SCHEDULER.CREATE_SCHEDULE(
  schedule_name => 'stats_schedule',
  start_date => SYSTIMESTAMP,
  end_date => SYSTIMESTAMP + 30,
  repeat_interval =>
   'FREQ=HOURLY;INTERVAL=1',
  comments => 'Every hour');
END;
/
```

14-7

2. Creating and Using Schedules

By using a schedule (instead of specifying the execution times for a job within the job definition), you can manage the scheduled execution of multiple jobs without having to update multiple job definitions. If a schedule is modified, then each job that uses that schedule automatically uses the new schedule.

Use the `CREATE_SCHEDULE` procedure in the `DBMS_SCHEDULER` PL/SQL package to create a schedule.

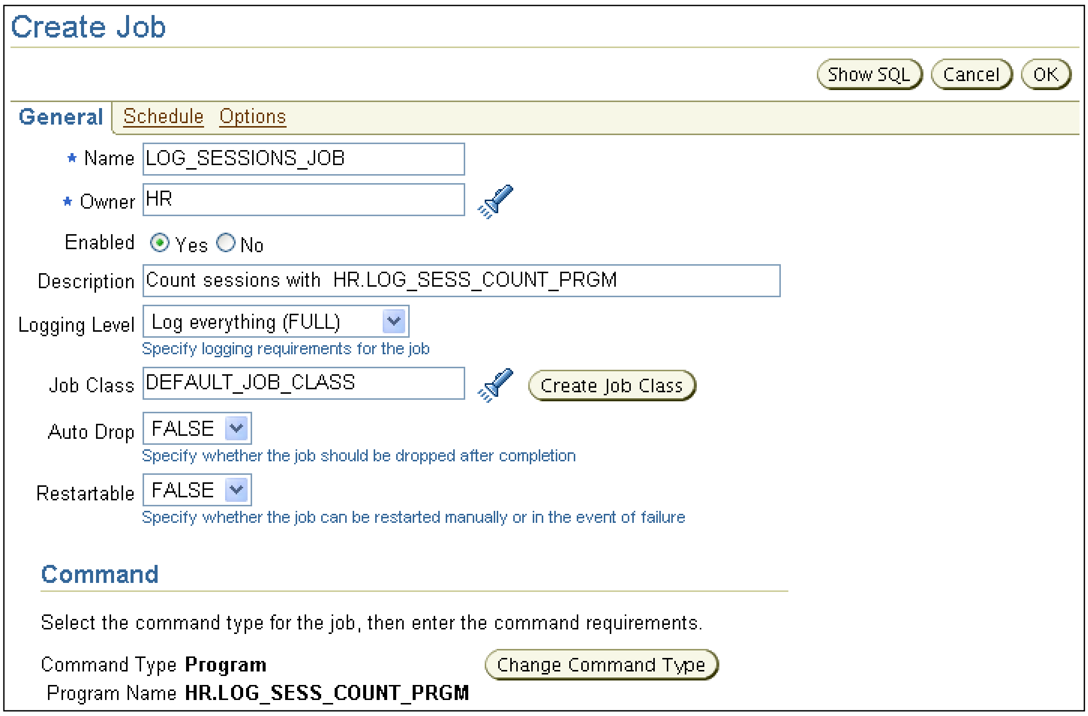
The `start_date` represents the date on which the schedule becomes active. The schedule cannot refer to any dates before this date. The schedule is not valid after the `end_date`.

You can schedule repeated executions by supplying a calendaring expression for `repeat_interval`. This calendaring expression is used to generate the next date of the schedule. Dates falling after the `end_date` time are not included in the schedule.

In the example shown in the slide, a schedule named `STATS_SCHEDULE` is created, specifying a repeat interval of every four hours, starting now, and continuing for 30 days.

You can use Enterprise Manager to create schedules as shown in the slide.

3. Creating and Running a Job



ORACLE

14-8

3. Creating and Running a Job

A job is a combination of a schedule and a description of what to do, along with any additional arguments that are required by the job.

The program or “Command” can be a precreated PL/SQL or Java program, an anonymous PL/SQL block, or an executable that is run from the operating system’s command line.

The schedule for a job can be a predefined schedule (created with the `DBMS_SCHDULER.CREATE_SCHEDULE` procedure) or defined as part of the job creation. The schedule specifies attributes about when the job is run, such as:

- A start time, which defines when the job is picked for execution and an end time, which specifies the time after which the job is no longer valid and is not scheduled any more
- An expression specifying a repeating interval for the job
- A complex schedule created by combining existing schedules
- A condition or change in state, called an event, that must be met before the job is started

There are many attributes that you can set for a job. Attributes control how the job executes.

To run a job in Enterprise Manager, select Administration > Jobs.

4. Monitoring a Job

```
SELECT job_name, status, error#, run_duration
FROM USER_SCHEDULER_JOB_RUN_DETAILS;

JOB_NAME           STATUS  ERROR#  RUN_DURATION
----------------   ------  ------  ------------
GATHER_STATS_JOB   SUCCESS      0 +000 00:08:20
PART_EXCHANGE_JOB  FAILURE   6576 +000 00:00:00
```

ORACLE

4. Monitoring a Job

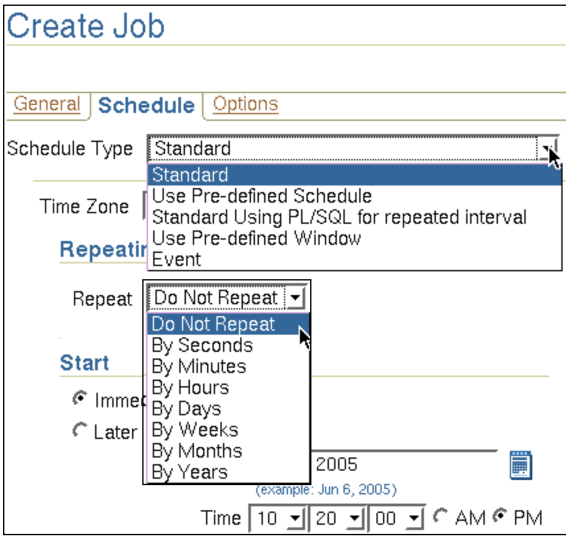
The DBA_SCHEDULER_JOB_RUN_DETAILS view has a row for each job instance. Each row contains information about the job execution for that instance.

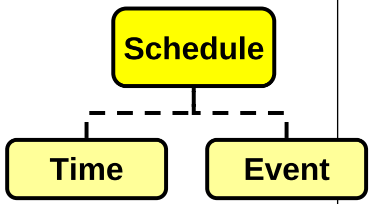
[DBA|ALL]_SCHEDULER_JOB_RUN_DETAILS views have the following columns:

- **LOG_ID:** The unique identifier of the log entry
- **LOG_DATE:** The time stamp of the log entry
- **OWNER:** The job owner
- **JOB_NAME:** The name of the job
- **STATUS:** The status of the job execution
- **ERROR#:** The number of the first error encountered
- **REQ_START_DATE:** The time at which the job was scheduled to start
- **ACTUAL_START_DATE:** The time at which the job was actually started
- **RUN_DURATION:** The duration of execution of the job
- **INSTANCE_ID:** The instance upon which the job ran
- **SESSION_ID:** The session the job ran within
- **SLAVE_PID:** The process ID of the slave process used to perform the job execution
- **CPU_USED:** The amount of CPU used for the job run
- **ADDITIONAL_INFO:** Additional information about the job run

Using a Time-Based or Event-Based Schedule

Key Comp.
& Steps
> Schedules
Job Chains
Adv.Concepts





Using a Time-Based or Event-Based Schedule

To specify a time-based schedule for a job, you can specify either a calendaring expression or a datetime expression

When using a calendaring expression, the next start time for a job is calculated using the repeat interval and the start date of the job. When using datetime expressions, the specified expression determines the next time that the job should run. If no repeat interval is specified, the job runs only once on the specified start date.

If a job uses an event-based schedule, the job runs when the event is raised. At a high level, an event can be viewed as a change in state. An event occurs when a Boolean condition changes its state from FALSE to TRUE, or TRUE to FALSE.

The Scheduler uses Oracle Streams Advanced Queuing (AQ) to raise and consume events.

Note: The Scheduler does not guarantee that a job executes on the exact time because the system may be overloaded and thus resources may be unavailable.

Creating a Time-Based Job

Example:

Create a job that calls a backup script every night at 11:00, starting tonight.

```
BEGIN
 DBMS_SCHEDULER.CREATE_JOB(
  job_name=>'HR.DO_BACKUP',
  job_type => 'EXECUTABLE',
  job_action => '/home/usr/dba/rman/nightly_incr.sh',
  start_date=> SYSDATE,
  repeat_interval=>'FREQ=DAILY;BYHOUR=23',
                /* next night at 11:00 PM */
  comments => 'Nightly incremental backups');
END;
/
```

ORACLE

14-11

Creating a Time-Based Job

Use the `CREATE_JOB` procedure of the `DBMS_SCHEDULER` package to create a job. Jobs are created disabled by default and they become active and scheduled only when they are explicitly enabled. All job names are of the form: `[schema.]name`.

You should use `SYSTIMESTAMP` and specify a time zone so that when the time changes because of daylight saving time, your job adjusts its execution time automatically.

By default, a job is created in the current schema. You can create a job in another schema by specifying the name of the schema, as shown in the example in the slide. The job owner is the user in whose schema the job is created, whereas the job creator is the user who created the job. Jobs are executed with the privileges of the job owner. The national language support (NLS) environment of the job when it runs is the same as that which was present at the time the job was created.

The `job_type` parameter indicates the type of task to be performed by the job. The possible values are:

- **`PLSQL_BLOCK`:** An anonymous PL/SQL block
- **`STORED_PROCEDURE`:** A named PL/SQL, Java, or external procedure
- **`EXECUTABLE`:** A command that can be executed from the operating system command line

Creating a Time-Based Job (continued)

The `job_action` parameter can be the name of the procedure to run, the name of a script or operating system command, or an anonymous PL/SQL code block, depending on the value of the `job_type` parameter.

In the example in the slide, `job_type` is specified as `EXECUTABLE` and `job_action` is the full OS-dependent path of the desired external executable plus optionally any command-line arguments.

An external job is a job that runs outside the database. All external jobs run as a low-privileged guest user, as has been determined by the database administrator while configuring external job support. Because the executable is run as a low-privileged guest account, you should verify that it has access to necessary files and resources. Most, but not all, platforms support external jobs. For platforms that do not support external jobs, creating or setting the attribute of a job or a program to type `EXECUTABLE` returns an error.

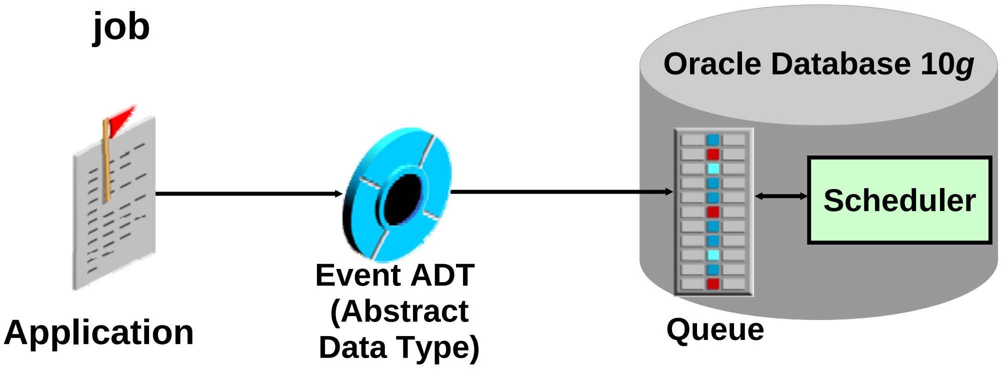
Refer to your Oracle database platform-specific documentation for more information about configuring the environment to run external programs with the Scheduler. For example, you may need to reference one or more of the following books:

- *Oracle Database Platform Guide 10g for Windows*
- *Oracle Database Installation Guide for UNIX Systems*
- *Oracle Database Release Notes 10g for AIX-Based Systems*
- *Oracle Database Release Notes 10g for hp HP-UX PA-RISC (64-bit*

Creating an Event-Based Schedule

To create an event-based job, you must set:

- **A queue specification (where your application enqueues messages to start a job)**
- **An event condition (same syntax as an Oracle Streams AQ rule condition) that if `TRUE` starts the job**



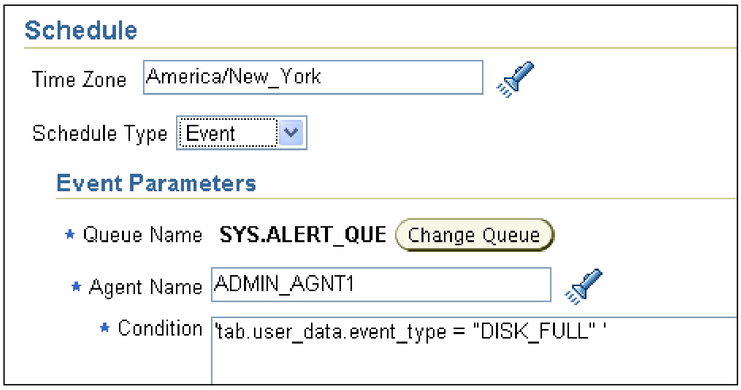
Creating an Event-Based Schedule

Jobs can be triggered based on events. An application can notify the Scheduler to start a job by enqueuing a message onto an Oracle Streams AQ queue. A job started in this way is referred to as an event-based job. To create an event-based job, you must set the following two additional attributes with the `CREATE_JOB` procedure:

- **`queue_spec`:** A queue specification that includes the name of the queue where your application enqueues messages to raise job start events, or in the case of a secure queue, the <*`queue_name`*>, <*`agent_name`*> pair
- **`event_condition`:** A conditional expression based on message properties that must evaluate to `TRUE` for the message to start the job. The expression must use the same syntax as an Oracle Streams AQ rule condition. You can include user data properties in the expression, provided that the message payload is a user-defined object type, and that you prefix object attributes in the expression with `tab.user_data`.

You can either specify `queue_spec` and `event_condition` as in-line job attributes, or create an event-based schedule with these attributes and then create a job that references this schedule.

Creating Event-Based Schedules with Enterprise Manager



14-14

Creating Event-Based Schedules with Enterprise Manager

The Create Schedule page enables you to choose between a standard, time-based schedule and an event-based schedule. If you choose an event-based schedule, then the interface changes and you can specify the queue name, agent name, and event condition, in addition to the other schedule attributes.

Note

The Scheduler runs the event-based job for each occurrence of an event that matches `event_condition`. However, events that occur while the job is already running are ignored; the event gets consumed, but does not trigger another run of the job.

References:

- See the *Oracle Streams Advanced Queuing User's Guide and Reference* for information about how to create queues and enqueue messages.
- For more information about Oracle Streams AQ rules and event conditions, see the `DBMS_AQADM.ADD_SUBSCRIBER` procedure in the *Oracle Database PL/SQL Packages and Types Reference 10g Release 2* manual.

Creating an Event-Based Job

Example: Create a job that runs if a batch load data file arrives on the file system before 9:00 a.m.

```
BEGIN
 DBMS_SCHEDULER.CREATE_JOB(
  job_name=>'ADMIN.PERFORM_DATA_LOAD',
  job_type => 'EXECUTABLE',
  job_action => '/home/usr/dba/rman/report_failure.sh',
  start_date => SYSTIMESTAMP,
  event_condition => 'tab.user_data.object_owner =
   ''HR'' and tab.user_data.object_name = ''DATA.TXT''
   and tab.user_data.event_type = ''FILE_ARRIVAL''
   and tab.user_data.event_timestamp < 9 ',
   queue_spec => 'HR.LOAD_JOB_EVENT_Q');
END;
```

14-15

Creating an Event-Based Job

To specify event information as job attributes, you use an alternate syntax of `CREATE_JOB` that includes the `queue_spec` and `event_condition` attributes. The job can include event information in-line as job attributes or can specify event information by pointing to an event schedule. The example shown in the slide uses an in-line event-based schedule.

The example in the slide shows a job that is started when a file arrives on the operating system, as long as the file arrives before 9:00 a.m. Assume that the message payload is an object with four attributes named `object_owner`, `object_name`, `event_type`, and `event_timestamp`.

The example uses a user-defined event. Therefore, before this job can be started, when the file arrives on the file system, a program or procedure must enqueue the event object type with the proper information into the specified event queue. The `HR.LOAD_JOB_EVENT_Q` queue must be of the same type as the event object type used for notifying the Scheduler of an event occurrence. That is, the `HR.LOAD_JOB_EVENT_Q` queue must be a typed queue where the type has four attributes named `object_owner`, `object_name`, `event_type`, and `event_timestamp`.

For more information about how to create queues and enqueue messages, refer to the *Oracle Streams Advanced Queuing User's Guide and Reference* documentation.

Event-Based Scheduling

Event types:

- User- or application-generated events
- Scheduler-generated events

Events raised by Scheduler jobs:

- `JOB_START`
- `JOB_SUCCEEDED`
- `JOB_FAILED`
- `JOB_BROKEN`
- `JOB_COMPLETED`
- `JOB_STOPPED`
- `JOB_SCH_LIM_REACHED`
- `JOB_DISABLED`
- `JOB_CHAIN_STALLED`
- `JOB_ALL_EVENTS`
- `JOB_RUN_COMPLETED`

Example of raising an event:

```
DBMS_SCHEDULER.SET_ATTRIBUTE('hr.do_backup',
 'raise_events', DBMS_SCHEDULER.JOB_FAILED);
```


Event-Based Scheduling

You can create a job that directly references an event as the means to start the job, instead of assigning a schedule to the job. There are two types of events:

- **User- or application-generated events:** An application can raise an event to be consumed by the Scheduler. The Scheduler reacts to the event by starting a job. An example of such events: a running job completes; a file arrives on the file system; an account within the database is locked; and the inventory reaches a low threshold.
- **Scheduler-generated events:** The Scheduler can raise an event to indicate state changes that occur within the Scheduler itself. For example, the Scheduler can raise an event when a job starts, when a job completes, when a job exceeds its allotted run time, and so on. The consumer of the event is an application that performs some action in response to the event.

You can configure a job so that the Scheduler raises an event when the job's state changes. You do this by setting the `raise_events` job attribute. By default, a job does not raise any state change events until you alter the `raise_events` attribute for a job. To alter this attribute, you must first create the job by using the `CREATE_JOB` procedure and then use the `SET_ATTRIBUTE` procedure to modify the attribute's default value. The example shows that the `hr.do_backup` job is altered, so that it raises an event if the job fails.

Event-Based Scheduling (continued)

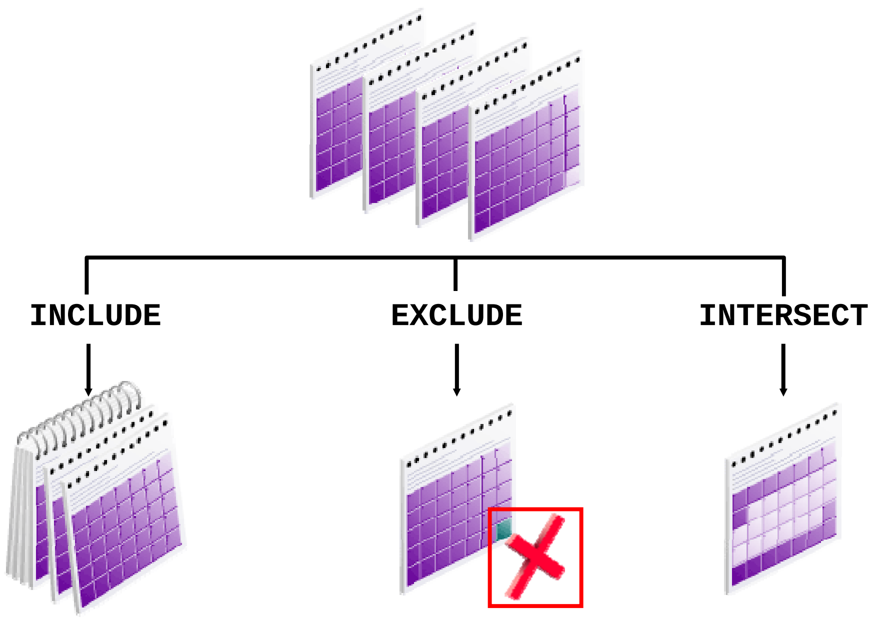
After you enable job state change events for a job, the Scheduler raises these events by enqueuing messages onto the default event queue `SYS.SCHEDULER$_EVENT_QUEUE`.

The default Scheduler event queue is a secure queue. Depending on your application, you may have to configure the queue to enable certain users to perform operations on it. See the *Oracle Streams Concepts and Administration* documentation for information about secure queues.

The default Scheduler event queue is intended primarily for Scheduler-generated events. Oracle does not recommend the use of this queue for user applications, or user-defined events.

Event Type	Description
`JOB_START`	The job is started.
`JOB_SUCCEEDED`	The job is successfully completed.
`JOB_FAILED`	The job failed, either by raising an error or by abnormally terminating.
`JOB_BROKEN`	The job is disabled and changed to the `BROKEN` state, because it exceeded the number of failures defined by the `MAX_FAILURES` job attribute.
`JOB_COMPLETED`	The job is completed, because it reached the values set by the `MAX_RUNS` or `END_DATE` job attributes.
`JOB_STOPPED`	The job is stopped by a call to the `STOP_JOB` procedure.
`JOB_SCH_LIM_REACHED`	The job's schedule limit is reached. The job is not started, because the delay in starting the job exceeded the value of the `SCHEDULE_LIMIT` job attribute.
`JOB_DISABLED`	The job is disabled by the scheduler or by a call to the `SET_ATTRIBUTE` procedure.
`JOB_CHAIN_STALLED`	A job running a chain is put into the `CHAIN_STALLED` state. A running chain becomes stalled if there are no steps running or scheduled to run and the chain `EVALUATION_INTERVAL` is set to `NULL`. The chain waits for manual intervention.
`JOB_ALL_EVENTS`	`JOB_ALL_EVENTS` is not an event, but a constant, that provides an easy way for you to enable all events.
`JOB_RUN_COMPLETED`	A job run is completed. It either failed, succeeded, or is stopped.

Creating Complex Schedules



Creating Complex Schedules

A schedule is an object in the database. When you create schedules, they are automatically saved. You can use combinations of schedules to create more complex schedules. By combining schedules, you can add specific dates to or exclude specific dates from a calendaring expression.

You can use the following options when defining the repeat interval for a schedule:

- **`INCLUDE`:** Adds a list of dates to the calendaring expression results
- **`EXCLUDE`:** Removes a list of dates from the calendaring expression results
- **`INTERSECT`:** Uses only the dates that are common to one or more schedules

When creating schedules to be used in combinations, you can code the list of dates by including hard-coded dates of the form `[`*`YYYY`*`]MMDD` or by including named schedules created with the `CREATE_SCHEDULE` procedure. For example, you can specify a list of dates by using the following values for the repeat interval of a schedule:

```
0115,0315,0325,0615,quarter_end_dates,1215
```

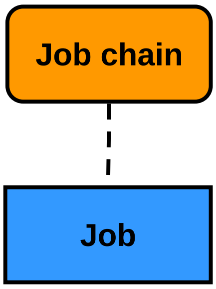
This string represents the dates January 15, March 15, March 25, June 15, December 15, and the list of dates specified by the `QUARTER_END_DATES` schedule.

If you do not specify the optional year component for hard-coded dates in your schedule, the dates are included for every year.

Creating Job Chains

Key Comp.
& Steps
Schedules
> **Job Chains**
Adv.Concepts

1. **Create a chain object.**
2. **Define chain steps.**
3. **Define chain rules.**
4. **Starting the chain:**
   – **Enable the chain.**
   – **Create a job that points to the chain.**



ORACLE

Creating Job Chains

A chain is a named series of programs that are linked together for a combined objective. This is known as “dependency scheduling.” An example of a chain may be the following:

Run program A and then program B, but only run program C if programs A and B complete successfully, otherwise run program D.

Each position within a chain of interdependent programs is referred to as a step.

To create and use a chain, you complete the following steps in order. All procedures mentioned are part of the `DBMS_SCHEDULER` package, unless noted otherwise.

1. **Create a chain** by using the `CREATE_CHAIN` procedure. The chain name can be optionally qualified with a schema name (for example, *`myschema.myname`*).
2. **Define** (one or more) **chain steps**. Defining a step gives it a name and specifies what happens during the step. Each step can point to one of the following:
   - A program
   - Another chain (a nested chain)
   - An event

   You define a step that points to a program or nested chain by calling the `DEFINE_CHAIN_STEP` procedure.

Creating Job Chains (continued)

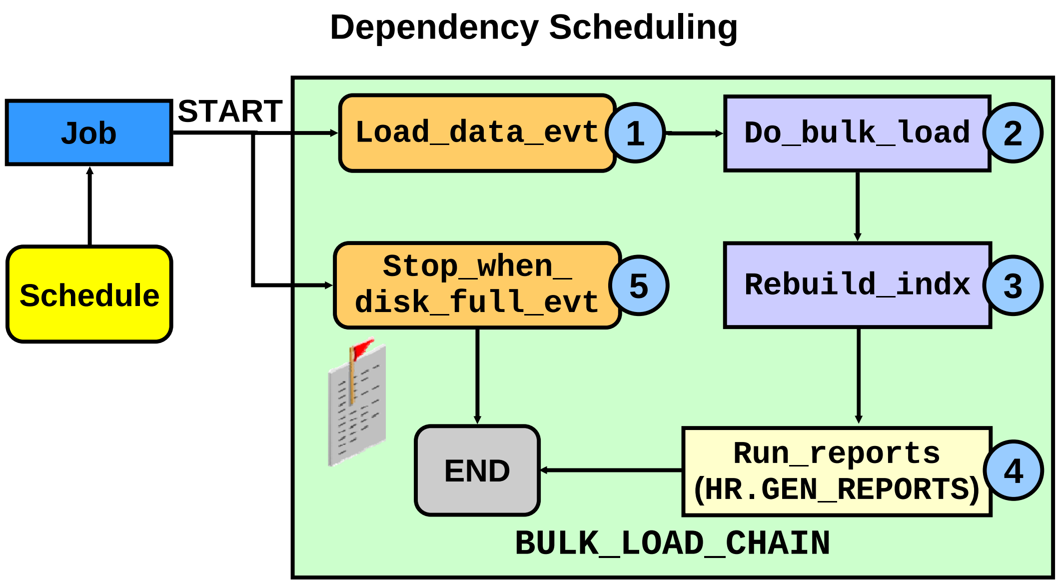
(Defining Steps, continued)

To define a step that waits for an event to occur, you use the `DEFINE_CHAIN_EVENT_STEP` procedure. Procedure arguments can point to an event schedule or can include an in-line queue specification and event condition. A step that points to an event waits until the specified event is raised. If the event occurs, the step completes successfully.

3. After creating the chain object, you **define chain rules**. Chain rules define when steps run, and define dependencies between steps. Each rule has a *condition* and an *action*:
   - If the condition evaluates to `TRUE`, the action is performed. The condition can contain any syntax that is valid in a SQL `WHERE` clause. Conditions are usually based on the outcome of one or more previous steps. For example, you may want one step to run if the two previous steps succeeded, and another to run if either of the two previous steps failed.
   - The action specifies what is to be done as a result of the rule being triggered. A typical action is to run a specified step. Possible actions include starting or stopping a step. You can also choose to end the execution of the job chain, returning either a value or a step name and error code.

   All rules added to a chain work together to define the overall behavior of the chain. When the job starts and at the end of each step, all rules are evaluated to see what action or actions occur next. You add a rule to a chain with the `DEFINE_CHAIN_RULE` procedure. You call this procedure once for each rule that you want to add to the chain.
4. **Starting the chain** involves two actions:
   - Enable a chain with the `ENABLE` procedure. (A chain is always created disabled, so you can add steps and rules to the chain before it is executed by any job.) Enabling an already enabled chain does not return an error.
   - To run a chain, you must create a job of type `'CHAIN'`. The job action must refer to the chain name. You can use either event-based or time-based schedules for this job.

Example of a Chain

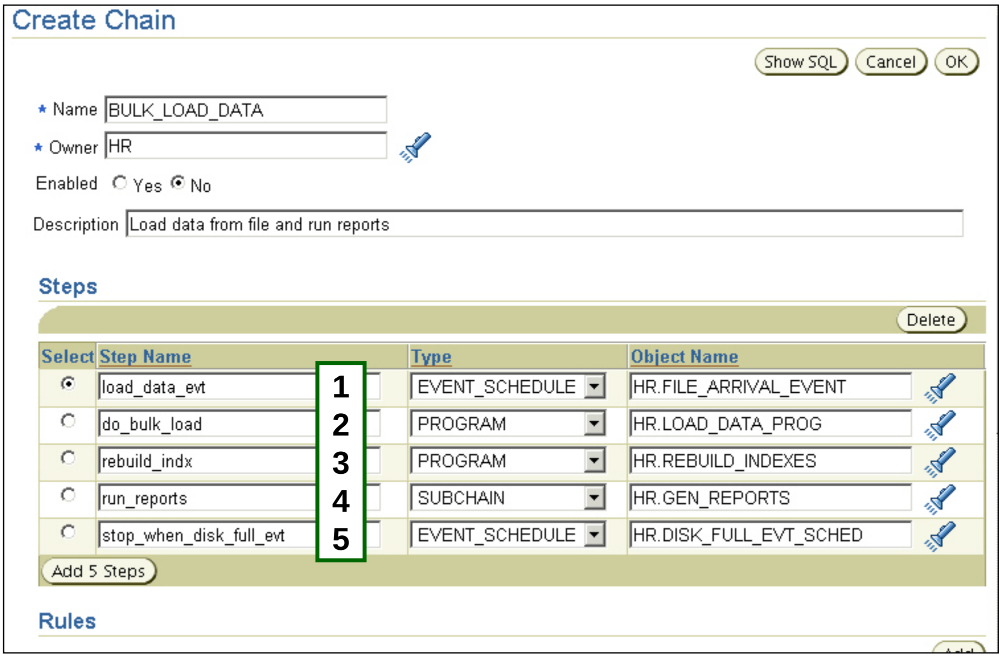


Example of a Chain

As an example of a chain, consider all the tasks and conditions that occur during a bulk data load. First, you must have data to load. Then load the data, observing the file system to make sure that you do not run out of space during the load. After the data load completes, you need to rebuild the indexes defined on the updated tables. Then you run reports against the newly loaded data.

This is an example of dependency scheduling.

1. Creating a Chain Object



1. Creating a Chain Object

On the Administration page, select Chains from the Scheduler region. On the Scheduler Chains page, you can create or edit a job chain. On the Create Chain page, you must enter the name and owner of the job chain. You can then choose whether the newly created job chain should be enabled or not. You can enable the chain at a later time.

PL/SQL Example:

```
DBMS_SCHEDULER.CREATE_CHAIN (
chain_name  => 'bulk_load_chain',
rule_set_name  => NULL, evaluation_interval => NULL,
comments  => 'Load data and run reports');
```

After naming the job chain and optionally providing a description, you then enter the job chain steps, one at a time. You can create job chain steps of the following type:

- A step that runs a program (`PROGRAM`)
- A step that is another job chain (`SUBCHAIN`)
- A step that uses a stored event-based schedule (`EVENT_SCHEDULE`)

Only one program can run during a step. Every step in a chain must be defined before the chain can be enabled and used.

2. Defining Chain Steps

```
DBMS_SCHEDULER.DEFINE_CHAIN_EVENT_STEP (
   chain_name  => 'bulk_load_chain',
   step_name  => 'load_data_evt',
   event_condition => 'tab.user_data.object_owner =
     ''HR'' and tab.user_data.object_name =
     ''DATA.TXT'' and tab.user_data.event_type =
     ''FILE_ARRIVAL'' ',
   queue_spec => 'HR.LOAD_JOB_EVENT_Q');
DBMS_SCHEDULER.DEFINE_CHAIN_STEP (
   chain_name  => 'bulk_load_chain',
   step_name  => 'do_bulk_load',
   program_name => 'hr.load_data_prog);
 DBMS_SCHEDULER.DEFINE_CHAIN_STEP (
   chain_name  => 'bulk_load_chain',
   step_name  => 'rebuild_indx',
   program_name => 'hr.rebuild_indexes');
```

1

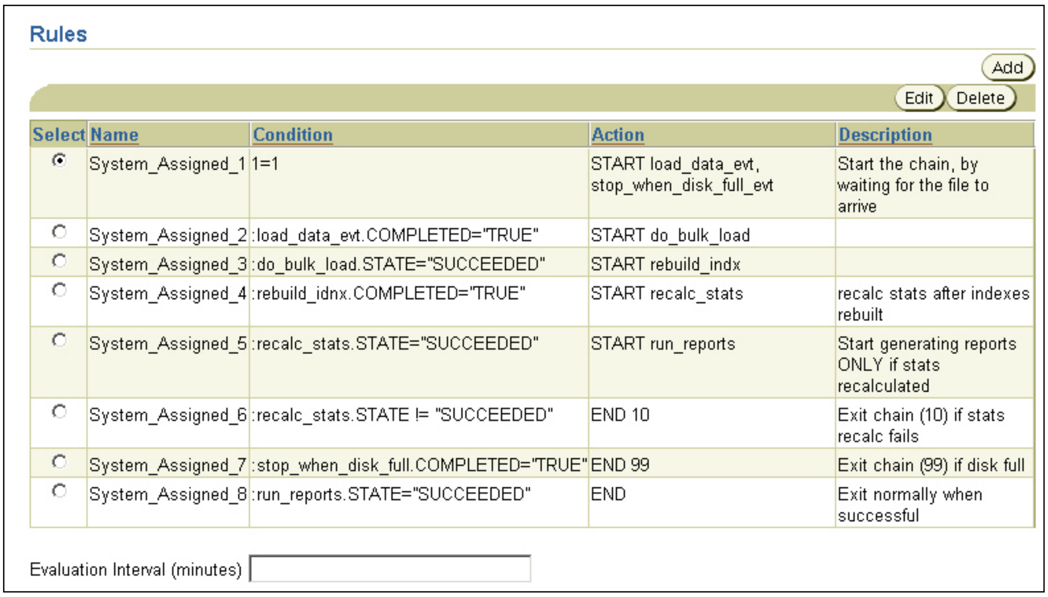
2

3

2. Defining Chain Steps

1. The `load_data_evt` step uses an event-based schedule. The `load_data_evt` step waits for a `FILE_ARRIVAL` event to be placed in `HR.LOAD_JOB_EVENT_Q`. This event notifies the Scheduler that the `DATA.TXT` data file has arrived on the file system. Because the `queue_spec` argument does not include an agent name, the specified queue is not a secure queue.
2. The `do_bulk_load` step performs a bulk data load into the schema tables.
3. The `rebuild_indx` step rebuilds the indexes for the tables following a data load.
4. The `run_reports` step runs a report against the new data. `HR.GEN_REPORTS` is another job chain.
```
DBMS_SCHEDULER.DEFINE_CHAIN_STEP (
 chain_name  => 'bulk_load_chain',
 step_name  => 'run_reports',
 program_name => 'hr.gen_reports');
```
5. The `stop_when_disk_full_evt` step ends the chain execution if the system runs out of disk space.
```
DBMS_SCHEDULER.DEFINE_CHAIN_EVENT_STEP (
chain_name  => 'bulk_load_chain',
step_name  => 'stop_when_disk_full_evt'
event_schedule_name => 'disk_full_sched')
```

3. Defining Chain Rules



Rules

Add

Edit Delete

Select	Name	Condition	Action	Description
◉	System_Assigned_1	1=1	START load_data_evt, stop_when_disk_full_evt	Start the chain, by waiting for the file to arrive
○	System_Assigned_2	:load_data_evt.COMPLETED="TRUE"	START do_bulk_load	
○	System_Assigned_3	:do_bulk_load.STATE="SUCCEEDED"	START rebuild_indx	
○	System_Assigned_4	:rebuild_idnx.COMPLETED="TRUE"	START recalc_stats	recalc stats after indexes rebuilt
○	System_Assigned_5	:recalc_stats.STATE="SUCCEEDED"	START run_reports	Start generating reports ONLY if stats recalculated
○	System_Assigned_6	:recalc_stats.STATE != "SUCCEEDED"	END 10	Exit chain (10) if stats recalc fails
○	System_Assigned_7	:stop_when_disk_full.COMPLETED="TRUE"	END 99	Exit chain (99) if disk full
○	System_Assigned_8	:run_reports.STATE="SUCCEEDED"	END	Exit normally when successful

Evaluation Interval (minutes)

ORACLE

3. Defining Chain Rules

After you have specified the job chain steps, you can create rules for the job chain. Chain rules define when steps run, and define dependencies between steps. Each rule has a condition and an action. If the condition evaluates to `TRUE`, the action is performed. The condition can also contain the Scheduler's chain syntax.

To create a rule in EM, you click the Add button in the Rules region.

When entering the rule conditions, character strings should be entered in single quotation marks. The GUI interface automatically escapes the quotation marks as needed when executing the commands.

PL/SQL Example

```
DBMS_SCHEDULER.DEFINE_CHAIN_RULE (
chain_name => 'bulk_load_chain',
condition  => 'TRUE,
action     => 'START load_data_evt,stop_when_disk_full_evt',
rule_name  => 'dataload_rule1',
comments   => 'start the chain');
```

Note: This PL/SQL example differs from the EM one in that it uses a user-defined rule name, whereas the EM example shows the default generated name.

4. Starting the Chain

```
BEGIN
  DBMS_SCHEDULER.ENABLE ('bulk_load_chain');
END;
/
```

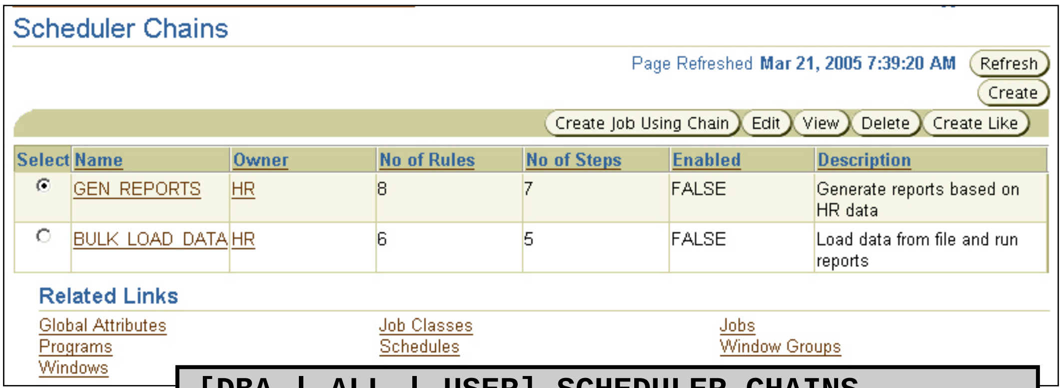
```
BEGIN
  DBMS_SCHEDULER.CREATE_JOB (
    job_name        => 'bulk_load_chain_job',
    job_type        => 'CHAIN',
    job_action      => 'bulk_load_chain',
    repeat_interval => 'freq=daily;byhour=7;
                        byminute=5;bysecond=0',
    enabled         => TRUE);
END;
/
```


4. Starting the Chain

After you have finished creating and modifying the job chain, you enable it by calling the `ENABLE` procedure.

To run a chain, you must create a job. Set the `job_type` to `'CHAIN'` and the job action to the name of the job chain you want to execute. The rest of the arguments are configured as you would configure them for any other type of job.

Monitoring Job Chains




```
[DBA | ALL | USER]_SCHEDULER_CHAINS
[DBA | ALL | USER]_SCHEDULER_CHAIN_RULES
[DBA | ALL | USER]_SCHEDULER_CHAIN_STEPS
[DBA | ALL | USER]_SCHEDULER_RUNNING_CHAINS
```

ORACLE

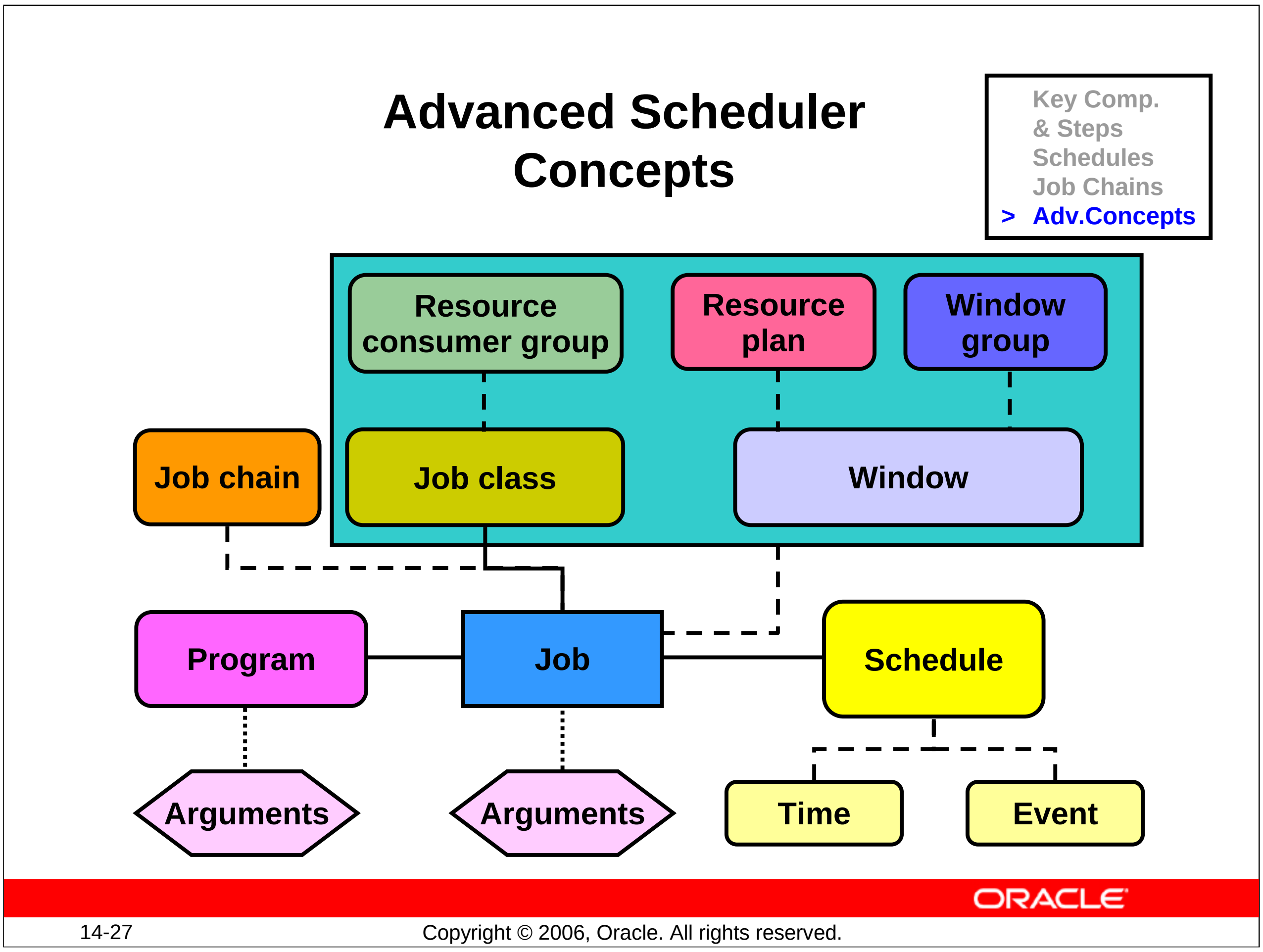
Monitoring Job Chains

The ALL_SCHEDULER_CHAINS view contains information about the chain owner and name; the rule set name and rule set owner for the chain; the number of rules; the number of steps; whether or not the chain is enabled; whether or not the chain uses an evaluation interval; and whether or not the chain uses a user-defined rule set.

The ALL_SCHEDULER_CHAIN_RULES view displays information such as the name and owner of the chain for which the rule was defined; the rule name, owner, and condition; and the action to be performed if the condition evaluates to TRUE.

The ALL_SCHEDULER_CHAIN_STEPS displays information such as the name and owner of the chain for which the step was created; the step name; the program name and owner; whether the step should be skipped or not; and whether or not the step should be paused after it completes.

The ALL_SCHEDULER_RUNNING_CHAINS view contains information such as the chain name and owner; the name and owner of the job that points to the chain; the name of the steps in the chain and their current state; errors encountered by the chain step; the time at which the chain step started and ended; how long it took the step to complete; and the name of the job running the step, if it is current executing.



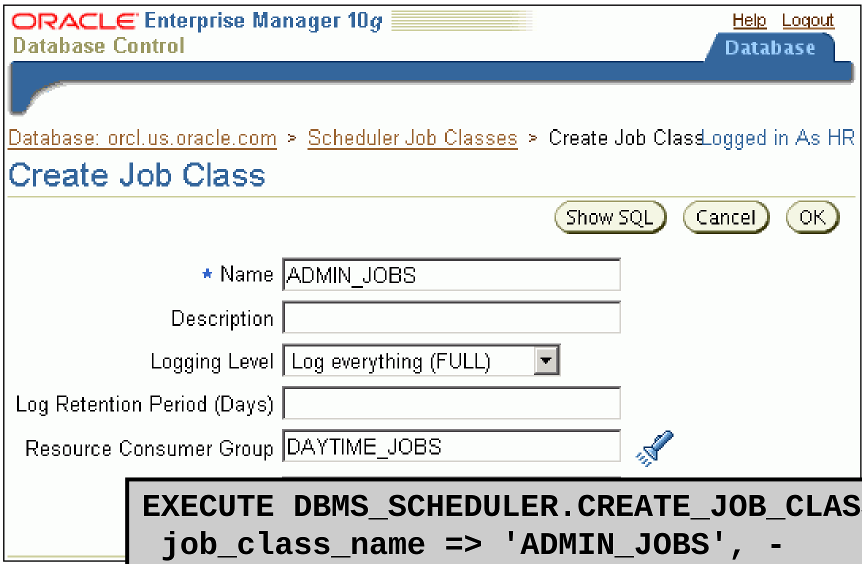
Advanced Scheduler Concepts

Using the advanced Scheduler concepts, you can have more advanced control of aspects of scheduling, such as prioritizing jobs. The components are summarized below, and are discussed in detail in the following slides.

- A **window** is represented by an interval of time with a well-defined beginning and end, and is used to activate different resource plans at different times. This allows you to change resource allocation during a time period such as time of day or time of the sales year.
- A **window group** represents a list of windows, and allows for easier management of windows. You can use a window or window group as the schedule for a job to ensure that the job runs only when a window and its associated resource plan are active.
- A **job class** defines a category of jobs that share common resource usage requirements and other characteristics. A job class groups jobs into larger entities.
- A **resource consumer group** associated with the job class determines the resources that are allocated to the jobs in the job class.
- A **resource plan** enables users to prioritize resources (most notably CPU) among resource consumer groups.

Note: For more information about resource consumer groups and resource plans, see the lesson titled “Managing Resources.”

Creating a Job Class




```
EXECUTE DBMS_SCHEDULER.CREATE_JOB_CLASS( -
 job_class_name => 'ADMIN_JOBS', -
 resource_consumer_group => 'DAYTIME_JOBS', -
 logging_level => DBMS_SCHEDULER.LOGGING_OFF);
```


Creating a Job Class

You can use the `CREATE_JOB_CLASS` procedure of the `DBMS_SCHEDULER` package to create a job class. A class always belongs to the `sys` schema. To create a class, you must have the `MANAGE SCHEDULER` privilege.

After a job class has been created, you can specify jobs as members of this job class when you create the jobs, or after the jobs are created, by using the `SET_ATTRIBUTE` procedure of the `DBMS_SCHEDULER` package.

If you are using Enterprise Manager Database Control, use the Job Class page to create or edit a job class that you will assign to a job. Enter the name of the job class and the resource consumer group with which this job class is associated. You can select the resource consumer group by using the search function.

There is a default job class named `DEFAULT_JOB_CLASS` that is created with the database. If a job is not associated with a job class, then the job belongs to this default job class.

If a resource consumer group is not specified when a job class is created, the job class maps to the `DEFAULT_CONSUMER_GROUP` resource consumer group. Jobs in the default job class or in a job class associated with the default resource consumer group might not be allocated enough resources to complete their tasks when the Resource Manager is enabled.

Creating a Window

Create a window for the month of December that uses the END_OF_YEAR resource plan and is active every night from 6:00 p.m. to 6:00 a.m. Eastern Standard Time (EST).

```
BEGIN
 DBMS_SCHEDULER.CREATE_WINDOW(
   window_name => 'DEC_NIGHTS',
   resource_plan => 'END_OF_YEAR',
   start_date => '01-DEC-03 06.00.00 PM EST',
   repeat_interval => 'FREQ=DAILY; BYHOUR=18',
   duration => '0 12:00:00',
   end_date => '31-DEC-03 06.00.00 AM EST',
   comments => 'Every day at 6:00 PM');
END;
/
```

ORACLE

14-29

Creating a Window

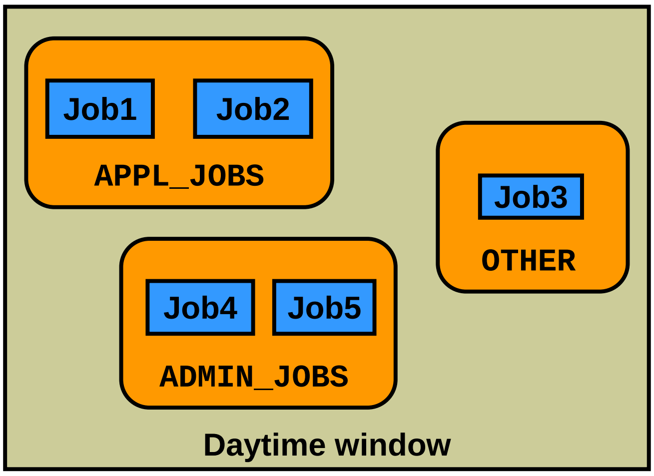
The priority of jobs changes over a period of time. For example, you might want to allocate a high percentage of the database resources to data warehouse loading jobs at night and allocate a higher percentage of the resources during the day to the application jobs. To accomplish this, you can change the database resource plan by using a Scheduler window.

The purpose of a window is to specify which resource plan is active for a specific time period. The window is represented by an interval of time, such as "every day, from 8:00 a.m. to 6:00 p.m." The recurring time window is defined as a schedule specifying a pattern of start dates and duration (in minutes).

A window is *open* if it is in effect. Only one window can be in effect at any given time. In the example shown in the slide:

- The window opens (becomes active) at 6:00 p.m. on December 1, 2003.
- The duration, specified as an `INTERVAL DAY TO SECOND` data type, indicates that the window closes at 6:00 a.m. on December 2, 2003.
- The next time the window opens is calculated using the value for `REPEAT_INTERVAL`, which evaluates to 6:00 p.m. on December 2, 2003.
- At 6:00 a.m. on December 31, 2003, the window closes and is disabled. While the `DEC_NIGHTS` window is open, the resources allocated to the jobs are determined by the guidelines specified in the `END_OF_YEAR` resource plan.

Prioritizing Jobs Within a Window



Job	Priority
Job1	1
Job2	2
Job3	3
Job4	5
Job5	2

Prioritizing Jobs Within a Window

When creating multiple jobs in a database, you need a way to align the job processing with your business requirements and specify which jobs have the highest priority. For a particular window, you may have several classes of jobs running, each with its own priority.

Job classes are used to categorize jobs. The job class maps to a resource consumer group. The active resource plan determines the resources allocated to each resource consumer group, and thus to each job class.

There are two levels at which jobs can be prioritized: at the class level and at the job level.

- The first prioritization is at the class level, using resource plans. Prioritization among jobs of different classes is done purely on a class resource allocation basis.
- The second prioritization is within the class, using the job priority attribute of the job.

Prioritization levels are relevant only when two jobs within the same class are supposed to start at the same time. The job with the higher priority starts first.

Prioritization is not guaranteed for jobs in different job classes. For example, a high-priority job in the `APPL_JOBS` job class might not get started before a low-priority job in the `ADMIN_JOBS` job class, even if they share the same schedule. If the `APPL_JOBS` job class has a lower level of resource available, then the high-priority job in that class has to wait for resources to become available, even if there are resources available to lower-priority jobs in a different job class.

Summary

In this lesson, you should have learned how to:

- Simplify management tasks by using the Scheduler
- Create a job, program, and schedule
- Monitor job execution
- Use a time-based or event-based schedule for executing Scheduler jobs
- Use job chains to perform a series of related tasks
- Use advanced Scheduler concepts to prioritize jobs

Practice Overview: Automating Tasks with the Scheduler

This practice covers the following topics:

- Creating a job that runs a program outside the database
- Creating a program and a schedule
- Creating a job that uses a program and a schedule
- Altering the program and schedule for the job and observing the behavior change of the job
- Monitoring job runs

Practice Overview

Note: This practice uses both the Enterprise Manager Database Control and SQL*Plus.

15

Database Security

Objectives

TDE
DP
RMAN
VPD

After completing this lesson, you should be able to do the following:

- **Implement Transparent Data Encryption (TDE)**
- **Use TDE with encrypted columns**
- **Describe Data Pump (DP) encryption**
- **Identify components of Recovery Manager (RMAN)–encrypted backups**
- **Define basic concepts of a Virtual Private Database (VPD)**
- **Apply a column-level VPD policy**

Additional Resources

Oracle by Example (OBE) for the Oracle Database 10*g*:
http://www.oracle.com/technology/obe/admin/db10gr2_manage.html

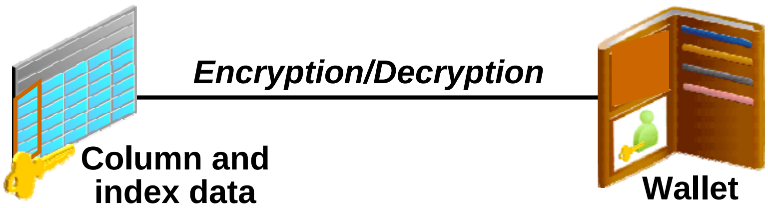
- "Using Transparent Data Encryption"
- "Restricting Data Access using Virtual Private Database"

Documentation:

- *Oracle Database Security Guide*
- *Oracle Database Advanced Security Administrator's Guide*

Oracle Transparent Data Encryption (TDE): Overview

- Need for secure information
- Automatic encryption of sensitive information:
  - Embedded in the Oracle database
  - No need to change application logic
  - Encrypts data and index values
- Using an encryption key:
  - Master key for the entire database
  - Stored in Oracle Wallet



Oracle Transparent Data Encryption (TDE): Overview

Need for Secure Information

Oracle Database 10*g* Release 2 Transparent Database Encryption simplifies encryption of sensitive personal information such as credit card numbers and social security numbers. Transparent Data Encryption eliminates the need to embed encryption routines in existing applications and dramatically lowers the cost and complexity of encryption. With a few simple commands, sensitive application data can be encrypted.

Automatic Encryption of Sensitive Information

Most encryption solutions require specific calls to encryption functions within the application code. This is expensive because it typically requires extensive understanding of an application as well as the ability to write and maintain software. In general, most organizations do not have the time or expertise to modify existing applications to make calls to encryption routines. Oracle Transparent Data Encryption addresses the encryption problem by deeply embedding encryption in the Oracle database.

Application logic performed through SQL will continue to work without modification. That is, applications can use the same syntax to insert data into an application table and the Oracle database automatically encrypts the data before writing the information to disk. Subsequent select operations will have the data transparently decrypted so the application will continue to work normally.

Oracle Transparent Data Encryption (TDE): Overview (continued)

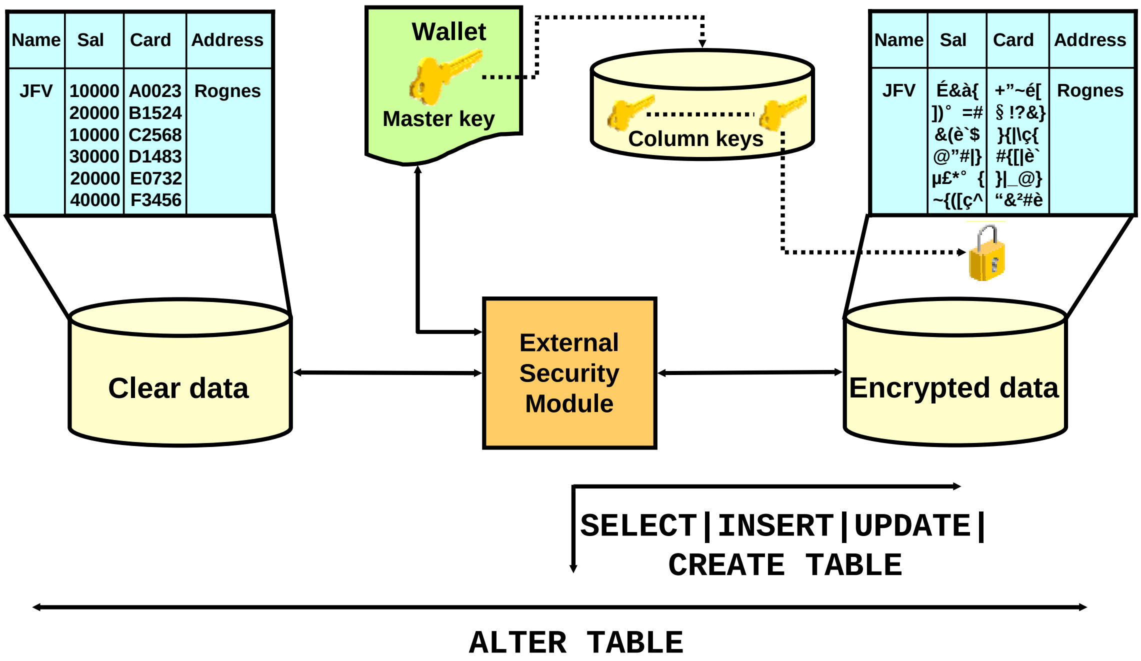
This is important because existing applications generally expect to see application data unencrypted. Displaying encrypted data may, at a minimum, confuse the application user and may even break an existing application.

Encryption typically creates problems for existing application indexes because the index data is not encrypted. Oracle Transparent Data Encryption encrypts the index value associated with a given application table. This means that equality searches within an application will see little to no decrease in performance.

Using an Encryption Key

Oracle Transparent Data Encryption provides the key management infrastructure necessary for implementing encryption. Encryption works by passing clear text data along with a secret, known as the key, into an encryption program. The encryption program encrypts the clear text data using the supplied key and returns the data encrypted. Historically, the burden of creating and maintaining the secret or key has been on the application. Oracle Transparent Data Encryption solves this problem by automatically generating a master key for the entire database. Upon starting up the Oracle database, an administrator must open an object known as an Oracle Wallet with a password separate from the system or DBA password. The wallet uses certificates from a Certificate Authority. The administrator then initializes the database master key. The master key is automatically generated.

TDE Process



TDE Process

Although authorization and authentication security mechanisms effectively protect data in the database, they do not prevent access to the operating system files where the data is stored. Transparent Data Encryption enables encryption of sensitive data in database columns as it is placed in, kept in, and retrieved from the operating system files.

TDE uses the External Security Module (ESM) to generate encryption keys, to provide functions for encryption and decryption, and to store encryption keys securely inside and outside the database.

When a table contains encrypted columns, a single column key is used regardless of the number of encrypted columns in that table. The keys for all tables containing encrypted columns are stored in a single column in a dictionary table in the database. That column is encrypted with the database server's master key, preventing any use of those keys through unauthorized access. The master key is stored in a wallet outside the database. The wallet is created using Oracle Wallet Manager, and the master key is generated by the ESM.

The graphic in the slide shows the `EMPLOYEES` table with two columns marked for encryption. The column key for the `EMPLOYEES` table is retrieved from the ESM and is used to encrypt the marked columns. Using this mechanism, you can either encrypt or decrypt columns in your database by using a simple `ALTER TABLE` command. After the columns have been encrypted, you can retrieve the clear text by issuing normal `SELECT` statements. The ESM transparently decrypts the data for you.

Implementing Transparent Data Encryption

1. **Create a wallet: automatically or by using Oracle Wallet Manager.**

Example `sqlnet.ora` entry:

```
ENCRYPTION_WALLET_LOCATION=
 (SOURCE=(METHOD=FILE)(METHOD_DATA=
 (DIRECTORY=/opt/oracle/product/10.2.0/db_1/)))
```


Implementing Transparent Data Encryption

Only a few steps are needed to implement and configure this feature:

1. You need to create a wallet. This can be done by either using the Oracle Wallet Manager or by letting the Transparent Data Encryption (TDE) software create it automatically when the directory for that wallet is specified in the `SQLNET.ORA` file. By default, an unencrypted wallet (`cwallet.sso`) is created when the database is installed. However, an encrypted wallet (`ewallet.p12`) is recommended for use with TDE. Here is an example of an entry for your `SQLNET.ORA` file:
   ```
   ENCRYPTION_WALLET_LOCATION=
   (SOURCE=(METHOD=FILE)(METHOD_DATA=
   (DIRECTORY=/opt/oracle/product/10.2.0/db_1/)))
   ```

Note: In the `sqlnet.ora` file, you may find two similar-looking entries: The Secure Sockets Layer (SSL) authentication uses the `WALLET_LOCATION` parameter, whereas TDE uses the `ENCRYPTION_WALLET_LOCATION` parameter.

Implementing Transparent Data Encryption

2. **Set the master key from within your instance:**

```
ALTER SYSTEM SET ENCRYPTION KEY IDENTIFIED BY <password>;
```

3. **Open the wallet from within your instance (future):**

```
ALTER SYSTEM SET ENCRYPTION WALLET OPEN
IDENTIFIED BY <password>;
```

4. **Create tables that contain encrypted columns:**

```
CREATE TABLE emp (
    first_name VARCHAR2(128),
    last_name VARCHAR2(128),
    empID NUMBER ENCRYPT NO SALT,
    salary NUMBER(6) ENCRYPT USING '3DES168',
    comm NUMBER(6) ENCRYPT
);
```

15-7

Implementing Transparent Data Encryption (continued)

2. You need to set the master key inside the wallet. Only if the master key has been compromised is it necessary to regenerate it. Frequent master key regeneration may exhaust all available storage in the wallet. You can set or reset the master key by using the `ALTER SYSTEM` command as shown in the slide. If no encrypted wallet is present in your directory, the command creates an encrypted wallet (`ewallet.p12`), opens the wallet, and creates the master key for TDE.
   If an encrypted wallet is present, the command opens the wallet and creates or re-creates the master key for TDE.
3. For later sessions, you do not want to use the command given in step 2; you need the wallet to be open (it was closed when you shut down your database), but you do not want to create a new master key. So, all you need to do is open the wallet by using the command shown in step 3.

Implementing Transparent Data Encryption (continued)

4. You can now create tables with encrypted columns. The slide example creates a table called `EMP` that contains three encrypted columns. By default, columns are encrypted with *salt*. Using salt is a way to strengthen the security of encrypted data. Salt is a random string that is added to the data before it is encrypted, making it more difficult for attackers to steal the data by matching patterns of ciphertext to known ciphertext samples. However, if you plan to create indexes on an encrypted column, you must create it with `NO SALT`. In addition, TDE uses the Advanced Encryption Standard with a 192-bit length cipher key (AES192) as its default encryption algorithm. As shown by the example, you can change it to another supported algorithm such as Triple Data Encryption Standard.

Existing Tables and TDE

- Add encrypted columns:

```
ALTER TABLE emp ADD (ssn VARCHAR2(11) ENCRYPT);
```

- Encrypt unencrypted columns:

```
ALTER TABLE emp MODIFY (first_name ENCRYPT);
```

- Disable column encryption:

```
ALTER TABLE emp MODIFY (first_name DECRYPT);
```

- Add or remove salt:

```
ALTER TABLE emp MODIFY (first_name ENCRYPT [NO] SALT);
```

- Change keys and the encryption algorithm:

```
ALTER TABLE emp REKEY USING '3DES168';
```

ORACLE

15-9

Existing Tables and TDE

- You can add an encrypted column to an existing table by using the ALTER TABLE ADD command, specifying the new column with the ENCRYPT clause.
- You can also encrypt existing unencrypted columns in tables. To do so, use the ALTER TABLE MODIFY command, specifying the unencrypted column with the ENCRYPT clause.
- It may be necessary to turn off encryption for reasons of compatibility or performance. Use the ALTER TABLE MODIFY command with the DECRYPT clause to turn off column encryption.
- By default, the database appends a random string, called "salt," to the cleartext of the column before encrypting it. If you want to use the column as an index or foreign key, you must specify the NO SALT option. To add or remove salt from encrypted columns, you again use the ALTER TABLE MODIFY command with either the SALT (default) or NO SALT parameter specified with the ENCRYPT clause.
- Each table can have at most one encryption key for its columns. This key can be changed using the original encryption algorithm or using a different algorithm specified by the REKEY option.

Note: For more information about the ALTER TABLE command and its options, see the *Oracle Database SQL Reference.*

Transparent Data Encryption: Considerations

- You cannot encrypt tables owned by SYS.
- LONG and LOB data types are not supported.
- The supported encryption algorithms are:
  - 3DES168
  - AES128
  - AES192
  - AES256
- NO SALT must be used to encrypt index columns.
- TDE works with indexes for equality searches.
- Encrypted data must be decrypted before expressions evaluation.
- Best practice tip: Back up the wallet.

15-10

Transparent Data Encryption: Considerations

- You cannot encrypt columns belonging to tables owned by SYS.
- LONG and LOB data types are not supported for data encryption.
- Any user allowed to create a table can create one with encrypted columns. The encrypted columns must share the same encryption key and algorithm. AES192 is the default.
- The NO SALT option must be used for indexed columns such as a primary key or unique key. In addition, the NO SALT option must also be used for foreign key columns.
- Indexes include encrypted data if the corresponding columns are encrypted. Because the encrypted data loses its logical structure, range scans become impossible.
- Encrypted data must be decrypted before expressions evaluation for any query or DML (that is, select list, check constraint expression, where or when conditions).

Note: Good security practices include backing up the wallet before and after you reset the master key.

Wallet Support for Usernames and Passwords

- **Wallets can now hold more than just a certificate:**
  - **You can store usernames and passwords in a wallet rather than providing them on the command line.**
- **Batch job processing:**
  - **Protects exposure of usernames and passwords when listing processes on the OS**
- **Set up using:**
  - **`WALLET_LOCATION` in `sqlnet.ora`**
  - **`mkstore` utility**

```
connect /@db_connect_string
```

15-11

Wallet Support for Usernames and Passwords

Password credentials for connecting to databases can now be stored in a client-side Oracle Wallet, a secure software container used to store authentication and signing credentials.

This wallet usage can simplify large-scale deployments that rely on password credentials for connecting to databases. When this feature is configured, application code, batch jobs, and scripts no longer need embedded usernames and passwords. Risk is reduced because such passwords are no longer exposed in the clear, and password management policies are more easily enforced without changing application code whenever usernames or passwords change.

When clients are configured to use the secure external password store, applications can connect to a database with the following `CONNECT` statement syntax, without specifying database login credentials: `connect /@db_connect_string`.

In this case, the database credentials are securely stored in an Oracle Wallet created for this purpose. The autologin feature of this wallet is turned on, so the system does not need a password to open the wallet.

To configure this feature, you need to create the Oracle Wallet on the client side by using the `mkstore` command. Then, add the username and password of the database connection for a specified connect string. This is also done using the `mkstore` utility. Then, make sure that your `sqlnet.ora` file points to the right location of the wallet by using the `WALLET_LOCATION` parameter.

Data Pump and Transparent Data Encryption

TDE
> DP
RMAN
VPD

- Use your own provided column key during export and import:

```
ENCRYPTION_PASSWORD = <password>
```

- Also true for external tables:

```
CREATE TABLE emp_ext (
   first_name, last_name, empID,
   salary ENCRYPT IDENTIFIED BY "xIcf3T9u" )
ORGANIZATION EXTERNAL
 ( TYPE ORACLE_DATAPUMP
   DEFAULT DIRECTORY "D_DIR"
   LOCATION('emp_ext.dat') )
REJECT LIMIT UNLIMITED
as select * from employees;
```


Data Pump and Transparent Data Encryption

Two factors are important when exporting tables containing encrypted columns: first, that the sensitive data remain unintelligible during transport, and second, that authorized users can decrypt that data after it is imported at the destination.

Because the key for decryption is local to the server where the tables originally reside, decryption at the destination is possible using the destination's key. Consequently, before exporting, the administrator re-keys the table(s) with a password key, which he or she then securely provides to the destination administrator. Upon import, that receiving administrator specifies the same password. The affected columns being imported are decrypted, enabling the receiving server to immediately reencrypt those columns with a local server key. The columns are then ready for standard authorized use in their new home.

This technique also applies to external tables that use the `ORACLE_DATAPUMP` access driver. If you want certain columns to be encrypted in an external table, you can specify the `ENCRYPT` clause in defining those columns. This specification causes a randomly generated key to be used to encrypt the columns.

However, if you intend to move your external table, that key will not be available in the new location. For such a table, you should specify your own password to encrypt the columns. Then, after you move the data, you can use the same password to regenerate the key so you can access the encrypted columns' data in the new location.

RMAN Encrypted Backups: Overview

TDE
DP
> RMAN
VPD

Three possible encryption modes for your backups:

- Transparent mode:
  – Requires Oracle Wallet
  – Is best suited for day-to-day backup and restore operations at the same location
  – Is the default encryption mode
- Password mode:
  – Requires you to provide a password
  – Is best suited for backups restored at remote locations
- Dual mode:
  – Can use either Oracle Wallets or passwords
  – Is best suited for backups restored locally and remotely

ORACLE

RMAN Encrypted Backups: Overview

For improved security, Recovery Manager (RMAN) backups can be encrypted. Encrypted backups cannot be read if they are obtained by unauthorized people.

RMAN offers three encryption modes:

- **Transparent mode:** Transparent encryption can create and restore encrypted backups with no further intervention, as long as the required Oracle key management infrastructure is available. Transparent encryption is best suited for day-to-day backup operations, where backups are restored at the same database that they were backed up from. Transparent encryption is the default mode for RMAN encryption.
- **Password mode:** Password encryption requires that you provide a password when creating and restoring encrypted backups. Restoring a password-encrypted backup requires the same password that was used to create the backup. Password encryption is useful for backups that are restored at remote locations, but that must remain secure in transit. Password encryption cannot be persistently configured. The Oracle Wallet need not be configured if password encryption is to be used exclusively.
- **Dual mode:** Dual mode–encrypted backups can be restored either transparently or by specifying a password. Dual mode–encrypted backups are useful when you create backups that are normally restored on-site using the wallet, but that occasionally need to be restored off-site, where the wallet is not available. When restoring a dual mode–encrypted backup, you can use either the Oracle Wallet or a password for decryption.

Transparent Mode Setup

1. Create a wallet: automatically or by using Oracle Wallet Manager.
2. Open the wallet from within your instance:

```
ALTER SYSTEM SET ENCRYPTION WALLET OPEN IDENTIFIED BY <password>;
```

3. Set the master key from within your instance:

```
ALTER SYSTEM SET ENCRYPTION KEY IDENTIFIED BY <password>;
```

4. Configure RMAN to use transparent encryption:

```
CONFIGURE ENCRYPTION FOR DATABASE ON
```

5. There are no changes to your backup or recover commands.
6. Permanent configuration can be temporarily overwritten:

```
SET ENCRYPTION OFF
```


Transparent Mode Setup

If you want to modify your existing backup environment so that all RMAN backups are encrypted using the transparent mode, perform the following steps:

1. Set up the Oracle Wallet as already described in this lesson.
2. Open the wallet by using the `ALTER SYSTEM` command shown in the slide.
3. Issue the following RMAN command: `CONFIGURE ENCRYPTION FOR DATABASE ON`

After these steps, all RMAN backup sets created by your database are encrypted, unless you temporarily override the permanent behavior from your RMAN session with `SET ENCRYPTION OFF`, or change the persistent setting again with the `CONFIGURE ENCRYPTION FOR DATABASE OFF` command. The `BACKUP` command arguments do not change for creating encrypted backups. Encryption is performed on the basis of encryption settings specified with `CONFIGURE ENCRYPTION` or `SET ENCRYPTION`.

RMAN automatically decrypts backup sets when their contents are restored. Transparently encrypted backups require no intervention to restore, as long as the Oracle Wallet is open and available.

Note: If you lose your Oracle Wallet, then you will be unable to restore any transparently encrypted backups.

Password Mode Setup

1. Set your RMAN session to use password encryption:

```
SET ENCRYPTION ON IDENTIFIED BY password ONLY
```

2. There are no changes to your backup commands.
3. Set your RMAN session to decrypt password-encrypted backups:

```
SET DECRYPTION IDENTIFIED BY password1
{, password2,…, passwordn}
```

4. There are no changes to your recover commands.

Password Mode Setup

For security reasons, it is not possible to permanently modify your existing backup environment so that all RMAN backups are encrypted using the password mode. Creating password-encrypted backups can be set up only inside your RMAN session by using the `SET ENCRYPTION ON IDENTIFIED BY` *`password`* `ONLY` command in your RMAN scripts. This command is taken into account only for the duration of your RMAN session.

After you set the password by using the `SET ENCRYPTION` command, you can use your regular `BACKUP` commands. All your backup sets are password encrypted.

To restore password-encrypted backups, you must enter the encryption password by using the `SET DECRYPTION IDENTIFIED BY` *`password1`* `{,` *`password2`*`,…,` *`passwordn`*`}` command. If you are restoring from a set of backups that were created with different passwords, then specify all the required passwords on the `SET DECRYPTION` command. RMAN automatically uses the correct password with each backup set.

Note: If you forget, or lose, the password that you used to encrypt a password-encrypted backup, you will be unable to restore that backup.

Dual Mode Setup

1. Create a wallet: automatically or by using Oracle Wallet Manager.
2. Open the wallet from within your instance:

```
ALTER SYSTEM SET ENCRYPTION WALLET OPEN IDENTIFIED BY <password>;
```

3. Set your RMAN session to use dual encryption:

```
SET ENCRYPTION ON IDENTIFIED BY password
```

4. There are no changes to your backup commands.
5. If necessary, set your RMAN session to decrypt your backups by using the password:

```
SET DECRYPTION IDENTIFIED BY password1 {, password2,…, passwordn}
```

6. There are no changes to your recover commands.

15-16

Dual Mode Setup

To set up the dual mode, you must create the wallet, open it, and use the `SET ENCRYPTION` command shown in the slide. After this is done, you can start creating backups from the same session that was used to set your password.

Later, when you need to decrypt these types of backups, you can either use the wallet without additional command, or use the correct password after you use the `SET DECRYPTION` command from your RMAN session.

RMAN-Encrypted Backups: Considerations

- Image copy backups cannot be encrypted.
- `COMPATIBLE` must be set to at least `10.2.0`.
- `V$RMAN_ENCRYPTION_ALGORITHMS` contains the list of possible encryption algorithms.

```
CONFIGURE ENCRYPTION ALGORITHM 'algorithmname'
```

```
SET ENCRYPTION ALGORITHM 'algorithmname'
```

- Backup encryption is available only with Oracle Database Enterprise Edition.
- One new encryption key is used for each new encrypted backup.
- You can increase disk performance by using multiple channels.
- You can change the master key anytime without affecting your transparent encrypted backups.

ORACLE

15-17

RMAN-Encrypted Backups: Considerations

- Any RMAN backups as backup sets can be encrypted. However, image copy backups cannot be encrypted.
- To use RMAN encryption, the `COMPATIBLE` initialization parameter at the target database must be set to at least `10.2.0`.
- The `V$RMAN_ENCRYPTION_ALGORITHMS` view contains a list of encryption algorithms supported by RMAN. If no encryption algorithm is specified, the default encryption algorithm is 128-bit AES. You can change the algorithm by using the commands shown in the slide.
- Backup encryption is available only in Oracle Database Enterprise Edition.
- The Oracle database uses a new encryption key for every encrypted backup. The backup encryption key is then encrypted with either the password or the database master key, or with both, depending on the chosen encryption mode. Individual backup encryption keys or passwords are never stored in the clear.
- Encryption can have a negative effect on disk backup performance. Because encrypted backups use more CPU resource than nonencrypted backups, you can improve the performance of encrypted backups to disks by using more RMAN channels.
- Because the Oracle key management infrastructure archives all previous master keys in the wallet, changing or resetting the current database master key does not affect your ability to restore encrypted backups performed using an older master key. You may reset the database master key at any time, and RMAN will always be able to restore all encrypted backups that were ever created by this database.

Need for Data Privacy

TDE
DP
RMAN
> VPD

Examples:

- **Employees: Protect salary and commission percent (used in the remainder of this lesson)**
- **Online banking: Protect access to accounts**
- **Web store: Supply individual shopping baskets**
- **Web host: Allow each customer to see only their own data**
- **Used in Oracle SalesOnline.com and Oracle Portal**

ORACLE

15-18

Need for Data Privacy

Virtual Private Database (VPD) provides row-level access control beyond the capabilities of roles and views. For Internet access, VPD can ensure that online banking customers see only their own accounts. The Web-hosting companies can maintain data of multiple companies in the same Oracle database, while permitting each company to see only its own data.

Security can be built once, in the data server, rather than in each application that accesses data. Security is stronger, because it is enforced by the database, no matter how a user accesses data. Security is no longer bypassed by a user accessing an ad hoc query tool or a new report writer. VPD is a key technology that enables organizations to build hosted, Web-based applications. Indeed, many Oracle applications themselves use VPD to enforce data separation for hosting, including Oracle SalesOnline.com and Oracle Portal.

VPD is enabled by associating one or more security policies with tables or views. Direct or indirect access to a table with an attached security policy causes the database to consult a function that implements the policy. The policy function returns an access condition known as a predicate (a `WHERE` clause), which the database appends to the user's SQL statement, thus dynamically modifying the user's data access.

Definition and Usage of Terms

- **Fine-grained access control (FGAC): Use of functions**
- **Application context: To preserve user identity and serve as a secure data cache for application attributes and values**
- **Application attributes: Used by fine-grained access policies**

15-19

Definition and Usage of Terms

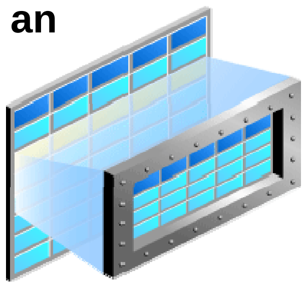
Fine-grained access control (FGAC) enables you to use functions to implement security policies and to associate those security policies with tables, views, or synonyms.

Application context is a feature that enables application developers to define, set, and access application attributes, and then use these attributes to supply the predicate values for fine-grained access control policies. Used alone, it enables application developers to define, set, and access application attributes by serving as a data cache. Such usage removes the repeated overhead of querying the database each time access to application attributes is needed.

Application attributes, defined inside an application context, are used by fine-grained access policies.

Virtual Private Database: Overview

- Virtual Private Database (VPD) consists of:
  - Fine-grained access control (FGAC)
  - Secure application context
- VPD uses policies to add conditions to SQL statements that protect sensitive data.
- VPD provides row-level access control.
- Application attributes defined inside an application context are used by fine-grained access policies.



ORACLE

Virtual Private Database: Overview

Virtual Private Database (VPD) is the aggregation of server-enforced, fine-grained access control and secure application context in the Oracle database. It enables you to build applications that enforce your security policies at the row level. When a user directly or indirectly accesses a table, a view, or a synonym associated with a VPD security policy, the server dynamically modifies the user's SQL statement. The modification is based on a `WHERE` clause returned by a function, which implements the security policy. The database modifies the statement dynamically (transparently to the user) by using any condition that can be expressed in, or returned by, a function.

An example of row-level access control is a shopping basket in a Web store, where you see only your items.

Application context is a feature that enables application developers to define, set, and access application attributes, and then use these attributes to supply the predicate values for fine-grained access control policies.

Note: Fine-grained access control and application context can be implemented as stand-alone options. If they are implemented together, they are the basis of VPD.

Virtual Private Database: Features

- Column-level VPD enforces row-level access control based on accessed security columns.
- With customization, you can define static and nonstatic policies.
- Using shared policies, you can associate one policy with multiple objects.
- Policy type can be `INDEX`.
- Policy predicate text string can be of size 32 KB.

ORACLE

Virtual Private Database: Features

- Column-level privacy enforces row-level access control only when a command accesses or references security-relevant columns. If you do not specify any relevant columns, then the database applies VPD rewrites to all commands that access or reference the object.
- Customization provides the flexibility for all types of policy implementations to base VPD on the individual requirements of customers' deployments. You can customize VPD to always enforce the same predicate with a static policy, or you can have VPD predicates that change dynamically with a nonstatic policy.
- Shared policies enable you to apply a single VPD policy to multiple objects. This feature reduces administration costs.
- You can now enforce security policies on index maintenance operations performed with the DDL statements `CREATE INDEX` and `ALTER INDEX`. This is important because users need full table access to create table indexes. Consequently, a user who has privileges to maintain an index can see all the row data, although the user does not have full table access under a regular query.
- `DBMS_RLS.ADD_POLICY` has the `LONG_PREDICATE` argument. Its default value is `FALSE` so that the policy function may return up to 4,000 bytes of predicate length. Setting this value to `TRUE` allows the function to return up to 32 KB of predicate text string.

Column-Level VPD: Example

- Statements are not always rewritten.
- Consider a policy protecting the SALARY and COMMISSION_PCT columns of the EMPLOYEES table. Fine-grained access control is:
  - Not needed for this query:

```
SQL> SELECT last_name FROM employees;
```

  - Enforced for these queries:

```
SQL> SELECT last_name, salary
  2  FROM employees;
```

```
SQL> SELECT * FROM employees;
```


Column-Level VPD: Example

In this example, the business policy, and therefore the imposed VPD policy, is that a manager can access sensitive information in the EMPLOYEES table only for his employees.

The Oracle database does not enforce the VPD policy when you select only the LAST_NAME column from the EMPLOYEES table. Therefore, all employees can access nonsensitive information in the EMPLOYEES table.

However, when you issue queries that access columns considered as security-relevant, VPD applies the fine-grained access control defined by the policy function.

One of the benefits of using column-level VPD is that the statements are rewritten only when they access security-relevant columns. Therefore, the combination of row-level access control and security-relevant columns implies that you can control access down to the element referenced.

Note: Some commands explicitly reference the columns and others reference them implicitly. Depending on how you defined the policy function, it can be applied for DML statements as well.

Creating a Column-Level Policy

1. Grant the privilege.
2. Create the function.
3. Apply the policy to the object.

```
BEGIN
 dbms_rls.add_policy(object_schema => 'hr',
  object_name => 'employees',
  policy_name => 'hr_policy',
  function_schema =>'hr',
  policy_function => 'hrsec',
  statement_types =>'select,insert',
  sec_relevant_cols=>'salary,commission_pct');
END;
/
```


Creating a Column-Level Policy

To apply a column-level VPD policy, you must perform the following steps:

1. Grant the appropriate privilege to the user who applies the policy.
   `GRANT EXECUTE ON dbms_rls to admin1;`
2. Create the function that implements the VPD policy. The policy can optionally access an application context or it can be simpler, such as dependent on the time of the day.
3. Apply the policy to the table, view, or synonym by using the `DBMS_RLS` package. In the example, you apply the policy implemented by the `HRSEC` function to the `EMPLOYEES` table. You also set the policy to only apply the VPD predicate for `SELECT` and `INSERT` statements. The two security-relevant columns in the `EMPLOYEES` table are `SALARY` and `COMMISSION_PCT`.

Summary

In this lesson, you should have learned how to:

- Implement Transparent Data Encryption
- Use TDE with encrypted columns
- Describe Data Pump encryption
- Identify components of RMAN-encrypted backups
- Define basic concepts of a Virtual Private Database
- Apply a column-level VPD policy

ORACLE

15-24

Practice Overview: Using Oracle Database Security

This practice covers the following topics:

- Implementing TDE by creating an encrypted wallet and encryption keys
- Using TDE with encrypted columns

16

Using Globalization Support

Objectives

After completing this lesson, you should be able to:

- **Determine a correct database character set that meets your business requirements**
- **Obtain globalization support configuration information**
- **Customize language-dependent behavior for the database and individual sessions**
- **Specify different linguistic sorts for queries**
- **Retrieve data that matches a search string ignoring case or accent differences**

16-2

Objectives

For more information, see the *Oracle Database Globalization Support Guide*.

What Every DBA Needs to Know

- What is a character set?
- How are character sets used?
- Problems to avoid
- Choosing your character set
- Obtaining character set information
- Specifying language-dependent behavior
- Using linguistic searching and sorting
- Using data conversion

What Is a Character Set?

The Oracle database supports different classes of character-encoding schemes:

- **Single-byte character sets**
  - **7-bit**
  - **8-bit**
- **Multibyte character sets, including Unicode**

What Is a Character Set?

When computer systems process characters, they use numeric codes instead of the graphical representation of the character. An *encoded character set* maps numeric codes to characters that a computer or terminal can display and receive. The Oracle database currently supports about 30 encoded character sets, but many more languages and territories (about 100). This is possible because Unicode is a universal character set, which encompasses most major scripts of the modern world.

Different character sets support different character repertoires. Because character sets are typically based on a particular writing script, they can support more than one language. However, script-based character sets are restricted in the sense that they are limited to groups of languages based on similar scripts. Universal character sets encompass most major scripts of the modern world and provide a more useful solution to multilingual support. For information about the Unicode standards, see the Web site at http:www.unicode.org.

The Oracle database provides different classes of encoding schemes:

- Single-byte
- Varying-width multibyte
- Universal

What Is a Character Set? (continued)

Single-Byte Character Sets

In a single-byte character set, each character occupies one byte. Single-byte 7-bit encoding schemes can define up to 128 (2^7) characters; single-byte 8-bit encoding schemes can define up to 256 (2^8) characters.

Examples of Single-Byte Schemes

7-bit character set:

- American Standard Code for Information Interchange (ASCII) 7-bit American (`US7ASCII`)

8-bit character set:

- International Organization for Standards (ISO) 8859-1 West European (`WE8ISO8859P1`)
- DEC 8-bit West European (`WE8DEC`)
- Extended Binary Coded Decimal Interchange Code (EBCDIC) Code Page 1144 8-bit Italian (`I8EBCDIC1144`)

Note: ASCII-based character sets are supported only on ASCII-based platforms. Similarly, you can use an EBCDIC-based character set only on EBCDIC-based platforms.

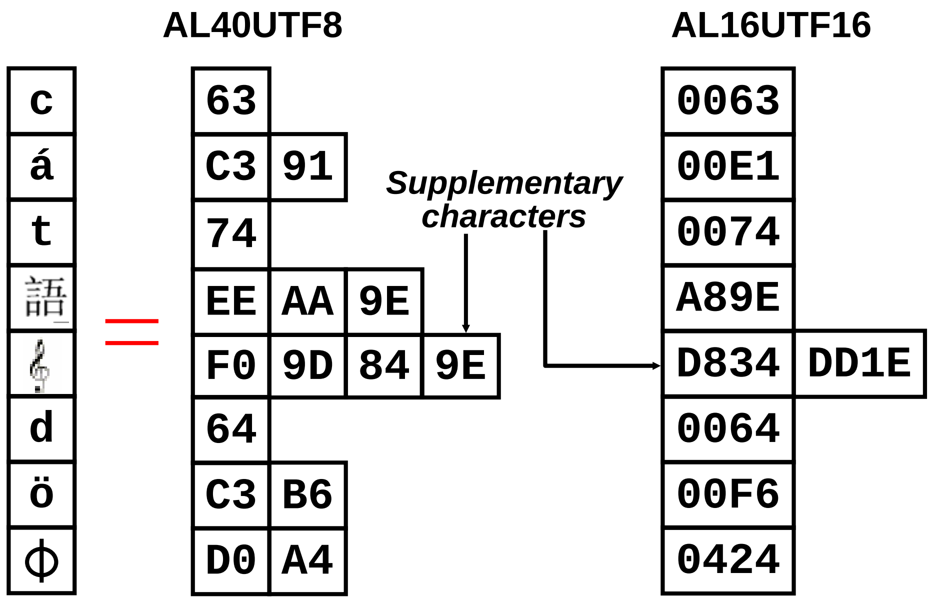
Multibyte Character Sets

A varying-width multibyte character set is represented by one or more bytes per character. Multibyte character sets are commonly used for Asian language support. Some multibyte encoding schemes use the value of the most significant bit to indicate whether a byte represents a single byte or is part of a series of bytes representing a character. However, other character-encoding schemes differentiate single-byte from multibyte characters. A shift-out control code, sent by a device, indicates that any successive bytes are double-byte characters until a shift-in code is encountered. Shift-sensitive encoding schemes are used primarily on IBM platforms.

Examples of Varying-Width Multibyte Schemes

- Shift-JIS 16-bit Japanese (`JA16SJIS`)
- MS Windows Code Page 950 with Hong Kong Supplementary Character Set HKSCS-2001 (`ZHT16HKSCS`)
- Unicode 4.0 UTF-8 Universal character set (`AL32UTF8`)

Understanding Unicode



Encoding: Representing characters with byte sequences

Understanding Unicode

Unicode is a universal encoded character set that enables information from any language to be stored using a single character set. Unicode provides a unique code value for every character, regardless of the platform, program, or language.

The Unicode standard has been adopted by many software and hardware vendors. Many operating systems and browsers now support Unicode. Unicode is required by standards such as XML, Java, JavaScript, LDAP, and WML. It is also synchronized with the ISO/IEC 10646 standard.

AL32UTF8 Encoding

AL32UTF8 encoding is the 8-bit encoding of Unicode. It is a variable-width type of encoding and also a strict superset of ASCII. A strict superset means that each and every character in 7-bit ASCII is available in AL32UTF8 with the same corresponding codepoint value.

One Unicode character can be 1, 2, 3, or 4 bytes in this encoding. Characters from the European scripts are represented in either 1 or 2 bytes; characters from most Asian scripts are represented in 3 bytes, whereas supplementary characters are represented in 4 bytes.

Understanding Unicode (continued)

AL16UTF16 Encoding

AL16UTF16 encoding is the 16-bit encoding of Unicode.

One Unicode character can be 2 to 4 bytes in this encoding. Characters from both European (including ASCII) and most Asian scripts are represented in 2 bytes. Supplementary characters are represented in 4 bytes. AL16UTF16 is the main Unicode encoding that is used by both Microsoft Windows 2000 and Windows XP.

Supplementary Characters

The initial version of Unicode used the 2-byte encoding format. By using 16 bits for every code point, a total of 65,536 characters can be represented. However, there is a need to support many more characters. For example, the Chinese-speaking community alone uses over 55,000 characters.

For languages such as Chinese, Japanese, and Korean, there are still tens of thousands of ideograms that are not yet encoded. And even though many of these are rarely used characters, they are still present in documents that must be preserved electronically.

To meet this requirement, the Unicode Standard defines *supplementary characters*. By taking two 16-bit code points (also known as *surrogate pairs*) to represent a single character, an additional 1,048,576 characters can be defined.

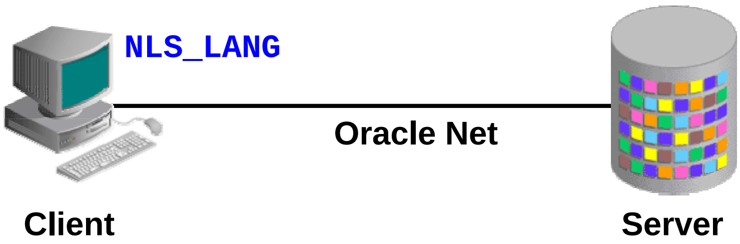
The first batch of the supplementary characters—44,944 of them—was added in the Unicode standard 3.1 released in March 2001. Together with the 49,194 already existing characters in Unicode 3.0, there are now a grand total of 94,140 encoded characters in Unicode 3.1. This introduces more complexity into the Unicode Standard, but far less than managing a large number of different encodings. Oracle Database 10*g* supports the Unicode 4.0 standard.

Note: Notice above that UTF-16 and UTF-8, with hyphens, refer to the Unicode Standard encodings, whereas UTF8, AL32UTF8, and AL16UTF16, without hyphens, refer to Oracle database character sets based on the Unicode Standard.

Note: For details on Oracle's support for Unicode, see the *Oracle Database Globalization Support Guide 10g Release 2 (10.2).*

How Are Character Sets Used?

- Oracle Net compares the client `NLS_LANG` setting to the character set on the server.
- If needed, conversion occurs automatically and transparently.



How Are Character Sets Used?

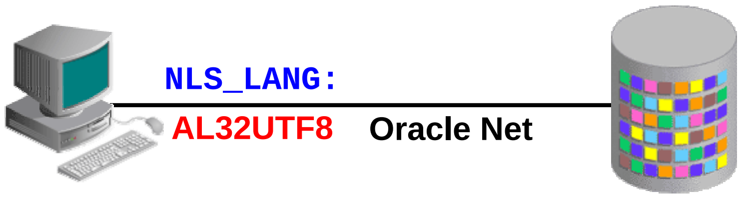
The `NLS_LANG` parameter defines a client terminal's character-encoding scheme. Different clients can use different encoding schemes. Data passed between the client and the server is converted automatically between the two encoding schemes. The database's encoding scheme should be a superset, or equivalent, of all the clients' encoding schemes. The conversion is transparent to the client application.

When the database character set and the client character set are the same, the database assumes that the data being sent or received is of the same character set, so no validations or conversions are performed.

Character set conversion may be required in a client/server environment, if a client application resides on a different platform than the server and if the platforms do not use the same character encoding schemes. Character data passed between the client and the server must be converted between the two encoding schemes. Character conversion occurs automatically and transparently through Oracle Net.

Problems to Avoid

Example:



Client
Windows English
Code page: WE8MSWIN1252

Server
Database character set:
AL32URF8

No conversion occurs, because it does not seem to be required.

Issue: Invalid data are entered into the database.

Problems to Avoid

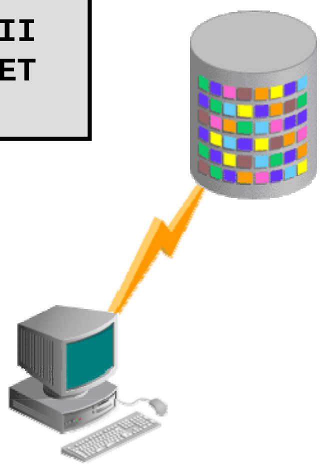
Invalid data usually enters a database when the `NLS_LANG` parameter is not set properly on the client. The `NLS_LANG` value should reflect the encoding of the incoming data.

- When the `NLS_LANG` parameter is set properly, the database can automatically convert incoming data from the client operating system.
- When the `NLS_LANG` parameter is not set properly, the data entering the database is not converted properly.

For example, suppose that the database character set is `AL32UTF8`, the client is an English Windows operating system (code page: `WE8MSWIN1252`), and the `NLS_LANG` setting on the client is `AL32UTF8`. Data entering the database is encoded in `WE8MSWIN1252` and is not converted to `AL32UTF8` data because the `NLS_LANG` setting on the client matches the database character set. Thus the Oracle database assumes that no conversion is necessary, and invalid data is entered into the database.

Another Sample Problem

```
CREATE DATABASE ...
CHARACTER SET US7ASCII
NATIONAL CHARACTER SET
UTF8 ...
```



```
% export NLS_LANG= SIMPLIFIED
CHINESE_HONGKONG.US7ASCII
```

16-10

Another Sample Problem

For example, your database character set is US7ASCII and you are using Simplified Chinese Windows as your client terminal. By setting NLS_LANG to SIMPLIFIED CHINESE_HONGKONG.US7ASCII as the client character set, it is possible for you to store multibyte Simplified Chinese characters inside a single-byte database. This means that the database treats these characters as single-byte US7ASCII characters, and therefore, all SQL string manipulation functions such as SUBSTR or LENGTH are based on bytes rather than characters. All of your non-ASCII characters could be lost following an export and import into another database.

Choosing Your Character Set

- Trade-offs to consider
- Choosing the correct character set that meets your business requirements now and in the future
- Specifying the character set
- Changing the character set after database creation

ORACLE

16-11

Choosing Your Character Set

For best performance, choose a character set that avoids character set conversion and uses the most efficient encoding for the languages desired. Single-byte character sets result in better performance than multibyte character sets, and they also are the most efficient in terms of space requirements. However, single-byte character sets limit how many languages you can support.

To choose your correct database character set, evaluate your current and future business requirements, as well as technical requirements (for example, the XML and Java standards require Unicode). In general, Oracle recommends the use of Unicode for all new databases, because it is the most flexible character set and avoids future conversions.

To specify the character set, use the `CREATE DATABASE` statement with the `CHARACTER SET` and `NATIONAL CHARACTER SET` clauses. If you do not use the `NATIONAL CHARACTER SET` clause, then it defaults to `AL16UTF16`.

You may need to change the character set after database creation, to support unforeseen requirements, for example, to provide support for new data sources (XA, data warehousing, and so on). This can often be a time-consuming and costly process. In most cases, you need to do a full export/import to properly convert all data to the new character set.

Database Character Sets and National Character Sets

Database Character Sets	National Character Sets
Defined at creation time	Defined at creation time
Cannot be changed without re-creation, few exceptions	Can be exchanged
Store data columns of type `CHAR`, `VARCHAR2`, `CLOB`, `LONG`	Store data columns of type `NCHAR`, `NVARCHAR2`, `NCLOB`
Can store varying-width character sets	Can store Unicode using either `AL16UTF16` or `UTF8`

Database Character Sets and National Character Sets

Because the database character set is used to identify and to hold SQL and PL/SQL source code, it must have either EBCDIC or 7-bit ASCII as a subset, whichever is native to the platform. Therefore, it is not possible to use a fixed-width, multibyte character set as the database character set; you can use this only as the national character set.

A national character set is an alternate character set that enables you to store Unicode character data in a database that does not have a Unicode database character set. SQL `NCHAR`, `NVARCHAR2`, and `NCLOB` data types support Unicode data only. You can use either the `UTF8` or the `AL16UTF16` character set.

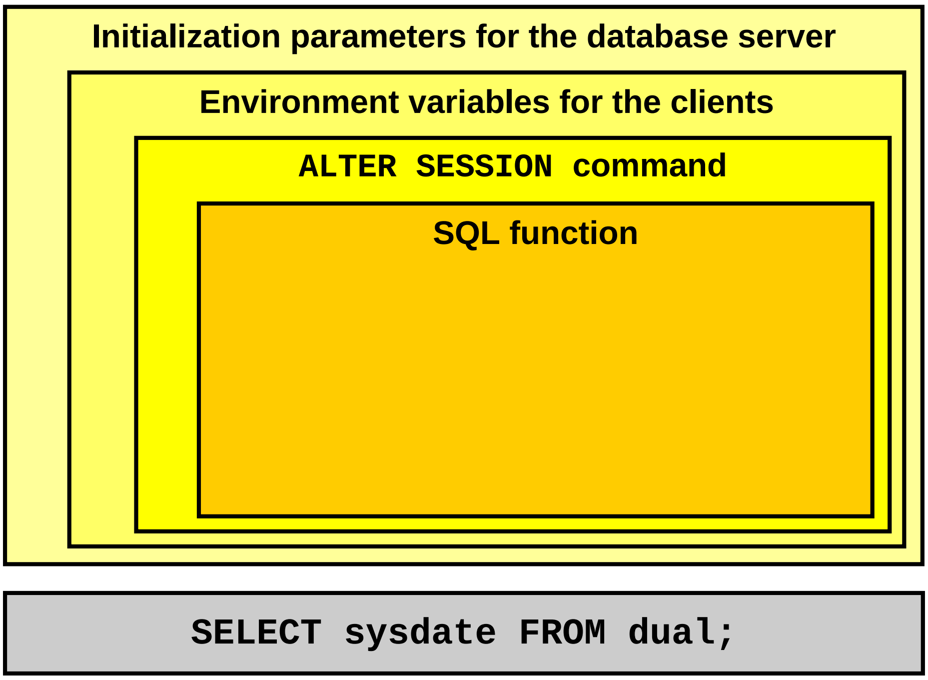
Obtaining Character Set Information

```
SQL> SELECT parameter, value
  2   FROM nls_database_parameters
  3   WHERE parameter LIKE '%CHARACTERSET%';

PARAMETER                VALUE
----------------------- -------------
NLS_CHARACTERSET          WE8ISO8859P1
NLS_NCHAR_CHARACTERSET    AL16UTF16

2 rows selected.
```


Obtaining Character Set Information

Use the `NLS_DATABASE_PARAMETERS` view to display the permanent NLS settings for the database, including the database and national character set. This view contains the explicitly set values, as well as the default values used by the database.

Specifying Language-Dependent Behavior



Specifying Language-Dependent Behavior

Beyond storing and retrieving data for most contemporary languages in a database, additional support is available for a subset of the languages. The database can display dates by using local date and time formats and can sort text data according to cultural conventions. The database also supports cultural conventions that are specific to geographical locations, or territories, such as numeric and monetary conventions.

NLS parameters determine the locale-specific behavior on both the client and the server. There are four ways to specify national language support (NLS) parameters:

- As initialization parameters on the server side to specify the default server environment. (These default settings have no effect on the client side.)
- As environment variables for the client to specify locale-dependent behavior overriding the defaults set for the server
- Using the `ALTER SESSION` command to override the defaults set for the client and the server
- In SQL functions, to explicitly to hard-code NLS behavior for an application or query overriding the default values that are set for the server and client, as well as any values specified with an `ALTER SESSION` statement

Specifying Language-Dependent Behavior for the Session

- Specify the locale behavior with the `NLS_LANG` environment variable:
  - Language
  - Territory
  - Character set

```
NLS_LANG=FRENCH_CANADA.WE8ISO8859P1
```

- Set other NLS environment variables to:
  - Override database initialization parameter settings for all sessions
  - Customize the locale behavior
  - Change the default location of the NLS library files

ORACLE

16-15

Specifying Language-Dependent Behavior for the Session

The Environment Variable NLS_LANG

A *locale* is a linguistic and cultural environment in which a system or program is running. Setting the `NLS_LANG` environment parameter is the simplest way to specify locale behavior for the Oracle database software. It sets the language and territory used by the client application and the database server. It also sets the character set for data entered or displayed by a client program. The value of `NLS_LANG` overrides any values of the NLS initialization parameters.

Each component controls a subset of NLS features:

```
NLS_LANG=<language>_<territory>.<charset>
```

`language` is used to override the value of `NLS_LANGUAGE`. `territory` overrides the value of `NLS_TERRITORY`. `charset` specifies the character-encoding scheme used by client application (usually that of the user's terminal).

All components of the `NLS_LANG` definition are optional; any item that is not specified uses its default value. If you specify territory or character set, then you *must* include the preceding delimiter [underscore (_) for territory, period (.) for character set]. For example:

```
NLS_LANG = _JAPAN
NLS_LANG = .US7ASCII
```

Language- and Territory-Dependent Parameters

Parameter	Default Values
NLS_LANGUAGE NLS_DATE_LANGUAGE NLS_SORT	AMERICAN AMERICAN BINARY
NLS_TERRITORY NLS_CURRENCY NLS_DUAL_CURRENCY NLS_ISO_CURRENCY NLS_DATE_FORMAT NLS_NUMERIC_CHARACTERS NLS_TIMESTAMP_FORMAT NLS_TIMESTAMP_TZ_FORMAT	AMERICA $ $ AMERICA DD-MON-RR ., DD-MON-RRHH.MI.SSXFF AM DD-MON-RRHH.MI.SSXFF AM TZR

ORACLE

16-16

Language- and Territory-Dependent Parameters

Setting the `NLS_LANGUAGE` and `NLS_TERRITORY` initialization parameters determines the default values that should be used by the Oracle database. You can override these default values by explicitly setting the values for those initialization parameters whose default values depend on the settings of `NLS_LANGUAGE` and `NLS_TERRITORY`.

NLS_LANGUAGE Initialization Parameter

The `NLS_LANGUAGE` initialization parameter determines the default values of the following parameters:

Column	Description
NLS_DATE_LANGUAGE	Determines the language for day and month names and abbreviations and spelled values of other date format elements
NLS_SORT	Changes the linguistic sort sequence that the Oracle database uses to sort character values. (The sort value must be the name of a linguistic sort sequence.)

Language and Territory Dependent Parameters (continued)

NLS_TERRITORY Initialization Parameter

NLS_TERRITORY determines the default values for the following initialization parameters:

Column	Description
NLS_CURRENCY	Specifies the local currency symbol
NLS_DATE_FORMAT	Specifies the date format. (The value must be a date format model.)
NLS_DUAL_CURRENCY	Defines a secondary currency symbol for a given territory
NLS_ISO_CURRENCY	Indicates the territory whose ISO currency symbol should be used
NLS_NUMERIC_CHARACTERS	Explicitly specifies a new decimal character and group separator
NLS_TIMESTAMP_FORMAT	Defines the default date format for the TIMESTAMP and TIMESTAMP WITH LOCAL TIME ZONE data types. **Must have NLS_LANG set.**
NLS_TIMESTAMP_TZ_FORMAT	Defines the default date format for the TIMESTAMP and TIMESTAMP WITH LOCAL TIME ZONE data types used with the TO_CHAR and TO_TIMESTAMP_TZ functions. **Must have NLS_LANG set.**

These are some of the NLS initialization parameters that are independent of the NLS_LANGUAGE and NLS_TERRITORY values:

Column	Description
NLS_CALENDAR	Specifies which calendar system is used by the Oracle database
NLS_COMP	Can be set to ANSI or BINARY. When NLS_COMP is set to ANSI, SQL operations perform a linguistic comparison based on the value of NLS_SORT.
NLS_LENGTH_SEMANTICS	Enables you to create CHAR, VARCHAR2, and LONG columns by using either byte or character length semantics.

Specifying Language-Dependent Behavior

```
ALTER SESSION SET
NLS_DATE_FORMAT='DD.MM.YYYY';
```

```
DBMS_SESSION.SET_NLS('NLS_DATE_FORMAT',
'''DD.MM.YYYY''') ;
```

Using NLS parameters in SQL functions

```
SELECT TO_CHAR(hire_date,'DD.Mon.YYYY',
 'NLS_DATE_LANGUAGE=FRENCH')
FROM employees
WHERE hire_date > '01-JAN-2000';
```

ORACLE

16-18

Specifying Language-Dependent Behavior

In addition to explicitly issuing ALTER SESSION commands, you can use the DBMS_SESSION.SET_NLS database procedure, specifying the name of the parameter to change and the new value of the parameter. The second example shown in the slide performs the same action as the first example, but uses the DBMS_SESSION package.

Client utilities such as *i*SQL*Plus, SQL*Plus, or SQL*Loader read the environment variables set on the client and issue the corresponding ALTER SESSION command after they are connected to the database.

The third example shows the use of the NLS_DATE_LANGUAGE NLS parameter in the TO_CHAR SQL function.

Linguistic Searching and Sorting

Sort order can be affected by:

- **Case sensitivity**
- **Diacritics or accent characters**
- **Combination of characters that is treated as a single character**
- **Phonetics or character appearance**
- **Cultural preferences**

16-19

Linguistic Searching and Sorting

Different languages have different sort orders. In addition, different cultures or countries that use the same alphabets may sort words differently. For example, in Danish, Æ is after Z, whereas Y and Ü are considered to be variants of the same letter. Sort order can:

- Be case sensitive or case insensitive
- Ignore or consider diacritics (a mark near or through a character or combination of characters that indicates a different sound than the sound of the character without the diacritic)
- Be phonetic or it can be based on the appearance of the character (such as the number of strokes in East Asian ideographs)

Another common sorting issue is combining letters into a single character. For example, in traditional Spanish, `ch` is a distinct character that comes after `c`, which means that the correct order is: *cerveza*, *colorado*, *cheremoya*. This means that the letter `c` cannot be sorted until the database has checked whether the next letter is an `h`.

To produce a sort sequence that matches the alphabetic sequence of characters, another sort technique must be used that sorts characters independently of their numeric values in the character-encoding scheme. This technique is called a *linguistic sort*. A linguistic sort operates by replacing characters with numeric values that reflect each character's proper linguistic order.

Linguistic Searching and Sorting

Three types of sorting:

- Binary sorting
  - Sorted according to the binary values of the encoded characters
- Monolingual linguistic sorting
  - A two-pass sort based on a character's assigned major and minor values
- Multilingual linguistic sorting
  - Based on the ISO standard (ISO 14651), and the Unicode 3.2 Standard for multilingual collation
  - Ordered by the number of strokes, PinYin, or radicals for Chinese characters

ORACLE

16-20

Linguistic Searching and Sorting (continued)

A binary sort is a conventional sorting mechanism by which letters are sorted according to the binary values used to encode the characters. Binary sorts are the fastest type of sort. They produce reasonable results for the English alphabet because the ASCII and EBCDIC standards define the letters A to Z in ascending numeric value. When characters used in other languages are present, a binary sort usually does not produce reasonable results.

For monolingual sorting, the Oracle database uses major and minor values to compare characters. Usually, letters with the same appearance have the same major value. For example, A, a and ä. The Oracle database defines letters with diacritics and case differences as having the same major value but different minor values.

In a monolingual sort, the database makes two passes when comparing strings in monolingual sorts. The first pass is to compare the major value of the entire string from the major table and the second pass is to compare the minor value from the minor table. Although this provides better sorting than binary, it is still limited.

Multilingual sorts enable you to sort data in more than one language in a single sort. This is useful for regions or languages that have complex sorting rules.

Refer to the *Oracle Database Globalization Support Guide* for more information about the supported linguistic sorts.

Using Linguistic Searching and Sorting

You can specify the type of sort used for character data with the:

- **`NLS_SORT` parameter**
  - **Default value derived from the `NLS_LANG` environment variable, if set**
  - **Can be specified for the session, client, or server**
- **`NLSSORT` function**
  - **Defines the sorting method at the query level**

Using Linguistic Searching and Sorting

To overcome the limitations of binary sorting, you can specify linguistic sorts by setting the `NLS_SORT` parameter or by using `NLSSORT` in your query.

The `NLS_SORT` Parameter

Consider the following words stored in a database by using the `WE8ISO8859P1` character set:

- `gelée`
- `gelé`
- `gèle`
- `gelez`

If `NLS_SORT` is set to `BINARY`, `gelez` is sorted before `gelé`. This occurs because `e` has a binary value lower than `è` in the `WE8ISO8859P1` character encoding.

If `NLS_SORT` is set to the `FRENCH` monolingual sort, the word `gelé` is sorted before `gelez` and `gèle`, which still does not satisfy all the nuances of the French language. For example, in the French language, letters are sorted from left to right and accents from right to left.

When `NLS_SORT` is set to the `FRENCH_M` multilingual sort, both the characters and the diacritics are sorted properly.

Using Linguistic Searching and Sorting (continued)

The `NLSSORT` Function

`NLSSORT` allows sorting to be defined at the query level. The following example sets `NLS_SORT` to `BINARY` at the session level but then changes the sort at the query level.

```
SQL> ALTER SESSION SET NLS_SORT=BINARY;
Session altered.

SQL> SELECT  fr_word
 2   FROM    words
 3   ORDER BY fr_word;

FR_WORD
-------
gelez
gelé
gelée
gèle

SQL> SELECT  fr_word
 2   FROM    words
 3   ORDER BY NLSSORT(fr_word,'NLS_SORT=FRENCH_M');

FR_WORD
--------
gèle
gelé
gelée
gelez
```

Case- and Accent-Insensitive Search and Sort

- Specify the linguistic name:

```
NLS_SORT = <NLS_sort_name>[_AI | _CI]
```

- Examples:

```
NLS_SORT = FRENCH_M_AI
```

```
NLS_SORT = XGERMAN_CI
```

- Specify the sort action for `WHERE` clauses and PL/SQL blocks:

```
NLS_COMP = BINARY | ANSI
```

- Useful for migrated databases

Case- and Accent-Insensitive Search and Sort

Use the session parameter `NLS_SORT` to specify the linguistic sort name. The default value is derived from the initialization parameter `NLS_LANGUAGE`. The `_AI` and `_CI` values are suffixed to the sort name to indicate an accent-insensitive sort or a case-insensitive sort. From the example in the slide, the following are determined:

- Accent-insensitive and case-insensitive “French_M” sort
- Accent-sensitive and case-insensitive “Xgerman” sort

Comparisons in the `WHERE` clause and in PL/SQL blocks are binary unless you use the `NLSSORT` function. By setting `NLS_COMP` to `ANSI`, you indicate that comparisons in the `WHERE` clause and in PL/SQL blocks should use the linguistic sort specified in the `NLS_SORT` parameter. You must also define an index on the column for which you want linguistic sorts.

Note: The format of the `NLS_SORT` parameter applies for both monolingual and multilingual linguistic sorts. In the monolingual sort, only major and minor levels are included. If the `NLS_COMP` parameter is set to ANSI, the options apply to any SQL or PL/SQL operators that already support collation-based comparisons in previous database releases. The `_AI` or `_CI` options are not affected in the `INSTR`, `TRIM`, and `LIKE` SQL functions because these functions compare strings only in binary order.

Note for database migrators: Sybase, SQL Server, and MS Access can use case-insensitive operations. These options can be used to preserve existing application functionality.

Support in SQL and Functions

- The following SQL clauses support `NLS_SORT` and `NLS_COMP` settings:
  – `WHERE`
  – `ORDER BY`
  – `START WITH`
  – `HAVING`
  – `IN/NOT IN`
  – `BETWEEN`
  – `CASE-WHEN`
- The `NLSSORT()` function supports the case-insensitive and accent-insensitive functionality.

ORACLE

16-24

Support in SQL and Functions

The SQL clauses listed in the slide are affected when the `_AI` or `_CI` options are appended to the `NLS_SORT` parameter.

```
SELECT cust_last_name
FROM customers
WHERE NLSSORT(cust_last_name, 'NLS_SORT = generic_m_ai')
       = NLSSORT('De Niro', 'NLS_SORT=generic_m_ai');

CUST_LAST_NAME
--------------------
de Niro
De Niro
dë Nirõ
```

You typically use the `NLSSORT` function in an `ORDER BY` or `WHERE` clause when the linguistic setting of the session parameter `NLS_SORT` is different from the linguistic setting in the SQL statement. The example (given on this page) searches for all occurrences of “De Niro” regardless of the case and accent. You can get the same result as shown in the example by setting the `NLS_COMP` parameter:

```
ALTER SESSION SET NLS_SORT=generic_m_ai;
ALTER SESSION SET NLS_COMP=ansi;
```

Linguistic Index Support

- Create an index on linguistically sorted values.
- Rapidly query data without having to specify ORDER BY clause and NLSSORT:

```
CREATE INDEX list_word ON
 list (NLSSORT(word, 'NLS_SORT=French_M'));

SELECT word FROM list;
```

- Set the NLS_SORT parameter to match the linguistic definition that you want to use for the linguistic sort when creating the index.

Linguistic Index Support

Linguistic sorting is language specific. When data in multiple languages is stored in the database, you may want to sort the data in different ways depending on the language. Creating a linguistic index for columns to be sorted greatly improves the performance of queries requiring linguistic sorting, although it can slow down inserts and updates.

Functional indexes are used to create linguistically sorted indexes. The SQL function NLSSORT returns the string of bytes used to sort the first parameter in the given linguistic sorting sequence. In the example shown in the slide, an index is created on WORD that is sorted according to the FRENCH_M sorting order. This enables you to perform index-based queries on data that is sorted according to the rules of each language.

You can also build a single linguistic index for all languages by using one of the multilingual linguistic sorts such as GENERIC_M or FRENCH_M. Or, for a small set of languages, use a language column to be used as a parameter of the NLSSORT function. The language column contains the NLS_LANGUAGE values for the data in the indexed column.

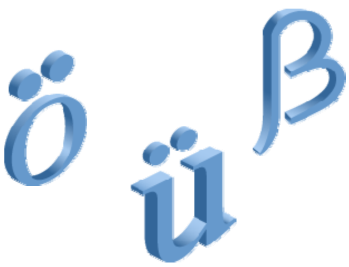
```
CREATE INDEX i2 on list (NLSSORT(word, 'NLS_SORT=GENERIC_M'));
CREATE INDEX word_all_idx ON
  list (NLSSORT(word, 'NLS_SORT=' || LANG_COL));
```

See the *Oracle Database Globalization Support Guide* for details on creating linguistic indexes.

Customizing Linguistic Searching and Sorting

You can customize linguistic sorting for:

- Ignorable characters
- Contracting or expanding characters
- Special combination letters or special letters
- Expanding characters or special letters
- Special uppercase and lowercase letters
- Context-sensitive characters
- Reverse secondary sorting
- Canonical equivalence



Customizing Linguistic Searching and Sorting

Linguistic searching and sorting has many features. Many of these features are customizable, so you can retrieve the desired results from your data. For example:

- Now you can also specify a sort or query on the base letters only (accent insensitive) or on the base letter and the accents (case insensitive).
- You can specify that the dash punctuation character should be ignored so that `e-mail` can be treated in the same way as `email`.
- The expanding character ö sorts as if it were `oe`, after `od` and before `of`.
- You can properly sort prolonged sound marks in Japanese.
- Making ä equivalent to its base letter, a, and an umlaut, ¨ , so that ä and a ¨ are considered equal.
- You can have a character with a diacritic placed before or after its unmarked variant.
- Whether or not in Thai and Lao, some characters first change places with the following character before sorting.
- You can map lowercase letters to multiple uppercase letters, such as the German ß to SS, and uppercase letters to multiple lowercase letters, such as the Turkish `I` becoming a small, dotless i: ı.

To create custom linguistic sorts, you need to use the Oracle Locale Builder utility.

Implicit Conversion Between `CLOB` and `NCLOB`

Transparent implicit conversion is supported in:

- **SQL `IN` and `OUT` bind variables for query and DML**
- **PL/SQL functions and procedure parameter passing**
- **PL/SQL variable assignment**

16-27

Implicit Conversion Between `CLOB` and `NCLOB`

Converting data between Unicode and the database national language character set is becoming a more frequent requirement. Explicit conversion between `CLOB` and `NCLOB` is already available in SQL and in PL/SQL with the `TO_CLOB` and `TO_NCLOB` functions. Oracle Database 10*g* introduces implicit conversion for SQL `IN` and `OUT` bind variables in queries and DML operations, as well as for PL/SQL function and procedure parameter passing and PL/SQL variable assignment. For example, conversion is completely transparent in the following scenario:

```
CREATE TABLE my_table (nclob_col NCLOB);
DECLARE
    clob_var CLOB;
    nclob_var NCLOB;
BEGIN
    clob_var := 'clob data'; -- initialize the CLOB
    INSERT INTO my_table VALUES (clob_var);
    -- Bind a CLOB into an NCLOB column
    SELECT nclob_col
      INTO clob_var FROM my_table;
    -- Define an NCLOB column as a CLOB var
END;
```

NLS Data Conversion with Oracle Utilities

- Multiple data conversions can take place when data is exported from one database and imported into another if the same character sets are not used.
- External tables use the NLS settings on the server for determining the data character set.
- SQL*Loader:
  - Conventional path: Data is converted into the session character set specified by `NLS_LANG`.
  - Direct path: Data is converted using client-side directives.

16-28

NLS Data Conversion with Oracle Utilities

Globalization Support for Export and Import

The Export utility always saves the data, including Unicode data, in the same character sets as the database from which the taken was exported. When exporting data definition language (DDL), Export writes export files using the character set specified in the `NLS_LANG` environment variable for the user session. A character set conversion is performed if the value of `NLS_LANG` differs from the database character set.

When importing user data, if the character sets of the source database (and the export dump file) are different from the character sets of the import database, a single conversion is performed to automatically convert the data to the character sets of the target database.

During the import of DDL, the data is automatically converted from the character set of the export file to the character set of the import user session. Import can perform this conversion only for single-byte character sets. This means that for multibyte character sets, the import file's character set must be identical to the export file's character set. If the character set used by the import user session is different from the target database's character set, a final character set conversion is performed.

Globalization Support for External Tables

The NLS environment variable settings on the **server** determine the character set and date masks for the table.

NLS Data Conversion with Oracle Utilities (continued)

Globalization Support for SQL*Loader

SQL*Loader supports four character sets:

- Client character set (`NLS_LANG` of the client SQL*Loader process)
- Data file character set (usually the same as the client character set)
- Database character set
- Database national character set

Performance is optimized if all character sets are the same.

SQL*Loader has the capability to convert data from the data file character set to the database character set. The character set of the data file can be set up by using the `NLS_LANG` parameter or by specifying the `CHARACTERSET` parameter in the SQL*Loader control file:

```
LOAD DATA
CHARACTERSET UTF16
INFILE ulcase11.dat
REPLACE …
```

The SQL*Loader control file itself is assumed to be in the character set specified for your session by the `NLS_LANG` parameter. If the control file character set is different from the data file character set, delimiters and comparison clause values specified in the SQL*Loader control file as character strings are converted from the control file character set to the data file character set before any comparisons are made. To ensure that the specifications are correct, you may prefer to specify hexadecimal strings, rather than character string values.

If the character set specified with the `NLS_LANG` parameter for your session is different from the character set of the data file, character strings in the control file are converted to the character set of the data file. This is done before SQL*Loader checks for the default record terminator.

The character set specified with the `CHARACTERSET` parameter does not apply to data in the control file (specified with `INFILE`). To load data in a character set other than the one specified for your session by the `NLS_LANG` parameter, you must place the data in a separate data file.

You can use SQL*Loader to load data using one of three methods: conventional path, direct path, or external table. During conventional path data loads, data is converted into the session character set specified by the `NLS_LANG` parameter for that session.

During a direct path load, data conversion occurs on the client side rather than on the server side. This means that NLS parameters in the initialization parameter file are not used. To override this behavior, you can specify a format mask in the SQL*Loader control file that is equivalent to the setting of the NLS parameter in the initialization parameter file, or set the appropriate environment variable.

If the target character set for the SQL*Loader data is not a superset of the source data file character set, characters that have no equivalent in the target character set are converted to replacement characters, such as a question mark, resulting in loss of data.

NLS Data Conversion with Data Pump

- Data Pump Export always saves data in the same character set as the database from which the data originates.
- Data Pump Import converts the data to the character set of the target database, if needed.
- The Data Pump log file is written in the language specified by `NLS_LANG` for the session that started Data Pump.

16-30

NLS Data Conversion with Data Pump

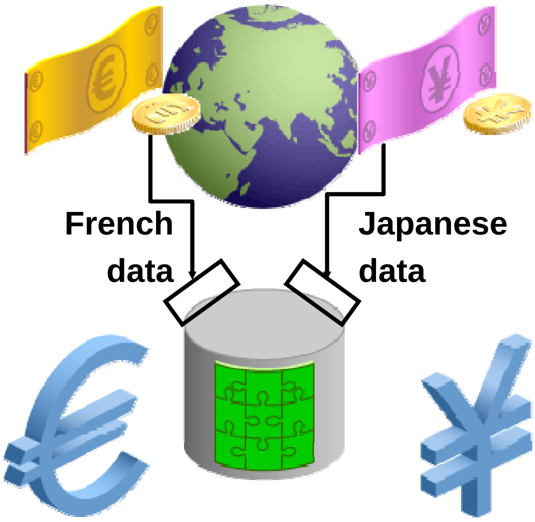
The NLS parameter settings used by the session that initiated Data Pump are used within the Data Pump job. Therefore, ensure that the parameters are set correctly before you start any Data Pump job. The client `NLS_LANG` settings are used only for messages returned by the Data Pump utilities, such as `impdp` or `expdp`.

During the execution of a job, a log file is optionally written. The log file summarizes the progress of the job and any errors that were encountered along the way. Data Pump writes the log file by using the `NLS_LANG` setting of the client. For example, setting `NLS_LANG` to `French.WE8DEC` causes all messages for the job to be displayed in French, even if the job is restarted from an `American.WE8DEC` client.

If you use a parameter file (`PARFILE`) with Data Pump, the parameter file is assumed to be in the client's character set. The Data Pump utility translates the text strings in the parameter files into the database character set. If the parameter file is in a different character set than that being currently used by the client, then you must alter the NLS settings of the client to ensure a proper translation.

Globalization Support Features

- Language support
- Territory support
- Character set support
- Linguistic sorting
- Message support
- Date and time formats
- Numeric formats
- Monetary formats



Globalization Support Features

Different countries and geographies dictate different cultural conventions that directly affect data formats. Globalization support ensures that utilities and error messages, sort order, date, time, monetary, numeric, and calendar conventions automatically adapt to the native language. Users can interact, store, process, and retrieve data in their native languages and formats:

- Time zones can be used to support daylight saving time.
- National calendars such as Gregorian, Japanese, Imperial, and Thai Buddha are supported.
- Currency symbols reflect the local economy and ISO conventions. Credit and debit symbols also differ from location to location.

Oracle's globalization support is implemented with Oracle NLS Runtime Library (NLSRTL). NLSRTL provides a comprehensive suite of language-independent functions that allow proper text and character processing and language convention manipulations. The behavior of these functions for a specific language and territory is governed by a set of locale-specific data that is identified and loaded at run time.

You can control the language-dependent operations by using several parameters and environment variables on both the client and the server sides. The server and the client may run in the same or different locations. When the client and the server use different character sets, the Oracle database handles character set conversion automatically.

Summary

In this lesson, you should have learned how to:

- Determine a correct database character set that meets your business requirements
- Obtain globalization support configuration information
- Customize language-dependent behavior for the database and individual sessions
- Specify different linguistic sorts for queries
- Retrieve data that matches a search string ignoring case or accent differences

16-32

Practice Overview: Using Globalization Support Features

This practice covers the following topics:

- Checking the database and national character set
- Identifying valid NLS values
- Setting NLS parameters

Practice Overview

Note: For this practice, you will be using *i*SQL*Plus.

17

Workshop

Objectives

After completing this lesson, you should be able to do the following:

- Document a database configuration by using a Database Configuration Worksheet
- Recover data while minimizing down time and data loss
- Use database tools and features to monitor and improve database performance

Workshop Methodology

- Team-oriented and interactive
- Tools used to keep the database performance at specified levels
- Hands-on diagnosis and problem resolution for a variety of failure scenarios
- Multiple solutions possible for each scenario
- Develop troubleshooting and administration skills

ORACLE

17-3

Workshop Methodology

Group-Oriented and Interactive Structure

The workshop is structured to allow individuals to work in groups to perform database backup, restore, and recovery operations. Each group is encouraged to share its approach to resolving database failures with other groups in the class.

Intensive Hands-On Diagnosis and Problem Resolution

The intent is to provide you with as much hands-on experience as possible to diagnose and work through backup and recovery scenarios. Experience and knowledge gained from the course will play a major role toward successfully completing the objectives of each session.

Using the Right Tools

Enterprise Manager Database Control for Oracle Database 10*g* provides a wealth of information to the DBA. Filtering through the information to identify problems and knowing what tool to use to resolve them can be a challenge. By simulating problems that are not known to you ahead of time, you gain experience in locating problems and resolving them on your own.

Workshop Methodology (continued)

Variety of Failure Scenarios

During this workshop, you will induce configuration errors by running a series of shell scripts. Your objective is to diagnose the nature of the problem and to make the necessary corrections or perform the appropriate recovery process. The types of failures that you may encounter include:

- Loss of a redo log group
- Media loss
- Data block corruption or incorrect data in application tables
- Loss of control files
- Loss of a table

Recovery Solutions

This workshop simulates a real-world environment in that exact solutions to problems may not be readily available in the event of a database failure. Therefore, only cursory solutions are provided in Appendix A for the workshop scenarios.

Business Requirements

- Twenty-four hour availability
- Varying peak usage across all time zones
- Daily backups required
- Complete database recovery required

17-5

Business Requirements

The following business requirements should be familiar to you when configuring your database for backup and recovery.

Twenty-four hour availability: The database must be available 24 hours a day, 7 days a week. An eight-hour period for maintenance is scheduled for the first Saturday of each month when the instance can be shut down.

Peak usage varies across available time frame: This database is accessed globally, so it is used throughout the 24-hour period of one day.

Daily backups: Full database backups are required on a daily basis.

Complete database recovery: This is a critical business application database and data loss cannot be tolerated. A high number of transactions occur over the 24-hour time frame.

Database Configuration

- Archiving is enabled.
- Log files are mirrored and distributed across multiple devices.
- Control files are mirrored and distributed across multiple devices.
- Flashback Database is enabled.
- Full backup of the database exists, including archive log files.

17-6

Database Configuration

The first scenario sets up your environment to meet these requirements. Because of the limitations of the servers used in the classroom, all the critical database files reside on the same disk for this workshop.

Method for Resolving Database Issues

- **Phase I: Diagnose the problem.**
- **Phase II: Determine the appropriate method to resolve the problem.**
- **Phase III: Resolve the problem.**
- **Phase IV: Back up the database, if needed.**

Method for Resolving Database Issues

The workshop is a hands-on exercise. For data failure scenarios, you can choose the restore and recovery operation that you deem appropriate for the situation. Multiple failure and recovery scenarios will be conducted during the workshop.

The instructor will not tell you which failure occurs in each scenario. To complete each task, use the features and techniques learned in this course.

Phase I: Diagnose the Problem

1. The first phase is to research the nature of the problem. Use the EM Database Control Console, data dictionary views, trace and log files, and basic operating system commands to collect information.
2. Determine whether the database instance is available and the database is open.
3. Attempt to start the instance.
4. Shut down the instance if a problem occurs while starting it or when opening the database.
5. Check the Database Alerts region in the Database home page. Also, check the trace files and the alert log file as needed.
6. Check the Job Activity section in the Database home page of the Database Control Console to verify that all application jobs are running without error. Investigate any execution problems.

Method for Resolving Database Issues (continued)

Phase I: Diagnose the Problem (continued)

7. If recovery is needed, determine the appropriate recovery method:
   - Complete recovery
   - Point-in-time recovery
   - Flashback Database or other flashback operations

Phase II: Decide on a Resolution Plan

Because each scenario can have multiple solutions, you should evaluate your options and decide on the best method for resolving the problem. You can use group discussion to formulate your resolution plan.

If your resolution plan involved data recovery, determine what files to restore and what state the instance and database must be in to perform the recovery. Remember that the objective is to minimize down time and loss of data, so do not restore a file or shut down the database unless you must.

Phase III: Resolve the Problem

Implement your solution. For example, if resolving a data failure, restore the appropriate files and initiate your recovery operation.

After completing the task, note any proactive measures that can be taken to prevent that type of problem in the future.

Phase IV: Back Up the Database

Not all recovery operations require a database backup when they are complete. However, determine whether your database needs to be backed up after performing your chosen recovery method, and if so, perform another backup.

Summary

- Instructor-facilitated workshop
- Team-oriented
- Hands-on approach
- Use tools and diagnostics to:
  - Monitor database performance
  - Identify problems and potential problems
- Minimize down time and data loss

Summary

Instructor-Facilitated Workshop

The instructor will facilitate the workshop by providing guidance and additional information as appropriate.

Group-Oriented Emphasis

A strong emphasis is placed on teaming with other students in the workshop for purposes of diagnosing and resolving failures. The ability to complete each scenario successfully is based on the cumulative knowledge and problem resolution skills of each group.

Hands-On Approach

This is meant to be a hands-on workshop, providing you with the maximum allowable time to be involved in a lab situation.

Practice Overview: Workshop Setup

This practice covers the following topics:

- Restoring the database to a previous point in time
- Performing a physical investigation of the database:
  - Using the Enterprise Manager Database Control Console
  - Using views and tools
  - Viewing command output and log files
  - Viewing trace files and the alert log
- Modifying the database configuration to meet business requirements
- Resolving typical database administrative issues

ORACLE

17-10

Practice Overview: Workshop Setup

For the practice exercise, you will restore the backup of the database taken in the first practice exercise of this course. After the database is restored, you will investigate the database, alter its configuration to meet business requirements, and work through various scenarios to simulate typical database administrator tasks.

Physical Investigation

Use the features of Oracle Database 10*g*, such as Enterprise Manager, SQL*Plus, the V$ views and other data dictionary views, to derive information about your database environment. Keep the business requirements in mind and note any deficiencies that you feel will need to be corrected to support these requirements.

Database Configuration

Physically modify the database configuration to ensure that the business requirements can be met.

Database Administration

Work through the scenarios, in any order, to gain experience in resolving typical database administrative tasks and procedures.

Workshop: Database Configuration Checklist

Use Enterprise Manager Database Control to determine and record your database's current settings for the following.

Tablespace and Data File Information

Navigation aid: Administration > Datafiles

Tablespace Name	Data File Name (full path)

Online Redo Log File Information

Navigation aid: Administration > Redo Log Groups

Group #	Redo Log File Name (full path)	Size	Status

Control File Information

Navigation aid: Administration > Control Files

Control File Name (full path)

Workshop: Database Configuration Checklist (continued)

Initialization Parameters

Navigation aid: Administration > All Initialization Parameters

Parameter Name	Value
BACKGROUND_DUMP_DEST	
CORE_DUMP_DEST	
DB_BLOCK_CHECKING	
DB_BLOCK_SIZE	
DB_CACHE_SIZE	
DB_FILES	
DB_NAME	
DB_RECOVERY_FILE_DEST	
DB_RECOVERY_FILE_DEST_SIZE	
LOG_ARCHIVE_DEST_*n*	
LOG_ARCHIVE_DEST_*n*_STATE	
LOG_ARCHIVE_FORMAT	
SGA_MAX_SIZE	
SGA_TARGET	
USE_RECOVER_FILE_DEST	
USER_DUMP_DEST	

E

Oracle Shared Servers

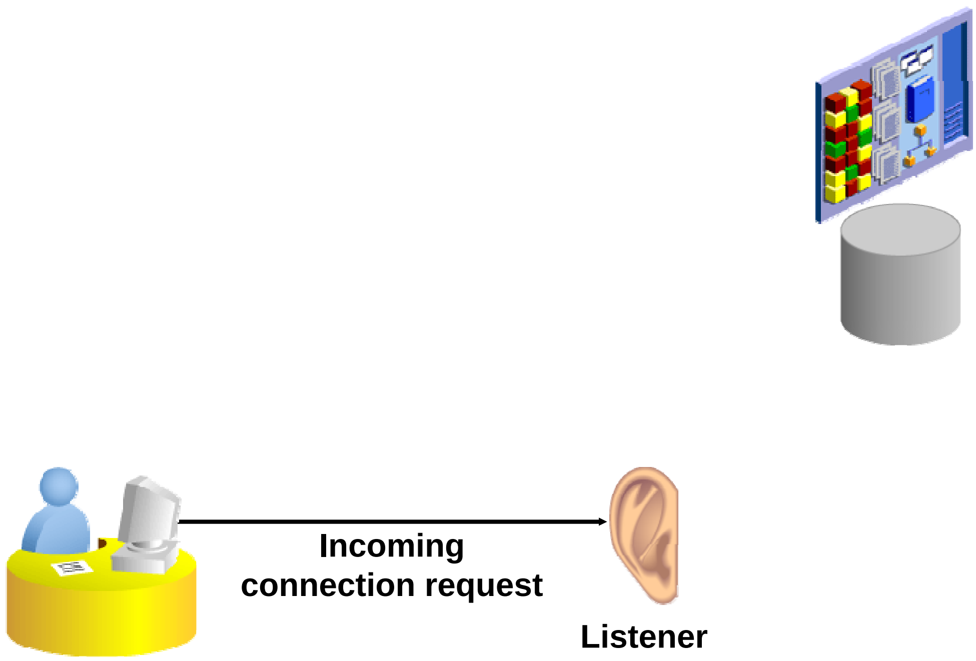
ORACLE

Objectives

After completing this lesson, you should be able to do the following:

- Identify when to use Oracle Shared Servers
- Configure Oracle Shared Servers
- Monitor shared servers

Establishing a Connection

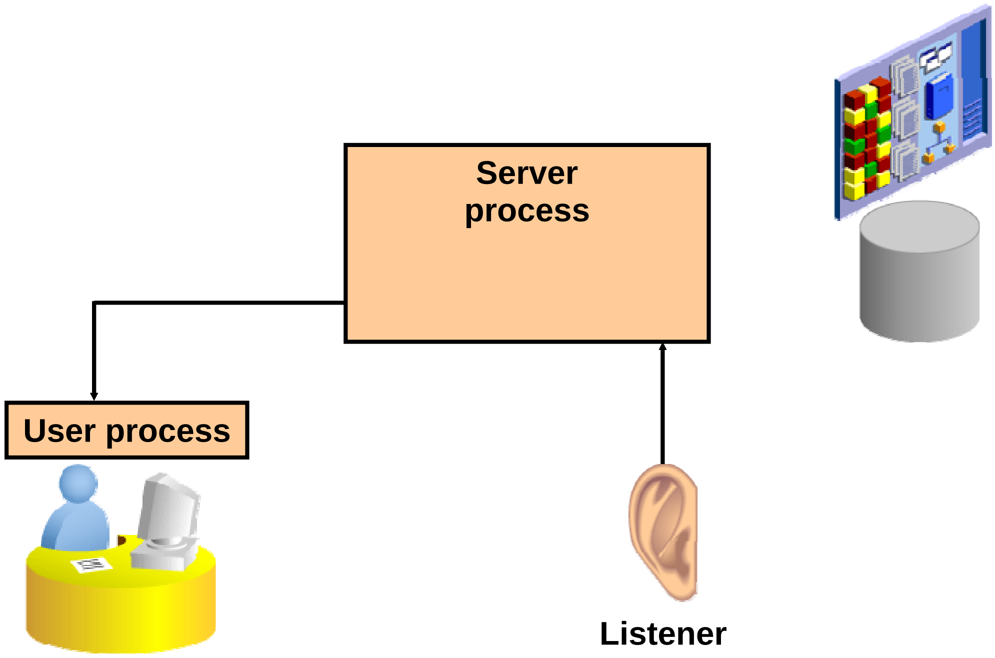


Establishing a Connection

After Oracle Net names resolution is complete, a connection request is passed from the user or middle-tier application (referred to as the user process from here on) to the Oracle Net Listener. The listener receives a `CONNECT` packet and checks to see whether that `CONNECT` packet is requesting a valid Oracle Net service name.

If the service name is not requested (as in the case of a `TNSPING` request), the listener acknowledges the connect request and does nothing else. If an invalid service name is requested, the listener transmits an error code to the user process.

Dedicated Server Process

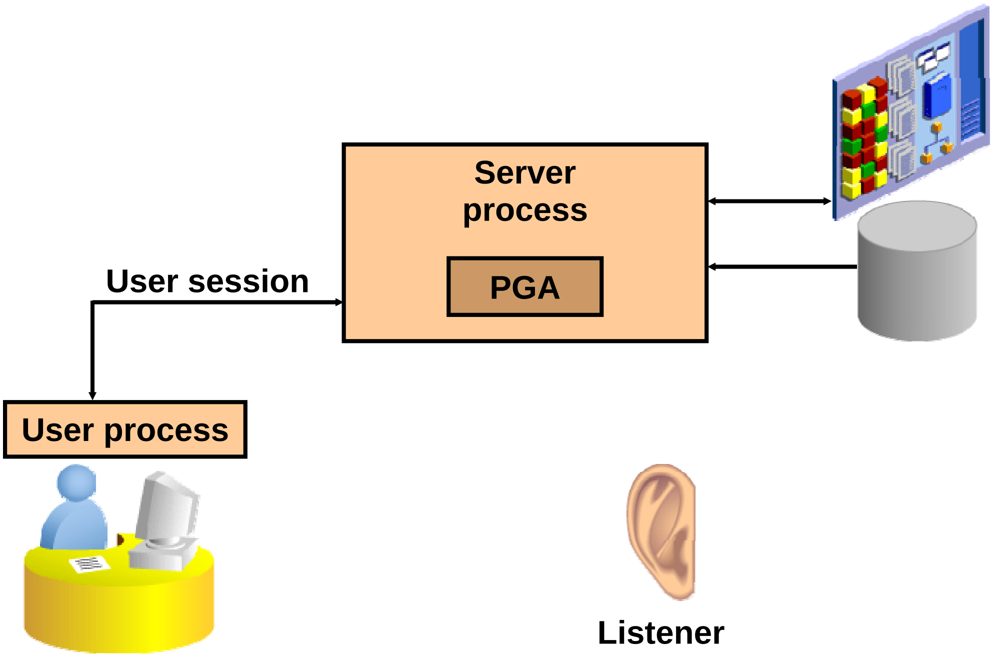


Dedicated Server Process

If the `CONNECT` packet requests a valid service name, the listener spawns a new process to deal with the connection. This new process is known as the "server process" and is sometimes also referred to as the "shadow process." After the process has been spawned, the listener connects to the process and passes it initialization information, including the address information for the user process. At this point, the listener no longer deals with the connection and all work is handed off to the server process.

The server process now transmits a `RESEND` packet back to the user process.

User Sessions



ORACLE

User Sessions

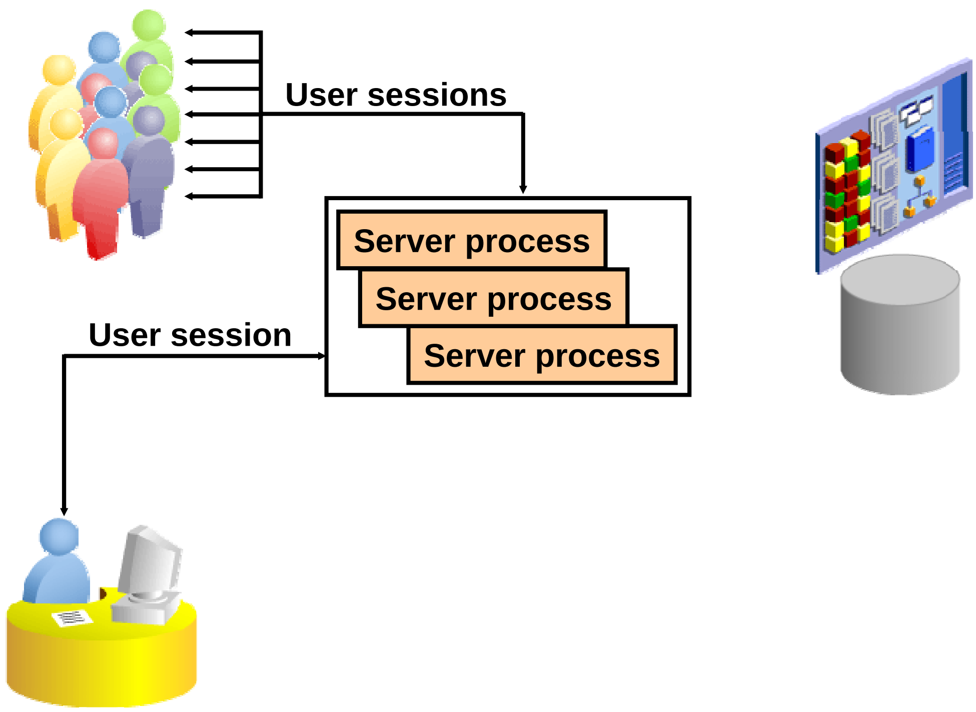
After the user session receives the `RESEND` packet, it retransmits the `CONNECT` packet. The server process checks the user’s authentication credentials (usually a password) and if the credentials are valid, a user session is created.

Dedicated server process: With the session established, the server process now acts as the user’s agent on the server. The server process is responsible for:

- Parsing and running any SQL statements issued through the application
- Checking the database buffer cache for data blocks required to perform SQL statements
- Reading necessary data blocks from data files on disk into the database buffer cache portion of the SGA, if the blocks are not already present in the SGA
- Managing all sort activity. A portion of the server process called the Program Global Area (PGA) contains a memory area known as the Sort Area that is used to work with sorting.
- Returning results to the user process in such a way that the application can process the information

Server processes also reserve memory for specialized work such as bitmap and hash joins. The amount of memory consumed by the dedicated server process depends on several initialization parameter settings. It can be automatically controlled through the use of `PGA_AGGREGATE_TARGET` and `WORKAREA_SIZE_POLICY` or fined-tuned if needed for advanced use.

User Sessions: Dedicated Server



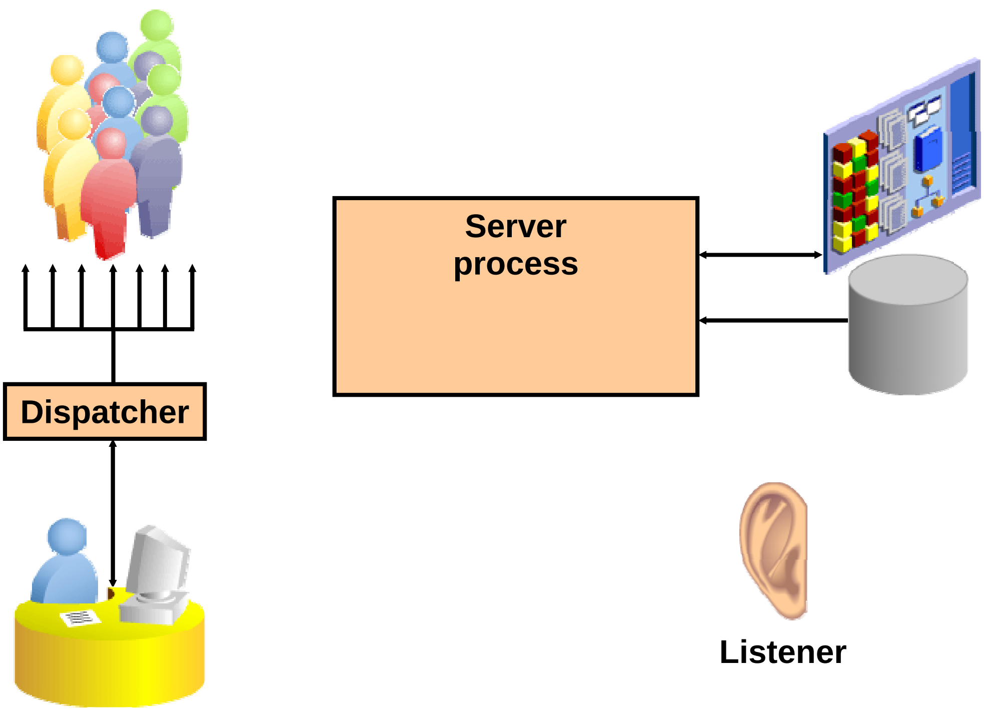
User Sessions: Dedicated Server

With dedicated server processes, there is a one-to-one ratio between server processes and user processes. Each server process consumes system resources including CPU cycles and memory.

In a heavily loaded system, the memory and CPU resources consumed by dedicated server processes can be prohibitive and negatively affect the system's scalability. If your system is being negatively impacted by the resource demands of the dedicated server architecture, you have two options:

- Increase system resources by adding more memory and additional CPU capability.
- Use the Oracle Shared Server architecture.

User Sessions: Shared Server



User Sessions: Shared Server

Each service that participates in the shared server architecture has at least one (and usually more) dispatcher process. When a connection request arrives, the listener does not spawn a dedicated server process. Instead, the listener maintains a list of dispatchers available for each service name, along with the connection load (number of concurrent connections) for each dispatcher.

Connection requests are routed to the lightest loaded dispatcher that is servicing a given service name. Users remain connected to the same dispatcher for the duration of a session.

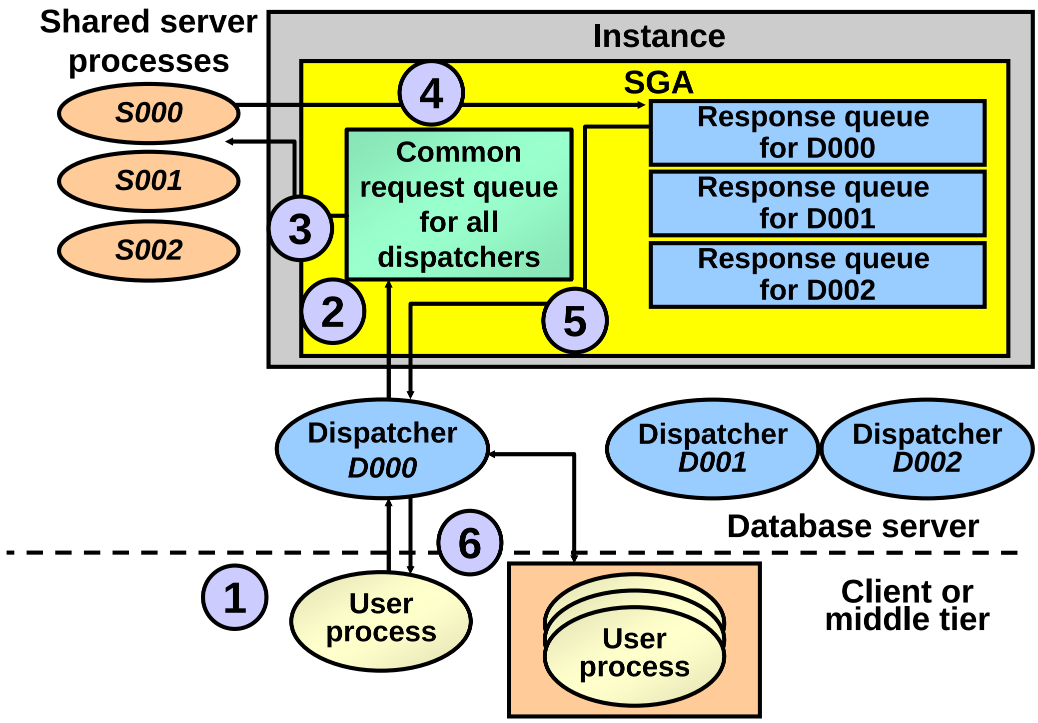
Unlike dedicated server processes, a single dispatcher can manage hundreds of user sessions.

Dispatchers do not actually handle the work of user requests. Instead they pass user requests to a common queue located in the shared pool portion of the SGA.

Shared server processes take over most of the work of dedicated server processes, pulling requests from the queue and processing them until complete.

Because a single user session may have requests processed by multiple shared server processes, most of the memory structures usually stored in the Program Global Area (PGA) must be in a shared memory location. In a shared server architecture, most of these memory areas are stored in the large pool portion of the SGA.

Processing a Request



ORACLE

Processing a Request

When a user connects through the shared server architecture and submits a database request, the following take place:

1. The user process forwards the request to its dispatcher.
2. The dispatcher places the request into the common request queue in the SGA.
3. The next available shared server picks up the request from the request queue and processes the request.
4. The shared server places the response on the calling dispatcher's response queue. Each dispatcher has its own response queue.
5. The dispatcher retrieves the response from its response queue.
6. The dispatcher returns the response to the user.

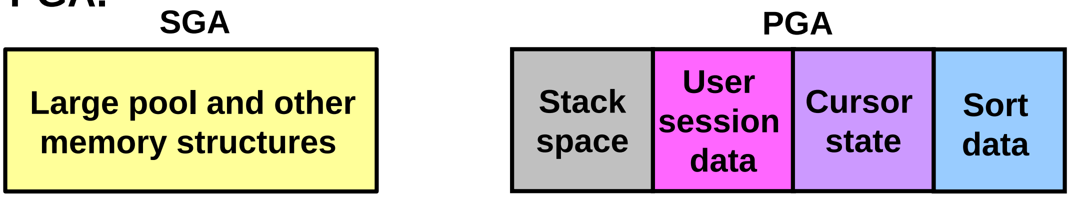
After the user call has been completed, the shared server process is released and is available to service another user call in the request queue.

Request Queue

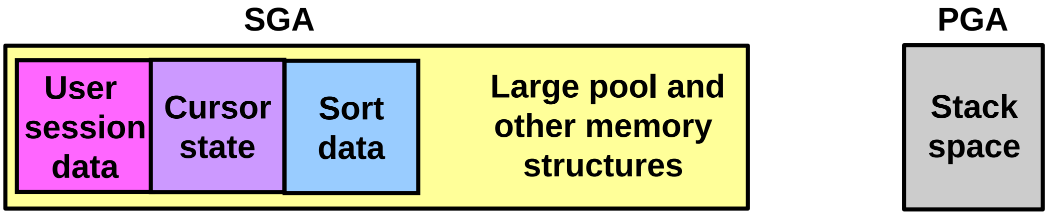
- One request queue is shared by all dispatchers.
- Shared servers monitor the request queue for new requests.
- Requests are processed on a first-in, first-out (FIFO) basis. There is no priority setting.

SGA and PGA

Dedicated server: User session data is kept in the PGA.



Oracle Shared Server: User session data is held in the SGA.



E-9

SGA and PGA

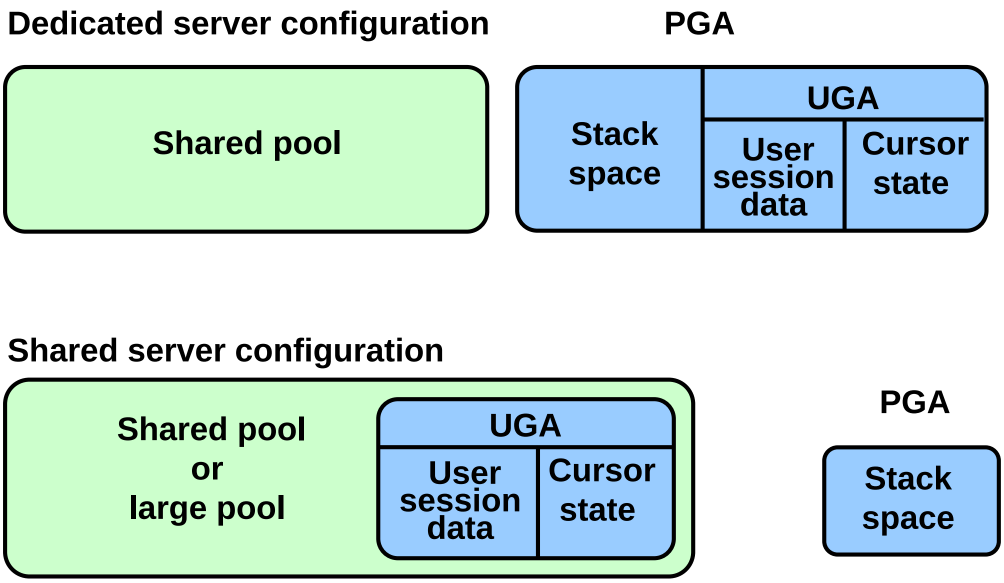
The contents of the SGA and the PGA differ when dedicated servers or shared servers are used:

- Text and parsed forms of all SQL statements are stored in the SGA.
- The cursor state contains run-time memory values for the SQL statement, such as rows retrieved.
- User-session data includes security and resource usage information.
- The stack space contains local variables for the process.

Technical Note

The change in the SGA and the PGA is transparent to the user; however, if you are supporting multiple users, you need to increase the `LARGE_POOL_SIZE` initialization parameter. Each shared server process must access the data spaces of all sessions so that any server can handle requests from any session. Space is allocated in the SGA for each session's data space. You can limit the amount of space that a session can allocate by setting the `PRIVATE_SGA` resource limit in the Database Services region of the General page of the user's profile.

UGA and Oracle Shared Server



ORACLE

E-10

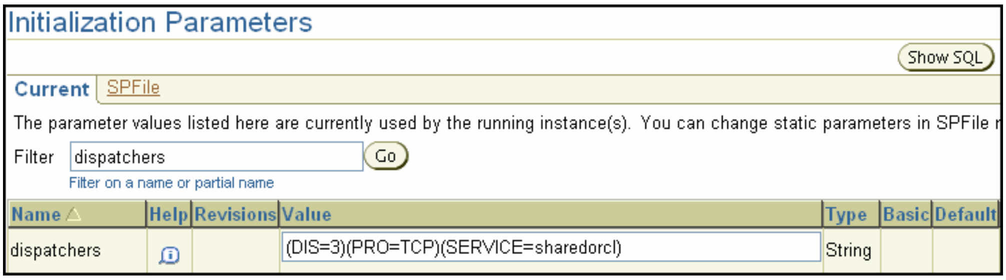
UGA and Oracle Shared Server

When you use a dedicated server configuration, the User Global Area (UGA) does not use any memory within the SGA. If you use Oracle Shared Server, then the UGA (which includes the user session and cursor state information) is stored in the shared pool instead of in private user memory. If a large pool has not been configured, then the UGA is stored in the shared pool. Sort areas and private SQL areas are included in the session information. This is because shared servers work on a per-call basis, so any server process may need access to any user's information.

The total memory requirement for Oracle Shared Server is no larger than if you use dedicated servers. You may need to increase the `SHARED_POOL_SIZE` parameter but your private user memory is lower.

If you are using shared servers, configure the large pool for better shared pool performance.

Configuring Oracle Shared Server



Required parameter
- **DISPATCHERS**

Optional parameters
- **SHARED_SERVERS**
- **MAX_SHARED_SERVERS**
- **CIRCUITS**
- **SHARED_SERVER_SESSIONS**

Configuring Oracle Shared Server

To configure Oracle Shared Server, you must edit the initialization parameters for your instance. Most of the optional parameters have sensible defaults. On many systems, the only parameter that must be configured is `DISPATCHERS`.

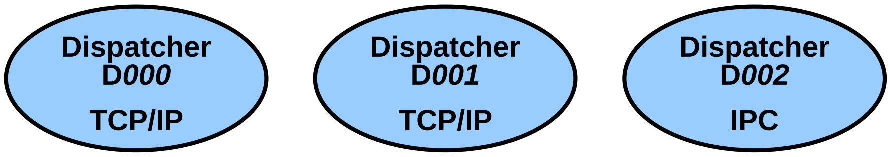
Depending on the options selected when you created your database, the `DISPATCHERS` parameter may already be configured to start one dispatcher to service the XML database. The `DISPATCHERS` parameter accepts multiple sets of values in the format:

```
'<parameters for first set>','<parameters for second set>'
```

DISPATCHERS

Specifies the number of dispatchers that are initially started for a given protocol:

```
DISPATCHERS = "(PROTOCOL=TCP)(DISPATCHERS=2)\
               (PROTOCOL=IPC)(DISPATCHERS=1)"
```



E-12

DISPATCHERS

The `DISPATCHERS` parameter enables various attributes for each dispatcher.

Oracle Database10*g* supports a name-value syntax (similar to the syntax used by Oracle Net Services) to enable the specification of existing and additional attributes in a position-independent, non-case-sensitive manner.

For example: `DISPATCHERS = '(PROTOCOL=TCP)(DISPATCHERS=3)'`

Parameter type	String (specify as a quoted string)
Parameter class:	Dynamic
Default value:	Null (no dispatchers will be started)

Although the number of connections a dispatcher can handle varies greatly depending on the type of workload, a good measure to use is to allow one dispatcher per every fifty concurrent database connections that use the shared server architecture.

DISPATCHERS (continued)

The only required dispatcher attribute is PROTCOL. All others are optional. A few of the possible arguments for the DISPATCHERS parameter are described below. Notice that arguments use a three-letter abbreviation instead of the full argument name.

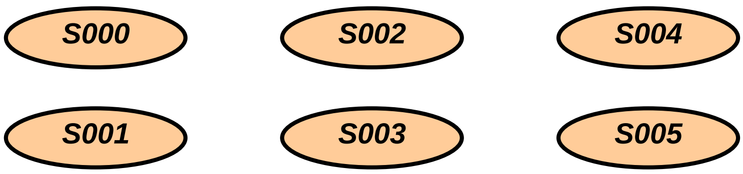
Attribute	Description
PROTOCOL (PRO or PROT)	Specifies the network protocol for which the dispatcher generates a listening endpoint (usually TCP)
DISPATCHERS (DIS or DISP)	The initial number of dispatchers to start (default is 1)
SERVICE (SER or SERV)	The Oracle Net Service name the dispatcher registers with the listener. If not given, the dispatcher registers the values in SERVICE_NAMES.
LISTENER (LIS or LIST)	Specifies an alias name for the listeners with which the PMON process registers dispatcher information. Set the alias to a name which is resolved through a naming method. This attribute need be specified only if the listener is a local listener that uses a nondefault port (not 1521) and is not specified with the LOCAL_LISTENER parameter *or* the listener is on another node.
SESSIONS (SES or SESS)	The maximum number of network sessions for each dispatcher. The default is operating system specific. Most operating systems have a default of 16 K.
CONNECTIONS (CON or CONN)	Specifies the maximum number of network connections to allow for each dispatcher. The default is operating system specific. For example, 1024 is the default for Sun Solaris and Windows.

Note: There are many more possible attributes for the DISPATCHERS parameter. Further details on the DISPATCHERS parameter can be found in the "Initialization Parameters" section in the *Oracle Database Reference Manual*.

SHARED_SERVERS

Specifies the number of shared server processes created when an instance is started up, and retained during instance operation

```
SHARED_SERVERS = 6
```



SHARED_SERVERS

`SHARED_SERVERS` specifies the minimum number of server processes that will be retained. Setting this parameter is not usually critical because the instance monitors the Common Request Queue and will start additional shared servers as needed to serve the queue, and then dispose of them when no longer needed.

Parameter type	Integer
Parameter class	Dynamic
Default value	0 if `DISPATCHERS` is NULL, 1 if `DISPATCHERS` is set
Range of values	Operating system dependent

A good measure to use is to retain one shared server for every twenty-five concurrent database connections using the shared server architecture.

MAX_SHARED_SERVERS

- Specifies the maximum number of shared servers that can be started
- Allows shared servers to be allocated dynamically on the basis of the length of the request queue

```
MAX_SHARED_SERVERS = 10
```

MAX_SHARED_SERVERS

`MAX_SHARED_SERVERS` specifies the maximum number of shared server processes that will be allowed to run simultaneously. The setting is important because the instance automatically creates additional shared server processes as needed to service the common request queue.

Parameter type	Integer
Parameter class	Dynamic
Default value	None (unlimited)
Range of values	Operating system dependent

Estimating the Maximum Number of Shared Servers

In general, set this parameter for an appropriate number of shared server processes at times of highest activity. Experiment with this limit, and monitor shared servers to determine an ideal setting for this parameter. To find the maximum numbers of servers started (high-water mark), query the `V$SHARED_SERVER_MONITOR` data dictionary view.

CIRCUITS

- Specifies the total number of virtual circuits that are available for inbound and outbound network sessions
- Contributes to total SGA size

```
CIRCUITS = 100
```

E-16

CIRCUITS

Virtual circuits are user connections to the database through dispatchers and servers. The `CIRCUITS` parameter specifies the total number of virtual circuits that are available for inbound and outbound network sessions.

Parameter type	Integer
Parameter class	Dynamic
Default value	If Oracle Shared Server is configured, then the value of `CIRCUITS` matches that of `SESSIONS`. Otherwise, the value is 0.

Set this parameter only if you want to limit the total number of connections that users can make via the shared server architecture. This parameter is of interest because it is one of several parameters that contribute to the total SGA requirements of an instance.

SHARED_SERVER_SESSIONS

- Specifies the total number of Oracle Shared Server user sessions to allow
- Enables you to reserve user sessions for dedicated servers

```
SHARED_SERVER_SESSIONS = 100
```

E-17

SHARED_SERVER_SESSIONS

This parameter controls the total number of shared server sessions open concurrently at any point in time. The use of this parameter allows resources for dedicated user sessions to be reserved.

Parameter type	Integer
Parameter class	Dynamic
Default value	None (unlimited)

Related Parameters

Other initialization parameters affected by Oracle Shared Server that may require adjustment:

- **LARGE_POOL_SIZE**
- **SESSIONS**
- **PROCESSES**
- **LOCAL_LISTENER**

E-18

Related Parameters

Other parameters affected by Oracle Shared Server that may require adjustment:

- LARGE_POOL_SIZE specifies the size in bytes of the large pool. Oracle Shared Server uses the large pool to store session information that usually resides in the PGA in a dedicate server session.
- SESSIONS specifies the maximum number of sessions that can be created in the system. This may need to be adjusted for Oracle Shared Server because your system can now service more sessions.
- PROCESSES controls the number of server-side processes.
- LOCAL_LISTENER defines the port and protocol used by the listeners. If your listener is not using TCP/IP on port 1521, or if you have multiple listeners, you must configure LOCAL_LISTENER so the dispatchers can register with the listeners.

If you do not set a value for LARGE_POOL_SIZE, then the Oracle database uses the shared pool for Oracle Shared Server user session memory. This can negatively impact the performance of PL/SQL, SQL, and other services that rely on the shared pool.

The Oracle database allocates some fixed amount of memory (about 10 KB) per configured session from the shared pool, even if you have configured the large pool.

Verifying Shared Server Setup

- Verify that the dispatcher has registered with the listener when the database is started by issuing:

```
$ lsnrctl SERVICES
```

- Verify that you are connected using shared servers by making a connection and then query the **V$CIRCUIT** view to show one entry per shared server connection.

Verifying Shared Server Setup

When using Oracle Shared Server, you should first start the listener and then the database so that the dispatchers can immediately register with the listener. If you later restart the listener, allow one minute for services to reregister. To verify that registration has taken place, issue the following command:

```
$ lsnrctl services
Service "TEST" has 1 instance(s).
Instance "TEST", status READY, has 3 handler(s) for this service.
 Handler(s):
"DISPATCHER" established:1 refused:0 curr:0 max:1022 state:ready
   D001 <machine: db.us.oracle.com, pid: 8705>
   (ADDRESS=(PROTOCOL=tcp)(HOST=db.us.oracle.com)(PORT=35230))
"DISPATCHER" established:1 refused:0 curr:0 max:1022 state:ready
   D000 <machine: db.us.oracle.com, pid: 8703>
   (ADDRESS=(PROTOCOL=tcp)(HOST=db.us.oracle.com)(PORT=35229))
"DEDICATED" established:0 refused:0
```

Verifying Shared Server Setup (continued)

Verify that your connections are using shared servers by making connections, and then query the `V$CIRCUIT` view to show one entry per shared server connection. This also verifies that the listener is performing load-balancing for incoming connections.

```
SQL>select dispatcher, circuit, server, status from v$circuit;

DISPATCH CIRCUIT  SERVER   STATUS
-------- -------- -------- ----------------
82890064 8257BA64 8288F6A4 NORMAL
8288F9E4 8257BBB0 00       NORMAL
8288FD24 8257BCFC 00       NORMAL
```

Data Dictionary Views

- V$CIRCUIT
- V$SHARED_SERVER
- V$DISPATCHER
- V$SHARED_SERVER_MONITOR
- V$QUEUE
- V$SESSION

ORACLE

Data Dictionary Views

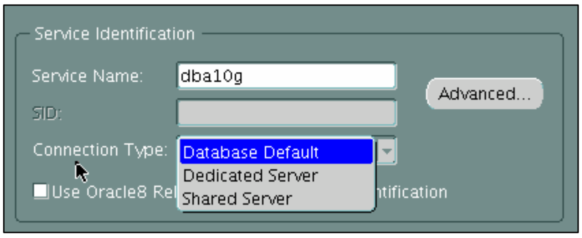
V$CIRCUIT	This view contains information about virtual circuits, which are user connections to the database through dispatchers and servers. Any shared server connection creates an entry in V$CIRCUIT.
V$SHARED_SERVER	This view contains information about the shared server processes.
V$DISPATCHER	This view provides information about the dispatcher processes.
V$SHARED_SERVER_MONITOR	This view contains information for tuning the shared server processes.
V$QUEUE	This view contains information about request and response queues.
V$SESSION	This view lists session information for each current session.

Choosing a Connection Type

Unless otherwise configured, Oracle Net connections use:

- **Shared server if one is available**
- **Dedicated server if a shared server connection is not available**

Using local or directory naming, the connection type can be specified as part of the Net service alias.



Choosing a Connection Type

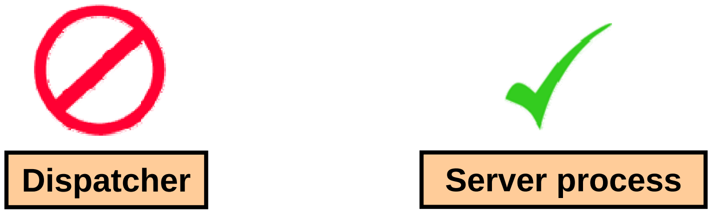
Oracle Net's default connection type is the shared server connection. If the instance has been configured for a shared server and a connect request does not specifically ask for a dedicated server, then the connection type is shared.

The Oracle Net Manager allows the connection type to be specified for both local naming and directory naming. Select the desired `Connection Type` from the drop-down list.

When Not to Use Shared Server

Certain types of database work should not be performed using shared servers:

- Database administration
- Backup and recovery operations
- Batch processing and bulk load operations
- Data warehouse operations



When Not to Use Shared Server

The Oracle Shared Server architecture is an efficient process and memory use model, but is not appropriate for all connections. Because of the common request queue, and the fact that many users may share a dispatcher response queue, shared servers do not perform well with operations that must deal with large sets of data such as warehouse queries or batch processing.

Backup and recovery sessions using Oracle Recovery Manager (discussed in later chapters) also deal with very large data sets and should make use of dedicated connections.

Many administration tasks cannot or should not be performed using shared server connections. These include startup and shutdown of the instance, creating tablespaces or data files, index and table maintenance, analyzing statistics, and many other tasks commonly performed by the DBA. All DBA sessions should choose dedicated servers.

Summary

In this lesson, you should have learned how to:
- Identify when to use Oracle Shared Servers
- Configure Oracle Shared Servers
- Monitor shared servers

F

Oracle Secure Backup

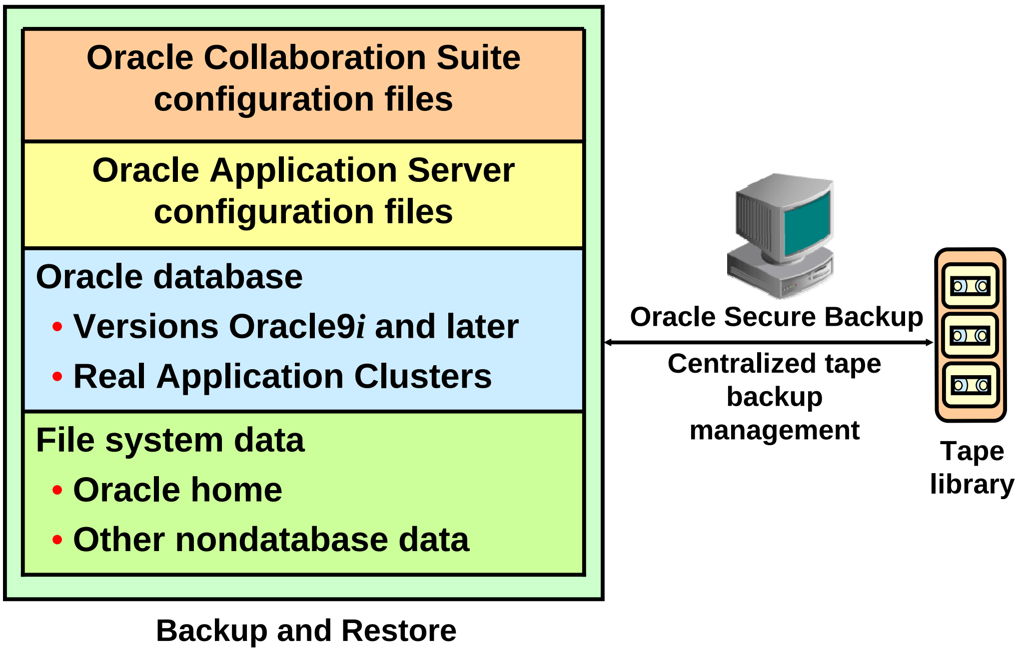
Objectives

After completing this lesson, you should be able to do the following:

- Describe the Oracle Secure Backup architecture and how it benefits your environment
- Discuss the basic Oracle Secure Backup media management concepts
- Install and configure Oracle Secure Backup
- Use RMAN and Oracle Secure Backup to back up and restore the Oracle database
- Use Oracle Secure Backup to back up and restore file system files

F-2

Data Protection to Tape for the Oracle Stack



F-3

Data Protection to Tape for the Oracle Stack

Some of the options available for protecting your Oracle data are: backing up solely to disk, backing up to disk as a staging area for tape backups, or backing up directly to tape. Disk backup and restore operations are generally faster than those of tape. However, tape backups provide some advantages for long-term backup requirements, off-site storage, and portability to move backups from one data center to another.

Oracle Secure Backup provides tape backup management for the Oracle ecosystem, which includes:

- Oracle database protection to tape through integration with Recovery Manager
- Seamless support of Oracle Real Application Clusters (RAC)
- Central administration of distributed clients and media servers including:
  - Oracle Application Servers
  - Oracle Collaboration Suites
  - Oracle home and binaries

The Customer Advantage: Complete Oracle Solution

- Oracle Secure Backup and RMAN provide an end-to-end backup solution for Oracle environments
  - Centralized backup management to tape for file system data and the Oracle database
  - Most well-integrated media management layer for RMAN backups
  - Backup of any data anywhere on the network
- A single technical support resource for the entire backup solution expedites problem resolution.
- This ensures reliable data protection at a lower cost and complexity.

ORACLE

F-4

The Customer Advantage: Complete Oracle Solution

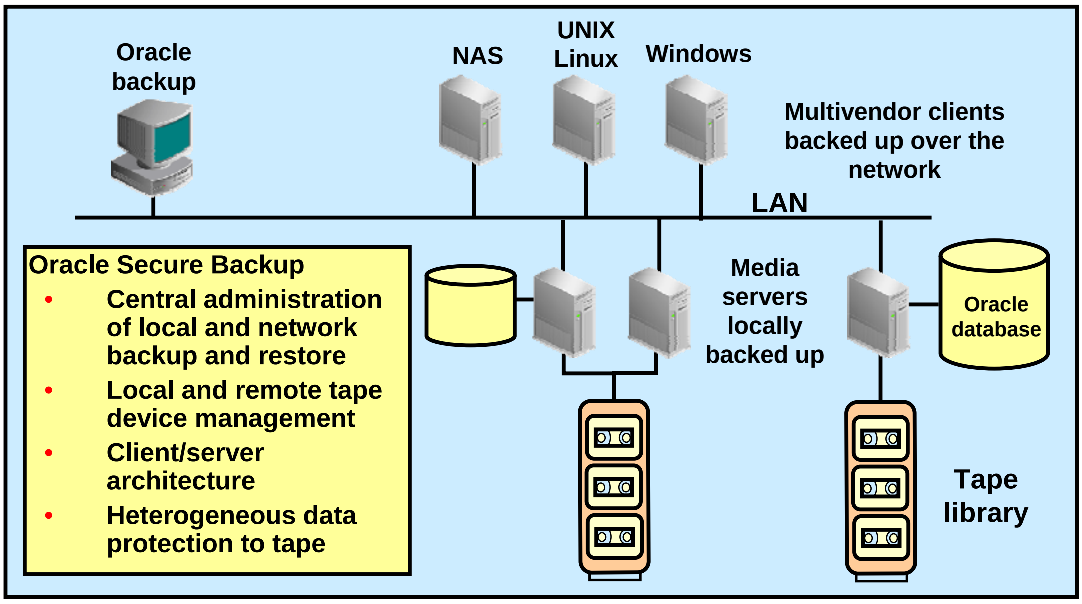
Oracle's current backup and recovery product for the database is Recovery Manager (RMAN), a utility that has been part of the Oracle server since Oracle 8.0. Oracle Secure Backup complements the existing functionality in the following ways:

- **Complete backup solution:** Oracle Secure Backup provides data protection for the database and nondatabase data to protect the whole Oracle environment.
- **Media management:** Oracle Secure Backup provides the media management layer for RMAN database backups to tape. Before Oracle Secure Backup, customers had to purchase expensive third-party media management products offering integration with RMAN tape backups.
- **Anywhere on the network:** Oracle Secure Backup backs up data from multiple network-attached computer systems to tertiary storage resources on the network. Oracle Secure Backup supports diverse configurations of servers, clients, Network Attached Storage (NAS) servers, and tertiary storage devices and protects network storage environments.

The combination of RMAN and Oracle Secure Backup provides an end-to-end backup solution, entirely within the Oracle product stack. This allows for better customer support because Oracle Corporation is responsible for the entire backup solution.

Oracle Corporation provides customers with the highest levels of data protection at the lowest possible cost.

Oracle Secure Backup for Centralized Tape Backup Management



F-5

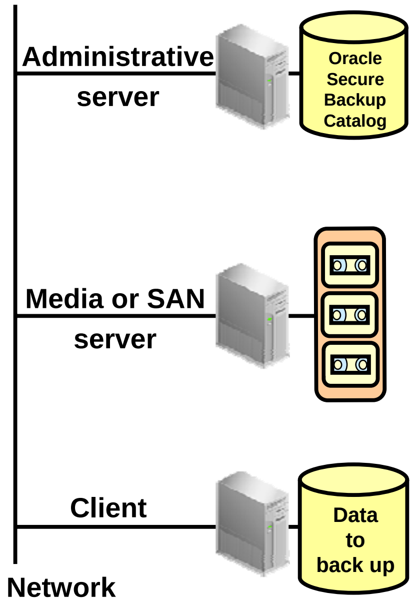
Oracle Secure Backup for Centralized Tape Backup Management

The Oracle Secure Backup software offers centralized backup management of heterogeneous clients and servers through a single point of administration called the Oracle Secure Backup Administrative Server. Through a central console that uses a consolidated backup catalog, you can easily manage backup policies, schedule backups for multiple platforms, and manage local and remote tape devices. The configured machines and devices managed by an administrative server make up the Oracle Secure Backup Administrative Domain as shown in the slide.

The Oracle Secure Backup tape management system minimizes the complexity of managing diverse architectures and provides:

- Unified heterogeneous data protection for multiple platforms including UNIX (HP-UX, Tru64, AIX, and Solaris), Linux (Red Hat, SuSE), Windows (2000, XP, 2003), and NAS servers
- Flexible tape device configuration with options for single and multihosted libraries or Storage Area Networks (SANs) offering dynamic drive sharing for optimal resource utilization
- Support for major tape libraries and drives in SAN, GbE, and SCSI environments
- Client or server architecture providing centralized administration of distributed media servers over a local area network (LAN) or wide area network (WAN)

Oracle Secure Backup Administrative Domain



- **Administrative server:**
  - **Maintains Oracle Secure Backup catalog files containing configuration settings and backup history**
  - **Has standard access mode only**
- **Media or SAN server:**
  - **Transfers data to or from attached devices**
  - **Has standard or NDMP access modes**
- **Client:**
  - **Is a server backed up by Oracle Secure Backup**
  - **Has standard or NDMP access modes**

F-6

Oracle Secure Backup Administrative Domain

An administrative domain has one administrative server, one or more clients, and one or more media servers.

- An *administrative server* is a machine in your administrative domain that contains a copy of the Oracle Secure Backup software and the catalog files that contain configuration settings and store backup history. The administrative server runs the Scheduler, which starts and monitors jobs within the administrative domain.
- A *media server* or SAN server is a machine that has one or more secondary storage devices, such as a tape library, connected to it. A media server transfers data to or from attached devices.
- A *client* is a machine whose locally accessed data is backed up by Oracle Secure Backup.

Each configured machine is characterized by the following access modes:

- **Standard:** A standard, configured machine runs the Oracle Secure Backup daemons that manage the client or server from a backup and restore perspective.
- **NDMP:** A Network Data Management Protocol (NDMP) host is a storage appliance from a third-party vendor such as Network Appliance, Mirapoint, or DinoStor. An NDMP host employs NDMP daemons to back up and restore file systems.

Note: Any machine in your network can serve in any of these roles or in any combination of these roles.

Oracle Secure Backup: Backup Management Overview

- Centralized management of the administrative domain
  - Consolidated catalog
  - Users and privileges
- Ease of administration with multiple interface options, backup policies, and much more
- Backing up and restoring data
  - File system and Oracle database
  - Management through policies
- Media management (tapes)
- Automated tape device management
- Flexible configuration options

ORACLE

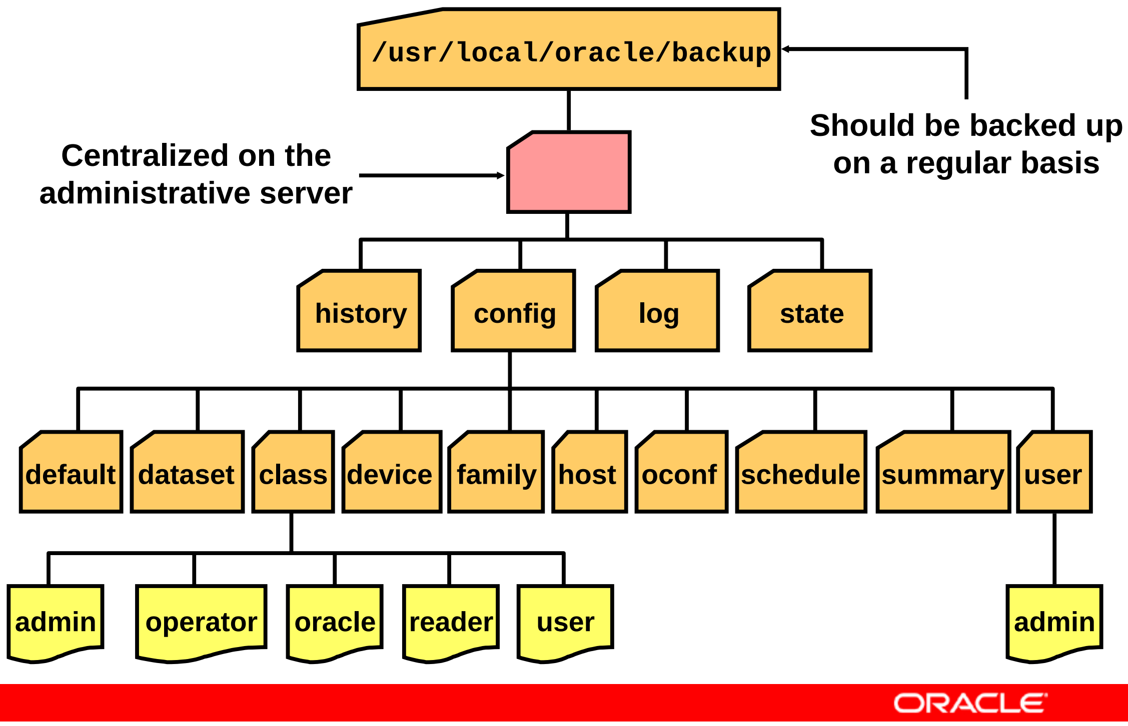
F-7

Oracle Secure Backup: Backup Management Overview

Oracle Secure Backup provides data protection to tape for the Oracle database and file system data. Addressing the needs of DBAs and system administrators, Oracle Secure Backup delivers reliability, scalability, and ease of use ideally suited for workgroups and Oracle ecosystems.

- Typical IT environments are heterogeneous and need the same level of protection to tape. Oracle Secure Backup minimizes the complexity of managing those diverse architectures from a central administrative server.
- Providing maximum flexibility and ease of use, Oracle Secure Backup is integrated with Oracle Enterprise Manager (EM) for database backups and most administrative tasks. File system backups are effectively managed using an intuitive Web tool or a uniform command interface, or both.
- Security to control unauthorized access to backups is key in protecting the data. Oracle Secure Backup provides password protection and user classes to govern backup and recovery operation permissions. Oracle Secure Backup is hardened against buffer overflow attacks.
- Tightly integrated with RMAN, Oracle Secure Backup provides performant database backup and recovery through familiar Oracle Enterprise Manager or RMAN interfaces, or both.
- With configurable management policies and flexible device configuration and scheduling options, Oracle Secure Backup delivers a cohesive data protection tape management tool.

Oracle Secure Backup Catalog



F-8

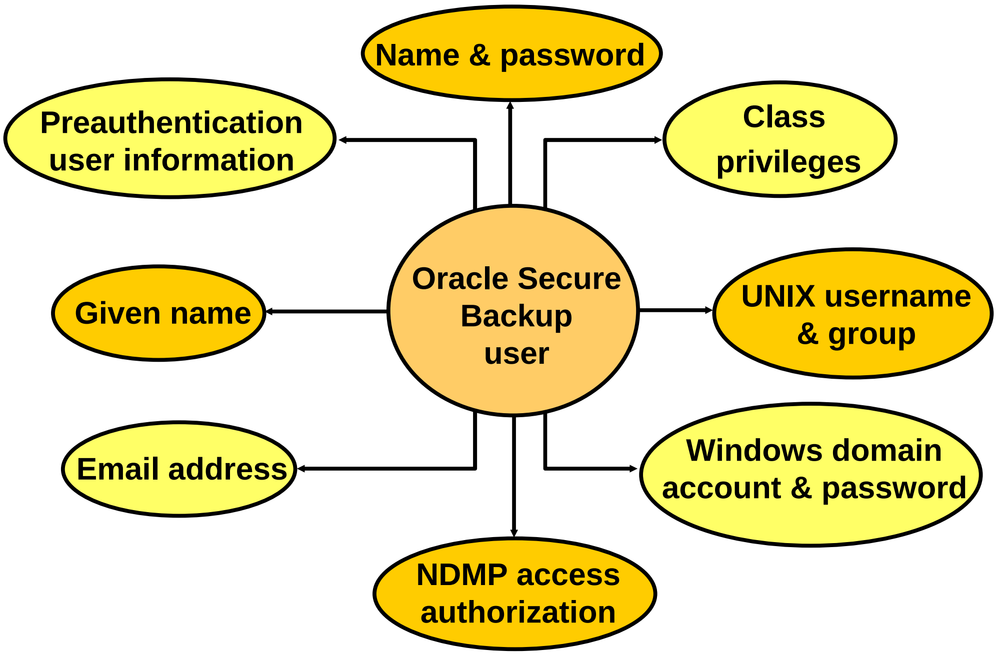
Oracle Secure Backup Catalog

Oracle Secure Backup maintains its own centralized catalog on the administrative server. The Oracle Secure Backup catalog contains all the information used to define your configuration. It also includes metadata relating to your backup and restore operations. The slide shows you the tree structure of directories installed by Oracle Secure Backup on an administrative server. Oracle Secure Backup organizes its catalog in a hierarchical manner. The `admin` directory contains the administrative domain catalogs. As shown in the slide, the `config` directory contains many subdirectories representing objects that Oracle Secure Backup maintains. In each of these directories, Oracle Secure Backup maintains files containing the characteristics of the corresponding objects.

As shown in the slide, it is recommended to back up the Oracle Secure Backup installation tree on your administrative server on a regular basis. That way, your Oracle Secure Backup data will not be lost in case your administrative server fails.

Note: For formatting reasons, the slide does not represent the complete set of directories used by Oracle Secure Backup. The administrative server also contains a set of executables. For more information about the entire tree structure, refer to the *Oracle Secure Backup Installation* guide. Also, the default Windows installation directory is `C:\Program Files\Oracle\Backup`, and the directory structure under the installation directory is the same for both Windows and UNIX systems.

Oracle Secure Backup Users



F-9

Oracle Secure Backup Users

Oracle Secure Backup manages its own catalog of users and their corresponding rights to maintain a consistent user identity across the various hosts (UNIX, Linux, and Windows) of your administrative domain. Although you can assign usernames and passwords that are identical to those of existing OS users, the namespace for Oracle Secure Backup users is distinct from the namespaces of existing OS users. The following is a description of the parameters that must be specified when creating Oracle Secure Backup users:

- The name of the Oracle Secure Backup user as well as its password
- The Oracle Secure Backup class associated to this user
- A UNIX or Windows username and the corresponding information. This username is used by Oracle Secure Backup's unprivileged operations to access file system data on your clients. An unprivileged operation is constrained by the rights of the UNIX user or Windows account having that identity.
- Whether the Oracle Secure Backup user is permitted to log in to an NDMP server. This login is done using an external client program.
- An e-mail address used to send Oracle Secure Backup operation notifications and reports

Oracle Secure Backup Users (continued)

- A given name. This is more like a comment.
- The possibility to specify preauthorized user information. This allows the use of Oracle Secure Backup without going through the normal Oracle Secure Backup login requirements.

Note: Configuring users is best accomplished using the Web tool or command-line interface.

Predefined Classes

Rights	ADMIN	OPERATOR	USER	ORACLE	READER
Browse backup catalogs with this access	privileged	not denied	permitted	permitted	named
Display administrative domain's configuration	✓	✓	✓	✓	
Modify own username and password	✓	✓	✓	✓	✓
Modify administrative domain’s configuration	✓				
Perform backups as self	✓	✓		✓	
Perform backups as privileged user	✓	✓			
List any jobs, owned by user	✓	✓	✓	✓	
Modify any jobs, owned by user	✓	✓	✓	✓	
Perform restores as self	✓	✓	✓	✓	
Perform restores as privileged user	✓	✓			
Receive e-mail requesting operator assistance	✓	✓		✓	
Receive e-mail describing internal errors	✓	✓		✓	
Query and display information about devices	✓	✓	✓	✓	
Manage devices and change device state	✓	✓		✓	
List any job, regardless of its owner	✓	✓			
Modify any job, regardless of its owner	✓	✓			
Access Oracle Secure Backups (database)	all	owner	owner	owner	none
User can perform Oracle database backups and restores	✓			✓	

ORACLE

F-11

Predefined Classes

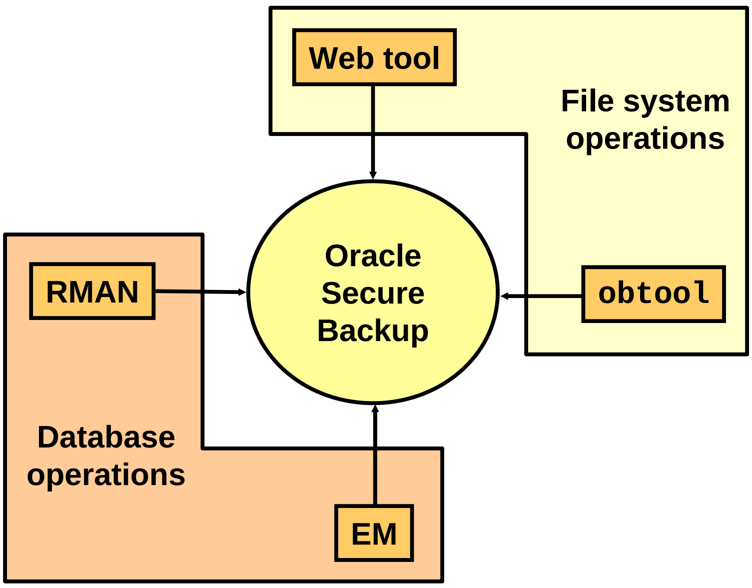
A class defines a set of rights or access privileges. A class may be assigned to multiple users but each user is a member of exactly one class. The following classes are key to understanding user access privileges in Oracle Secure Backup:

- **Admin:** Class used for overall administration of a domain. The admin class has all the rights and privileges needed to modify domain configurations and perform backup and restore operations.
- **Operator:** Class used for standard, day-to-day operations. The operator class lacks configuration privileges but has all the rights needed for backup and restore operations as well as device management browsing capabilities.
- **User:** Class assigned to specific users giving them permission to interact in a limited way with their domains. This class is reserved for users who need to browse their own data within an index and perform user-based restores.
- **Oracle:** Similar to the operator class with specific privileges to modify Oracle database configuration settings as well as to perform Oracle database backups
- **Reader:** Class assigned that enables users to view index information. Readers are permitted to perform no operation other than modifying their usernames and passwords.

Configuring classes is best accomplished using the Web tool or command-line interface.

Note: For more information about individual rights, refer to the *Oracle Secure Backup Administrator’s Guide*.

Oracle Secure Backup Interface Options



Oracle Secure Backup Interface Options

As shown in the slide, you can access Oracle Secure Backup in four different ways depending on what you want to do.

- Management operations for administering the domain, such as adding or managing devices, is best accomplished using Enterprise Manager. The Oracle Secure Backup Web tool or command line is also available for administrative management tasks, including adding clients and configuring users and classes.
- Oracle database backup and restore operations are managed using the Oracle Enterprise Manager or RMAN interface.
- File system backup and restore operation are managed using the Oracle Secure Backup Web tool or the command-line interface.

Note: In terms of backup and recovery operations, the difference between the Oracle Secure Backup Web interface and `obtool` is the same as the difference between the EM interface and RMAN.

Managing Data to Be Protected

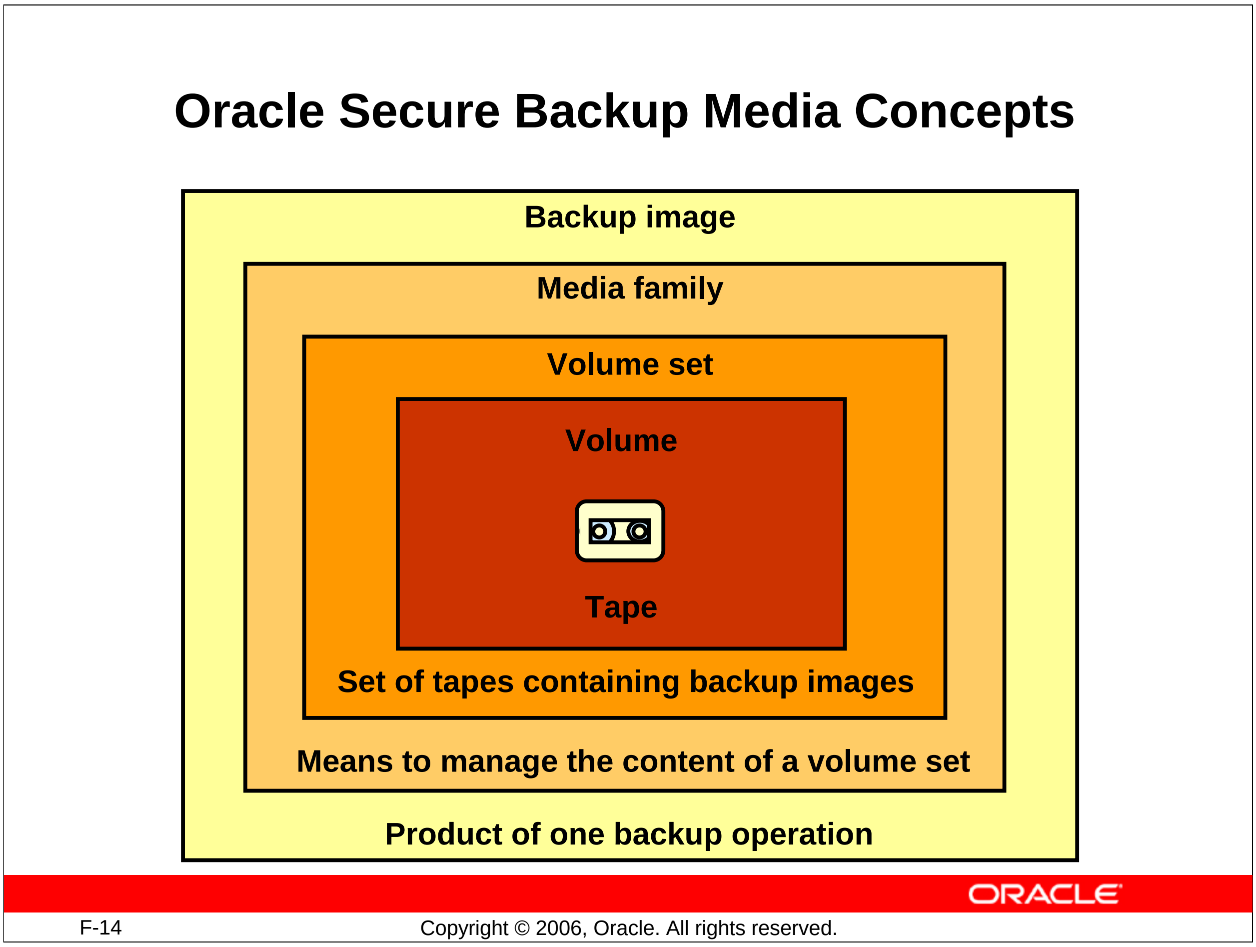
	Oracle Database	File System Data
Defining what data to back up	RMAN backup sets	Oracle Secure Backup data sets: User defined
Backup options	Use RMAN backup levels: Full and incremental	Multilevel backups: Full, incremental, or off-site
Frequency of backups	Intuitive Enterprise Manager scheduling interface	Flexible date/time calendar–based scheduling On-demand backups

Managing Data to Be Protected

Managing the backup infrastructure of file system data and Oracle database data is easily administered with Oracle Secure Backup and RMAN. Defining what data to back up is conceptually similar for file system and database data. Both require that you, the user, define what to include in the backup. For the database, you use the RMAN backups sets created using RMAN or Enterprise Manager. For file systems, Oracle Secure Backup uses data sets. Defining file system data sets is easily accomplished using the Oracle Secure Backup Web tool.

After defining what data to back up, you must determine what type of backups are most appropriate to meet your backup and restore requirements. Oracle Secure Backup offers multiple backup levels for file system backups including full backup levels, multiple incremental levels, and an off-site backup level. The off-site level is actually a full backup performed without interfering with any incremental backup strategies. Oracle Secure Backup also provides flexible scheduling options enabling you to determine ongoing backup schedules based on the day and time granularity. For the Oracle database, RMAN offers full and incremental backup levels that are backed up to tape by Oracle Secure Backup.

After you have defined what to back up, how to back it up, and how often to back up the data through scheduling, Oracle Secure Backup can automatically implement your backup schedules only requiring manual intervention for hardware errors or media needs.



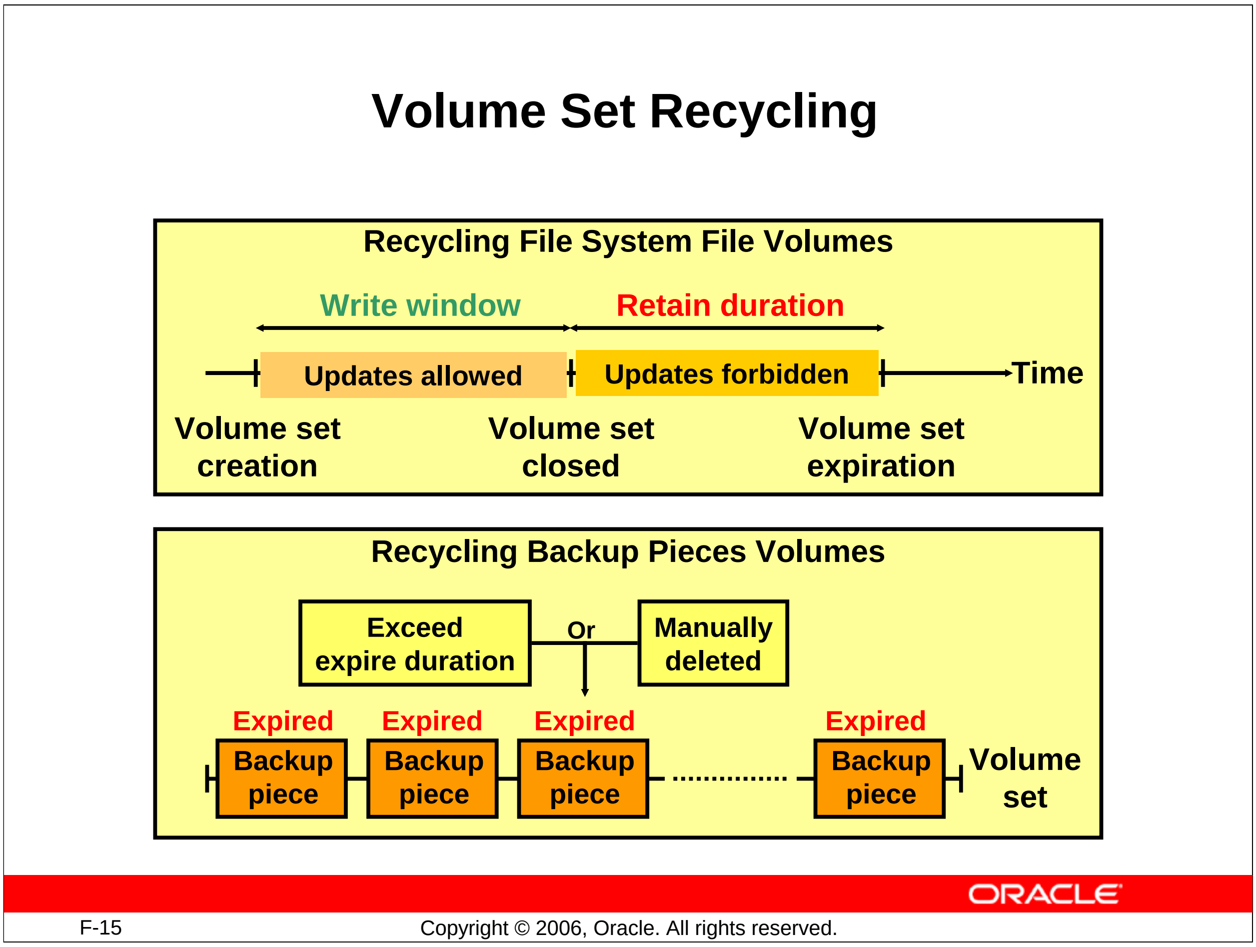
Oracle Secure Backup Media Concepts

Oracle Secure Backup organizes backups that it creates in a simple hierarchy that comprises the following concepts:

- A backup image (archive) is the product of a backup operation. Basically, it can be seen as the list of files that are backed up in one operation.
- A volume is a single unit of media, such as an 8-mm tape.
- A volume set is a group of volumes that a backup image spans.
- A media family is a named classification of volumes that share some common attributes, such as the way volumes are named, and the policies used to write and keep data stored in the media family volumes.

So, when you back up files by using Oracle Secure Backup, you generate a volume set that has some common characteristics defined by the corresponding media family that you have associated with your backup operation.

Note: The graphic in the slide illustrates these concepts from the most logical one to the most physical one.



Volume Set Recycling

Oracle Secure Backup has two volume-recycling concepts:

- **Recycling volumes containing file system file backups:** The retention period for file system backups is managed at the volume level in that a volume (tape) or volume set containing one or more file system backups may not be overwritten until the retention period for the volume has expired. Oracle Secure Backup continues to append backups to the volume set until its write window period has expired, at which time it considers the volume set closed to further updates. After the volume set is closed, its data are kept for the retention duration, then expired and automatically available to be overwritten. The retention period is the total time of the user-defined write window plus retain duration.

Volume Set Recycling (continued)

- **Recycling volumes containing backup pieces:** Oracle Secure Backup uses content-managed volume recycling for Oracle database backups, where each backup piece is managed discretely, not at the volume level. There are two ways in which backup pieces may expire:
  1. A backup administrator manually deletes the piece from the backup catalog.
  2. The life of the piece exceeds its expiration date. This expiration date is determined when the backup piece is created, and corresponds to its creation time plus its expire duration. The expire duration is set in the corresponding Oracle Secure Backup Configuration object. If either of these conditions is satisfied, the piece is considered expired. When *all* backup pieces written to a volume have expired, the volume may be overwritten.

Automated Device Management

- Oracle Secure Backup automates the control of tape libraries.
  - Accepts SCSI commands from the library to:
    - Manage the tapes inventory
    - Move tapes to or from storage elements and drives
  - Automates tape drive cleaning
  - Supports bar code readers and media verification
- Automated device discovery and configuration for NDMP v3 and v4 capable servers

ORACLE

Automated Device Management

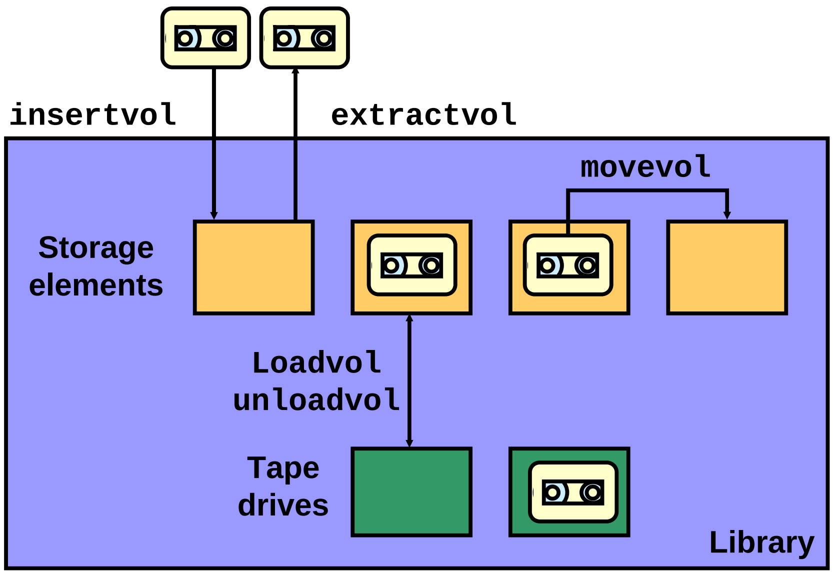
Oracle Secure Backup automates the management of tape libraries, enabling efficient and reliable use of its capabilities (including bar code readers). Oracle Secure Backup communicates with a tape library controlling the robotics to facilitate the management of tapes within the library. A tape library is often referred to as a robotic tape device, autochanger, or medium changer. A list of supported tape drives and libraries is available on OTN.

A library accepts small computer system interface (SCSI) commands to move media between storage locations and drives. Oracle Secure Backup uses the following SCSI terms to describe basic components of libraries:

- A storage element (se) contains a volume when it is not in use.
- An import-export element (iee) or mail slot is used to move volumes into and out of the library without opening the door. Availability of an iee is dependent on the library. Some offer a media access port, whereas some require manual action by the operator to open the door, and remove a tape from a slot in the library.
- A medium transport element (mte) moves a volume from a storage element to another element, such as a drive.
- A data transfer element (dte) is, for Oracle Secure Backup’s purposes, a tape drive.

Each element has a user-defined name that Oracle Secure Backup uses to identify it. The first storage element, for example, is usually called se1, and the first tape drive is dte1.

Library Management Operations



F-18

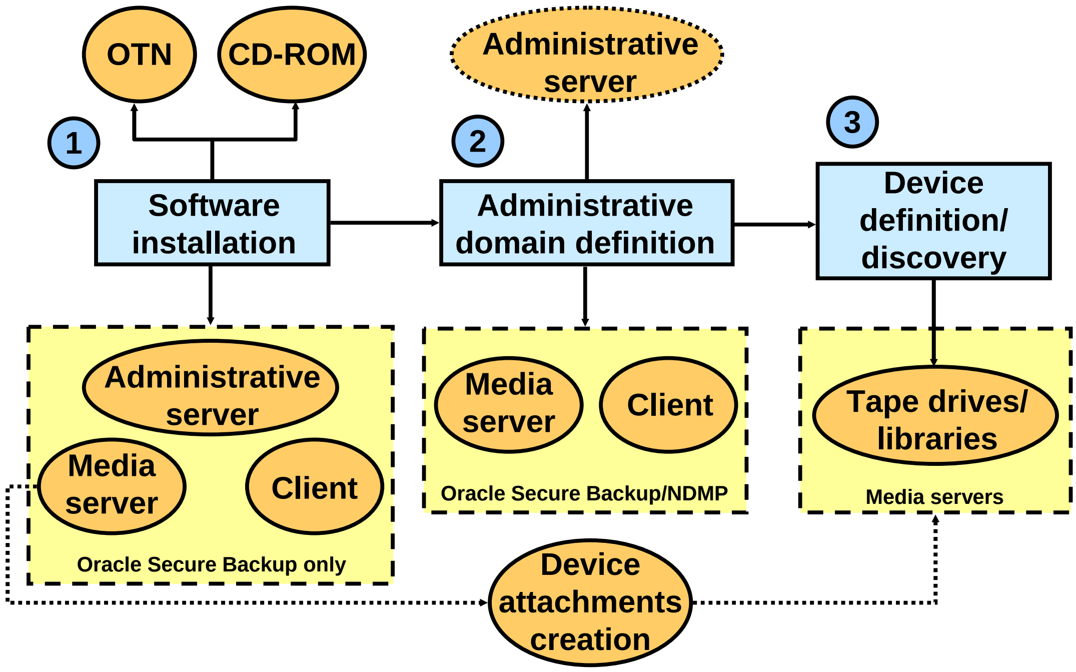
Library Management Operations

The illustration in the slide shows you a library with its storage elements and drives. The following are some basic operations that you can perform on the components of a library.

- You can express that you have inserted one or more volumes into the library’s storage elements.
- Similarly, you can extract one or more volumes from a tape library’s storage elements. This command notifies Oracle Secure Backup that you are removing a volume manually from the library.
- You can also load a volume from a storage element into a drive, to be ready to start backup operations.
- Similarly, you can unload a volume from a drive to a particular storage element.
- You can also move one volume from one storage element to another.

Note: For more information about the possible library commands, refer to the *Oracle Secure Backup Reference* guide.

Oracle Secure Backup: Installation

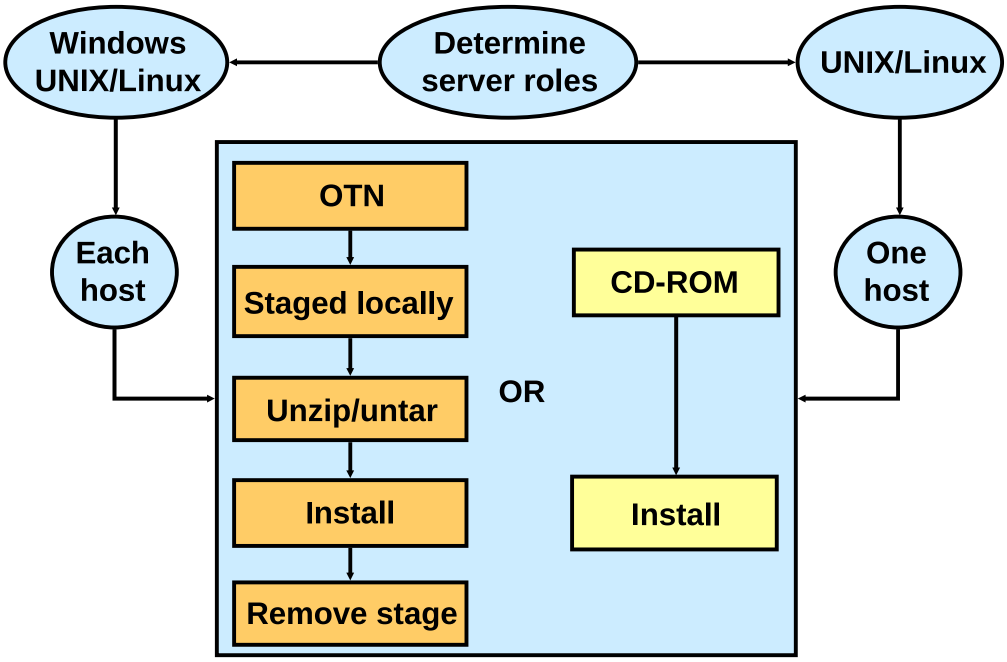


Oracle Secure Backup: Installation

The installation and configuration of your administrative domain is generally done in three steps:

1. Install the Oracle Secure Backup software on each of your hosts except the ones on which NDMP daemons are already running. This can be done either by using a CD-ROM or by downloading the software from OTN.
2. Make sure that your complete administrative domain is defined on the administrative server. This involves defining all media servers, client servers, and Network Attached Storage (NAS) filers. You do this directly from the administrative server, which is defined during the software installation process.
3. Make the administrative server aware of the tape devices that exist in your administrative domain. This third step is reserved for media servers only, and it allows you to configure the SCSI and Fiber Channel devices (libraries and tape drives) directly attached to an Oracle Secure Backup host in your administrative domain, or it allows you to discover the libraries and tape drives attached to an NAS Filer so that the filer can communicate with Oracle Secure Backup.

Installing Oracle Secure Backup Software



Installing Oracle Secure Backup Software

Before you start the Oracle Secure Backup software installation on a particular host, you need to determine its Oracle Secure Backup role (administrative, media, or client).

Whatever the platform you are using (Windows, UNIX/Linux), you can select to install the Oracle Secure Backup software in one of the following ways:

- Install Oracle Secure Backup on each host from the supplied CD-ROM.
- Download Oracle Secure Backup on each host from OTN, and install it from your local staged directory.

However, with UNIX/Linux platforms it is also possible to distribute the Oracle Secure Backup software remotely to other UNIX/Linux hosts on the network, after the software has been downloaded through OTN or the CD-ROM to one machine. This distribution method requires you to be able to issue the `rsh` command as `root` to push the software across the network.

A complete domain installation is possible only for UNIX-like systems. Windows systems require separate installation on each system in the administrative domain.

Note: On UNIX-like systems, an Oracle Secure Backup installation can be done interactively, but also in batch mode by using network description files.

Administrative Server Installation: Example

```
[root@EDRSR14P1 stage]# mkdir -p /usr/local/oracle/backup
[root@EDRSR14P1 stage]# cd /usr/local/oracle/backup
[root@EDRSR14P1 backup]# /stage/ob-4.1cdrom040914/setup
Welcome to Oracle's setup program for Oracle Secure Backup. This
program loads Oracle Secure Backup software from the CD-ROM to a
filesystem directory of your choosing.
This CD-ROM contains Oracle Secure Backup version 10.2.
Please wait a moment while I learn about this host... done.
-  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
You may load any of the following Oracle Secure Backup packages:
1. solaris (Solaris 32, SPARC) administrative server, media
server, client
2. linux32 (RH 2.1, RHEL 3, RHEL 4, SuSE 8, SuSE 9)
administrative server, media server, client
3. solaris64 (Solaris 2.8 and later, SPARC) administrative
server, media server, client

Enter a space-separated list of packages you'd like to load. To
load all packages, enter 'all' [2]:  2
```

F-21

Administrative Server Installation: Example

Although not mandatory, most of the time, the installation directory that is used to install the Oracle Secure Backup software is `/usr/local/oracle/backup`.

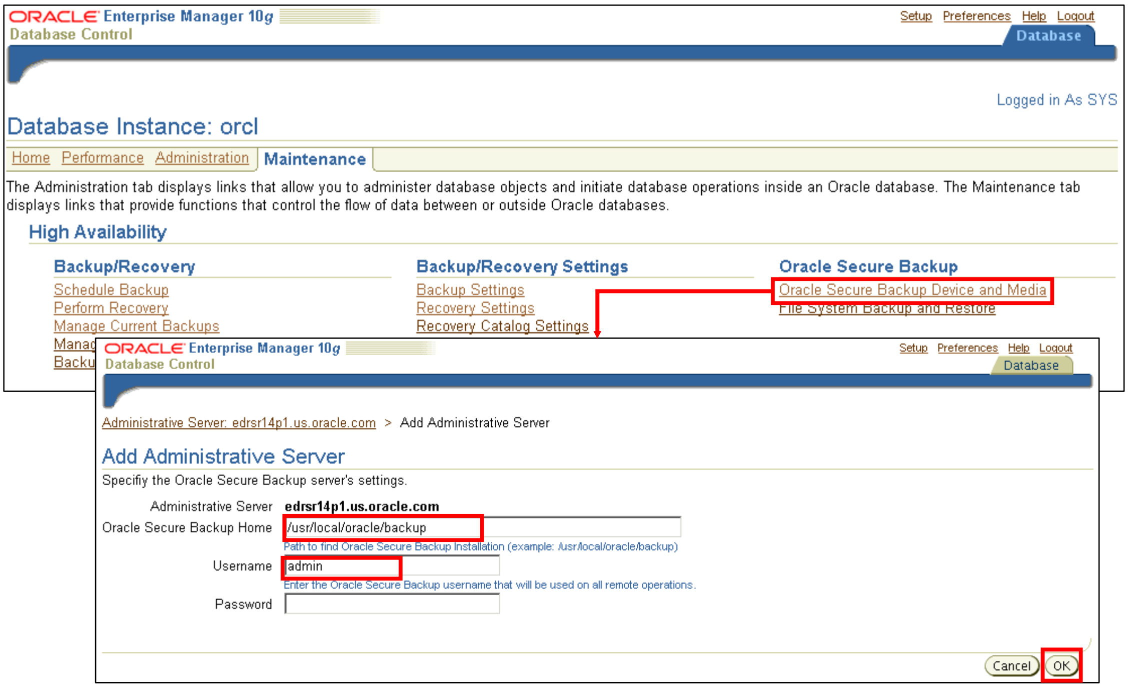
After your installation directory is created, change your current directory to the installation directory, and execute the setup program from either your CD-ROM or your staging area. In the slide example, a stage directory is used instead of a CD-ROM.

As you can see, several numeric choices are displayed for various platforms, including Solaris, and several flavors of Linux. Select the number that corresponds to the installation package for the UNIX platform you are running. The example uses Linux.

You have the option of selecting multiple machines on which to install Oracle Secure Backup. Simply list all package numbers, separated by spaces, on the same line. For example, to install Oracle Secure Backup software on Solaris and Linux machines, enter: `1 2`.

For the following steps, it is recommended that you accept the default option provided. The `obparameters` file has been preconfigured for use during the installation process. Alternatively, open a text editor and inspect `/usr/local/oracle/backup/install/obparameters`. Various parameters are defined that you may customize to suit the needs of your Oracle Secure Backup installation. For example, you can ask Oracle Secure Backup to automatically create an Oracle Secure Backup user that is assigned the `oracle` class, and is preauthenticated to use with RMAN.

Defining Your Administrative Server in EM



F-22

Defining Your Administrative Server in EM

After you have completed the Oracle Secure Backup software installation, you need to define your administrative domain.

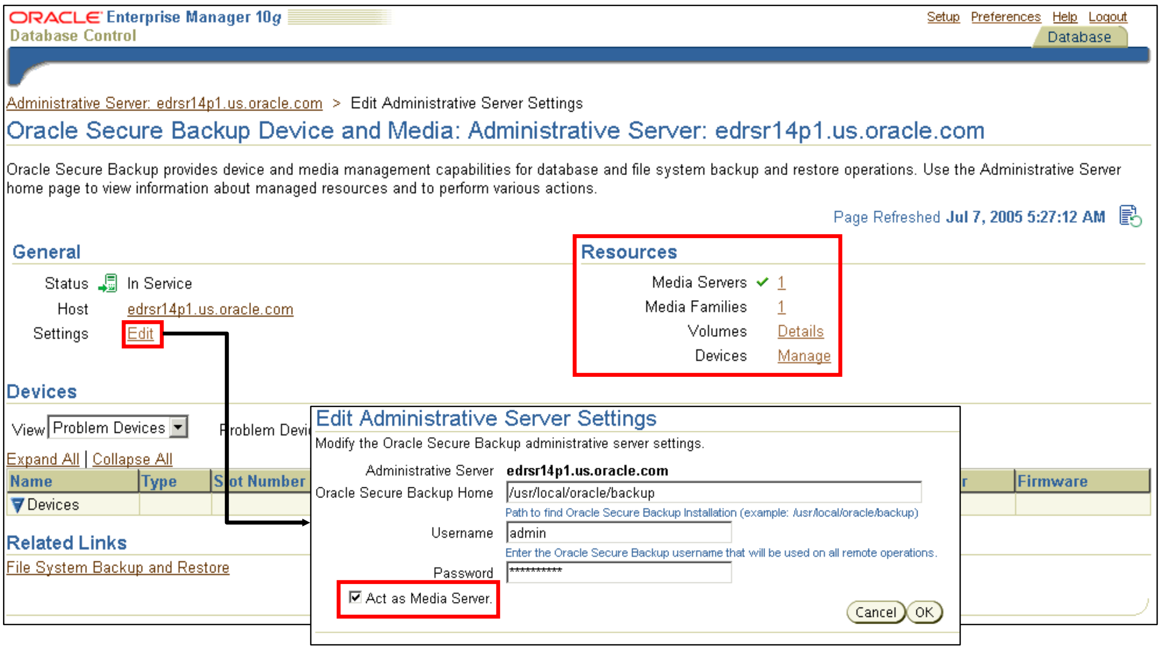
On the Database Control Maintenance page, you need to click the Oracle Secure Backup Device and Media link in the Oracle Secure Backup section.

This displays the Add Administrative Server page if this is the first time you are trying to access Oracle Secure Backup from Database Control.

On the Add Administrative Server page, you must specify the Oracle Secure Backup Home directory used during the installation process. It is assumed that your host is also an Oracle Secure Backup administrative server. Then, you need to specify the Oracle Secure Backup Username that will be used for all remote operations.

After this is done, click OK.

The Oracle Secure Backup Device and Media Page

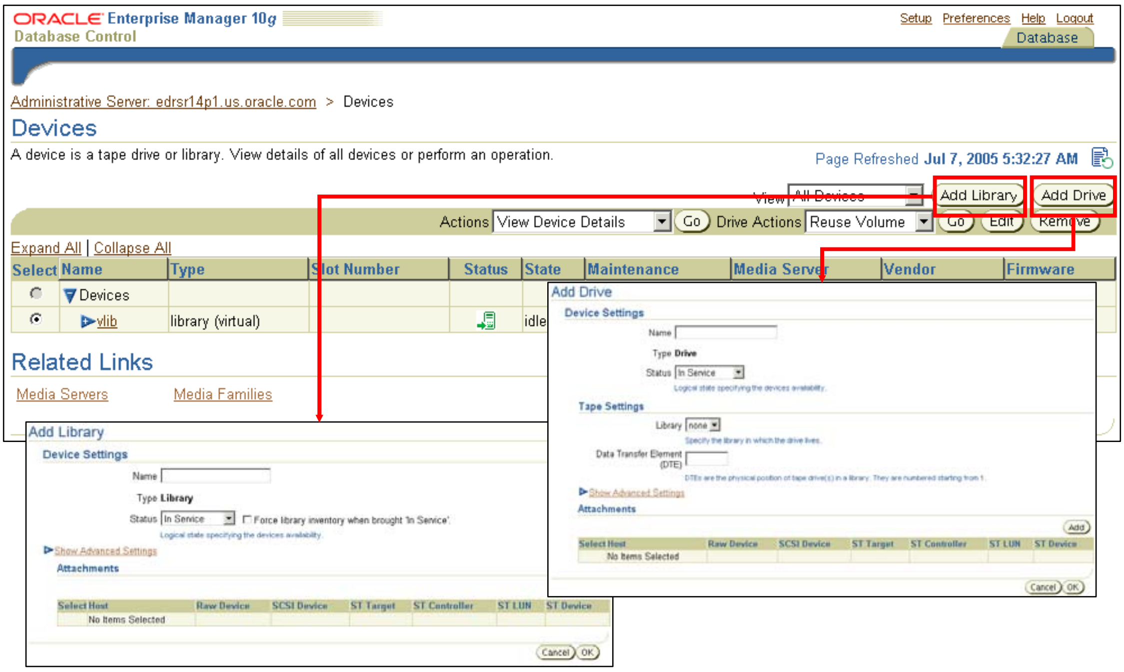


The Oracle Secure Backup Device and Media Page

On the Oracle Secure Backup Device and Media Page, you can manage your administrative domain by using the links available in the Resources section. Using this section, you can manage:

- Devices
- Media servers
- Media families
- Volumes

Adding Devices



Adding Devices

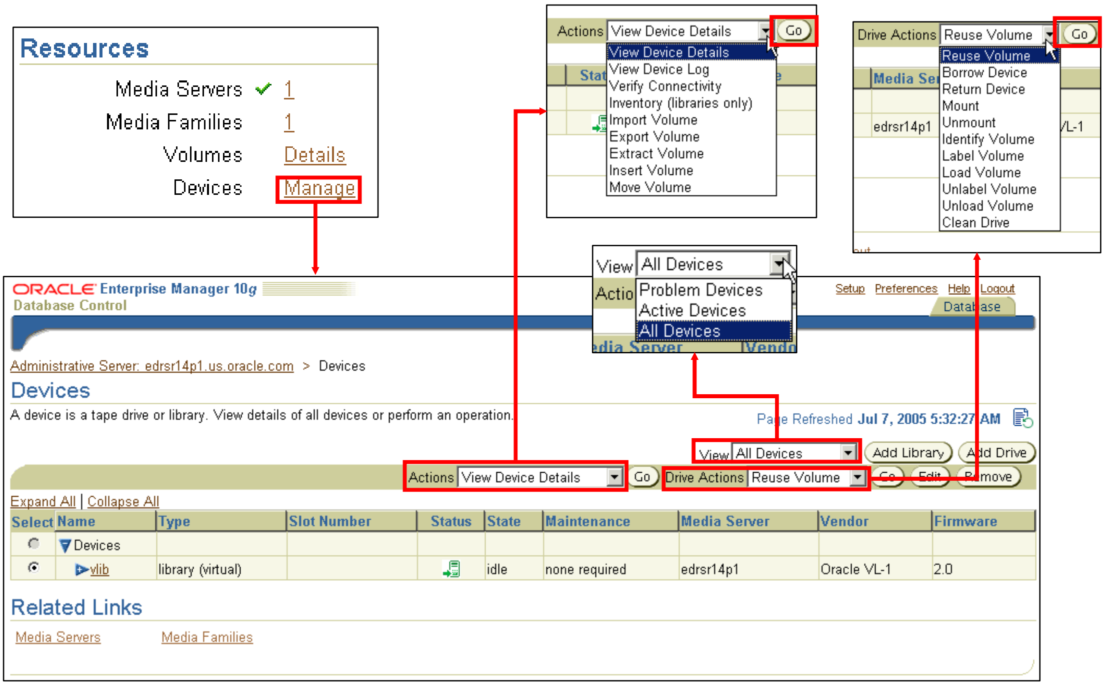
After your administrative domain has been established, you can proceed to configure libraries and tape drives for use with Oracle Secure Backup. Oracle Secure Backup supports SCSI and Fiber Channel devices.

You can add new devices in one of two ways:

- By automatically discovering them. Oracle Secure Backup can automatically discover and configure secondary storage devices connected to certain types of NDMP servers, such as Network Appliance filers.
- By configuring them through Enterprise Manager, the Web tool, or command-line interface.

On the Devices page, click either Add Library or Add Drive to add a new device to your configuration.

Managing Devices by Using EM

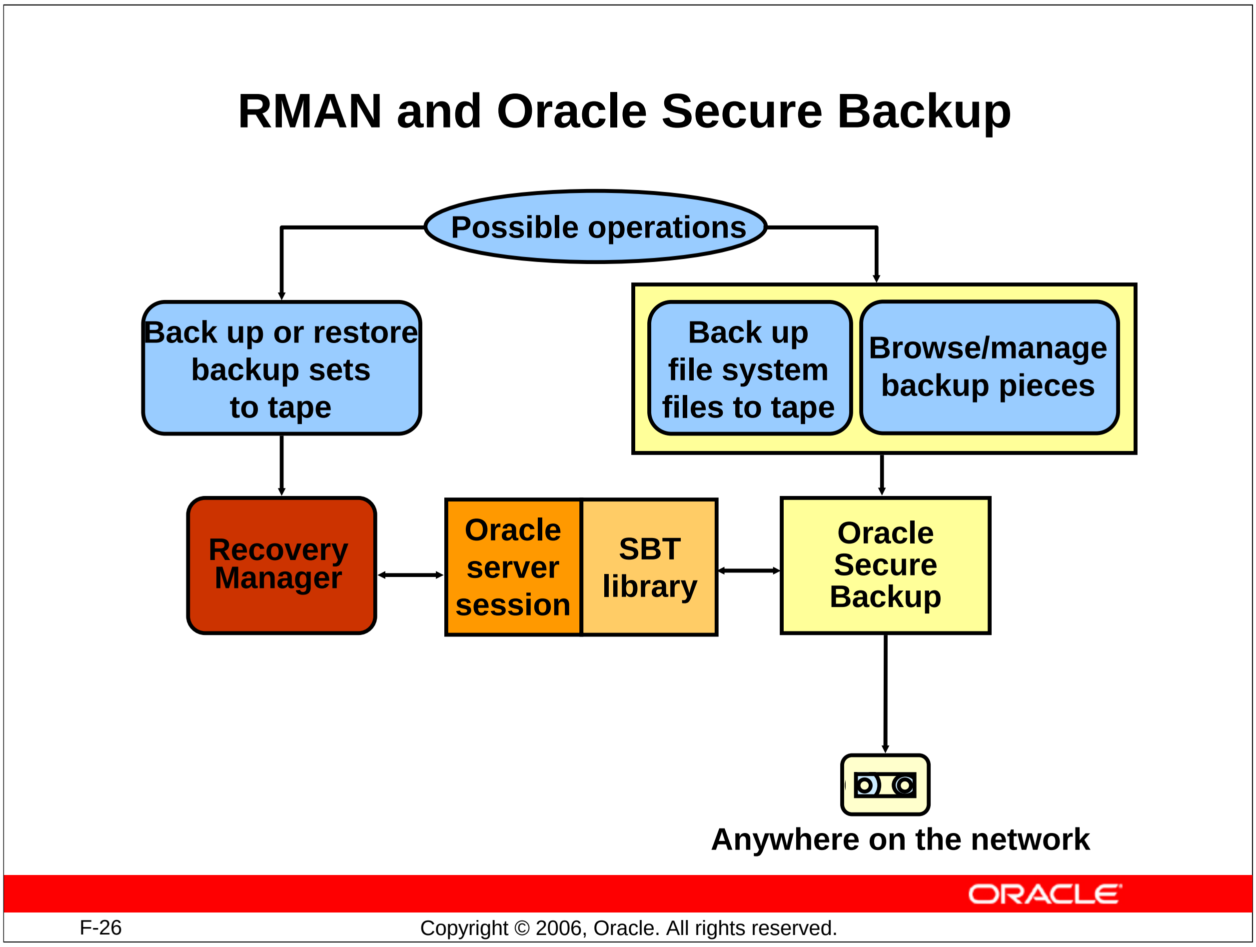


Managing Devices by Using EM

On the EM Administrative Server page, you can click the Manage link corresponding to the Devices line.

This displays the Devices page; here, you can Add Library and Add Drive. You can also select an existing device, and edit or remove that device by using the Edit and Remove buttons, respectively.

As you can see, after a device has been created, you can select that device, and apply certain actions to that device, such as Mount, Load Volume, and so on, using the Actions and Drive Actions list. Then, click Go.



RMAN and Oracle Secure Backup

Oracle Secure Backup provides the ability to back up and restore UNIX, Linux, Windows, and NAS file systems. In addition, Oracle Secure Backup also implements the RMAN media management interface, allowing it to provide seamless database backups via RMAN.

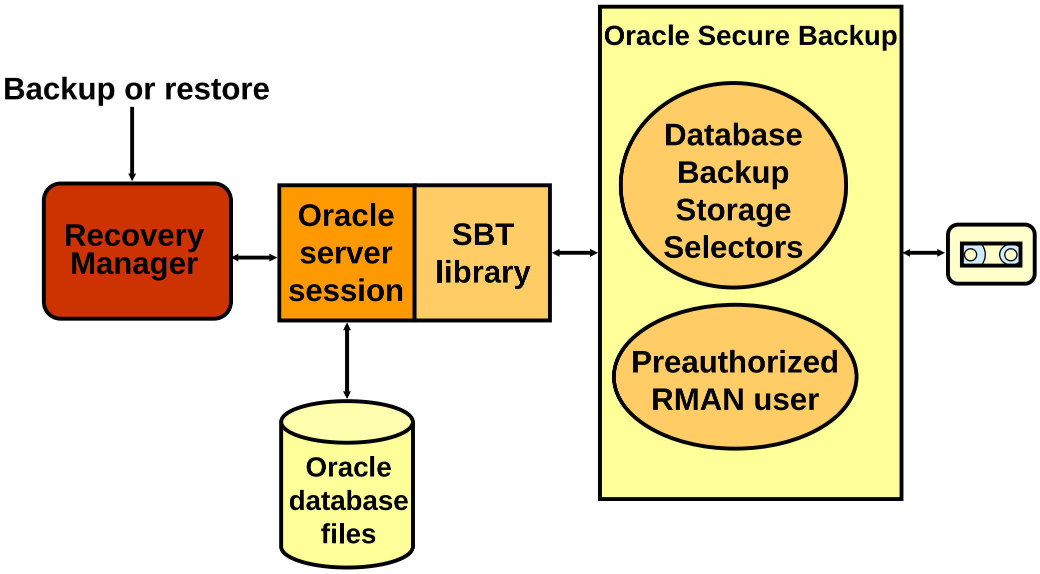
Oracle Secure Backup thus performs two separate functions: the backup of Oracle databases and the backup of other file system objects. For the backup of Oracle databases, Oracle Secure Backup is accessed via the RMAN or the EM interface. For the backup of other file system data, Oracle Secure Backup is accessed via its `obtool` command-line interface, or its Web tool.

Oracle Secure Backup can browse backup pieces and manage them individually. This is important when a backup piece becomes orphaned. An *orphan* is a backup piece that exists in the Oracle Secure Backup catalog but not in the RMAN catalog. Oracle Secure Backup stores and reports Oracle-specific metadata about the contents of each backup piece type.

Backup sets are the only form in which RMAN can write backups to media manager devices such as tape libraries. Each RMAN backup piece is created as one Oracle Secure Backup backup image when using Oracle Secure Backup to store your backups on tapes.

Note: SBT stands for System Backup to Tape.

Accessing Oracle Secure Backup from RMAN

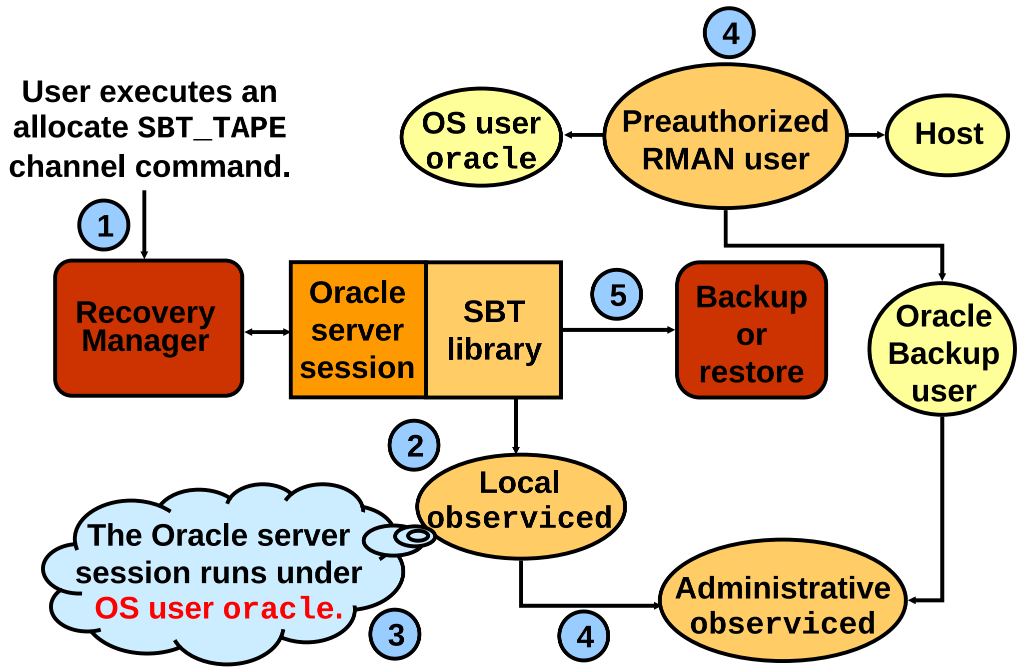


Accessing Oracle Secure Backup from RMAN

When you access Oracle Secure Backup from RMAN, all you need to do is allocate a channel of the SBT_TAPE type, and then run RMAN commands to back up or restore your database. On the Oracle Secure Backup side, you must predefine two important Oracle Secure Backup objects:

- **Database Backup Storage Selectors:** These objects are configured to represent backup and restore parameters that describe an Oracle database. They act as a *glue layer* between RMAN, which accesses the database, and the Oracle Secure Backup software, which manages the underlying media.
- **Preauthorized RMAN user:** RMAN preauthorization is used to determine the Oracle Secure Backup user under which a specific RMAN operation, such as backup or restore, is performed.

User Preauthorization

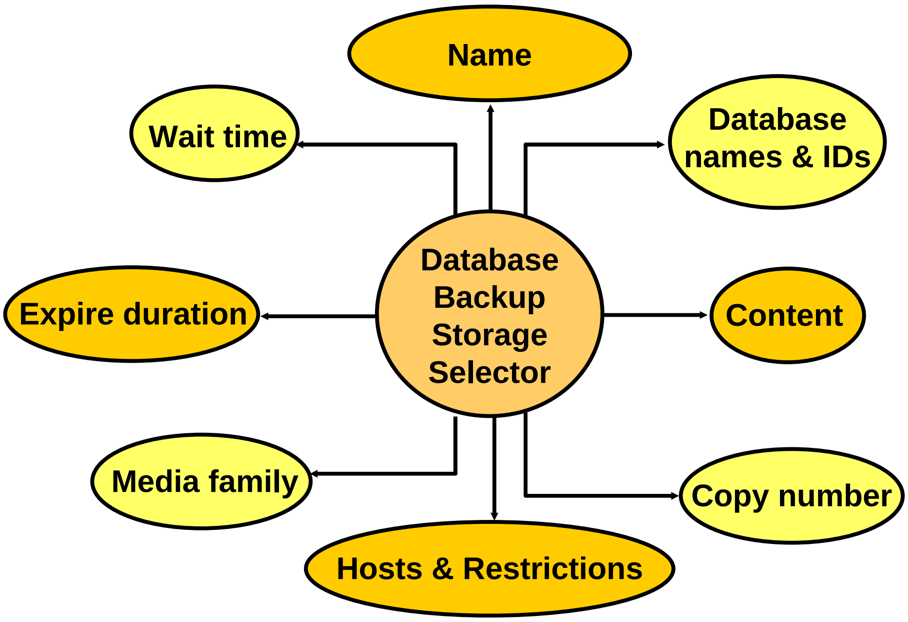


User Preauthorization

It is possible to preauthorize an OS user for RMAN access to Oracle Secure Backup when logged in to a given host. This allows for the use of Oracle Secure Backup without going through the normal Oracle Secure Backup login requirements. Preauthorization is used to determine the Oracle Secure Backup user under which a specific RMAN operation, such as backup or restore, is performed. The slide shows you an example for the RMAN case:

1. When you start RMAN and allocate an SBT channel, the Oracle database spawns an Oracle foreground process to actually perform operations.
2. The Oracle process connects to the Oracle Secure Backup service daemon running locally on its host.
3. The service daemon determines the OS user and host under which the Oracle process runs.
4. The local service daemon checks the user information in the administrative service daemon. If there is an Oracle Secure Backup user that supports preauthentication for this host and OS user, the login is successful.
5. The Oracle foreground process uses the preauthenticated Oracle Secure Backup user to perform its Oracle Secure Backup operations. Note that Oracle Secure Backup operations submitted through the SBT interface use the OS user defined by the Oracle Secure Backup user to access the host.

Database Backup Storage Selector

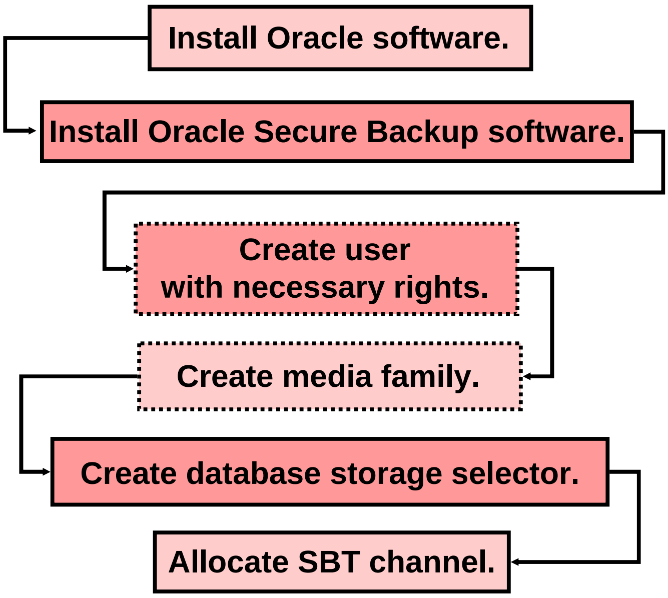


Database Backup Storage Selector

Using Database Backup Storage Selectors, you can exercise fine-grained control over database backup and restore operations. Oracle Secure Backup uses the information encapsulated in Database Backup Storage Selectors when interacting with RMAN. A Database Backup Storage Selector contains the following information:

- The name of the storage selector itself
- The names of the databases to which this selector applies
- The IDs of the databases to which this selector applies
- The names of the hosts to which this selector applies
- The backup piece contents to which this selector applies: archivelogs, full, incremental, and autobackup. A combination of these values is also possible.
- The RMAN copy number to which this selector applies. This is configured generally using the RMAN commands `BACKUP … COPIES` or `CONFIGURE BACKUP COPIES` to duplex backup sets to protect against disaster, media damage, or human error.
- The name of the media family to use
- The names of devices to which operations are restricted
- The expiration time (duration) of backup pieces
- How long to wait (duration) for resource availability

RMAN and Oracle Secure Backup: Usage Model



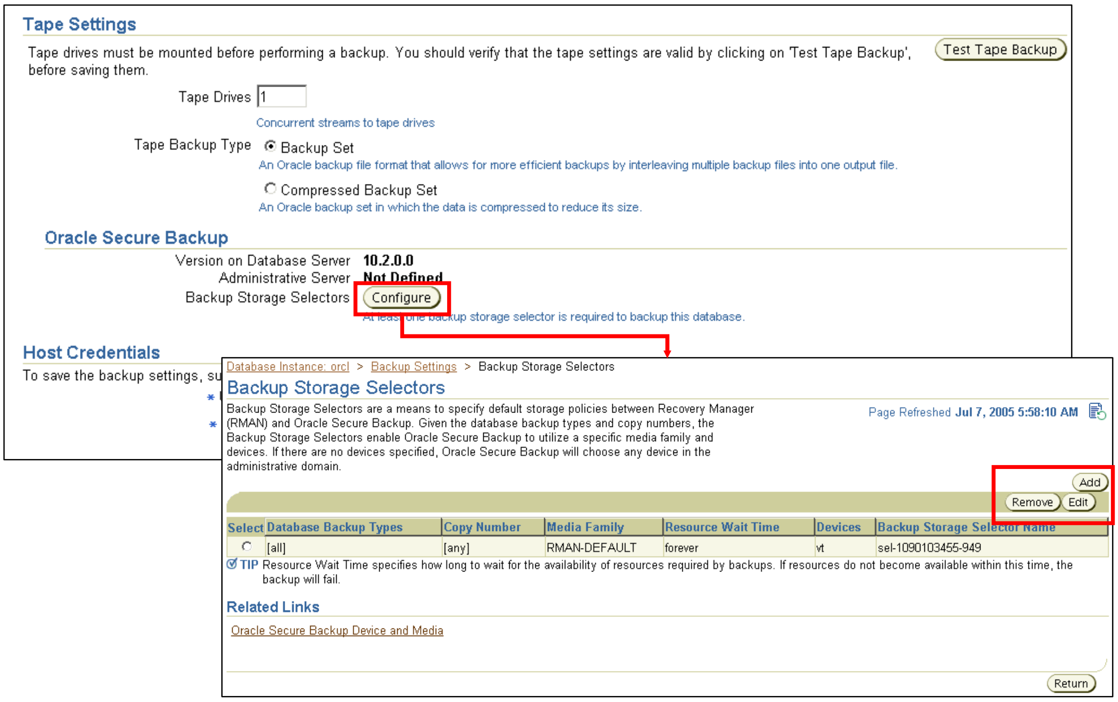
RMAN and Oracle Secure Backup: Usage Model

Oracle Secure Backup functions in exactly the same way as any other backup product that provides an SBT implementation. Before using RMAN with Oracle Secure Backup, perform the following steps:

1. Install the Oracle software as well as the Oracle Secure Backup software.
2. Create an Oracle Secure Backup user assigned to the "oracle" class, and with RMAN preauthorization. To create such a user during the Oracle Secure Backup installation, simply change the value of the `create pre-authorized oracle user` parameter to `yes` in the `obparameters` file before installation.
3. Create media families. For example, you could create different media families depending on the type of backup set created: archived logs and data files. By default, Oracle Secure Backup creates the `RMAN-DEFAULT` media family to be used with RMAN.
4. Create Oracle Secure Backup Database Backup Storage Selectors. You could, for example, create one selector for each database.
5. Before submitting RMAN commands to generate backups, or to restore databases, allocate channels of the `SBT_TAPE` type.

Note: When installing the Oracle Secure Backup software, the installer automatically copies the `libobk.so` file to the `/lib` directory. Therefore, by default, you automatically use Oracle Secure Backup each time you allocate an `SBT_TAPE` channel.

Defining Database Storage Selector



Defining Database Storage Selector

After you define the administrative server, you need to configure a Database Backup Storage Selector so that you can start creating backups using Oracle Secure Backup through RMAN and Enterprise Manager.

To create a storage selector, perform the following steps:

1. On the Database Control home page, click the Maintenance tab.
2. On the Maintenance page, click the Configure Backup Settings link.
3. On the Configure Backup Settings page, click Configure in the Oracle Secure Backup section. The Backup Storage Selectors page opens. Using this page, you can manage your backup storage selectors. After creating the selector, click Return.

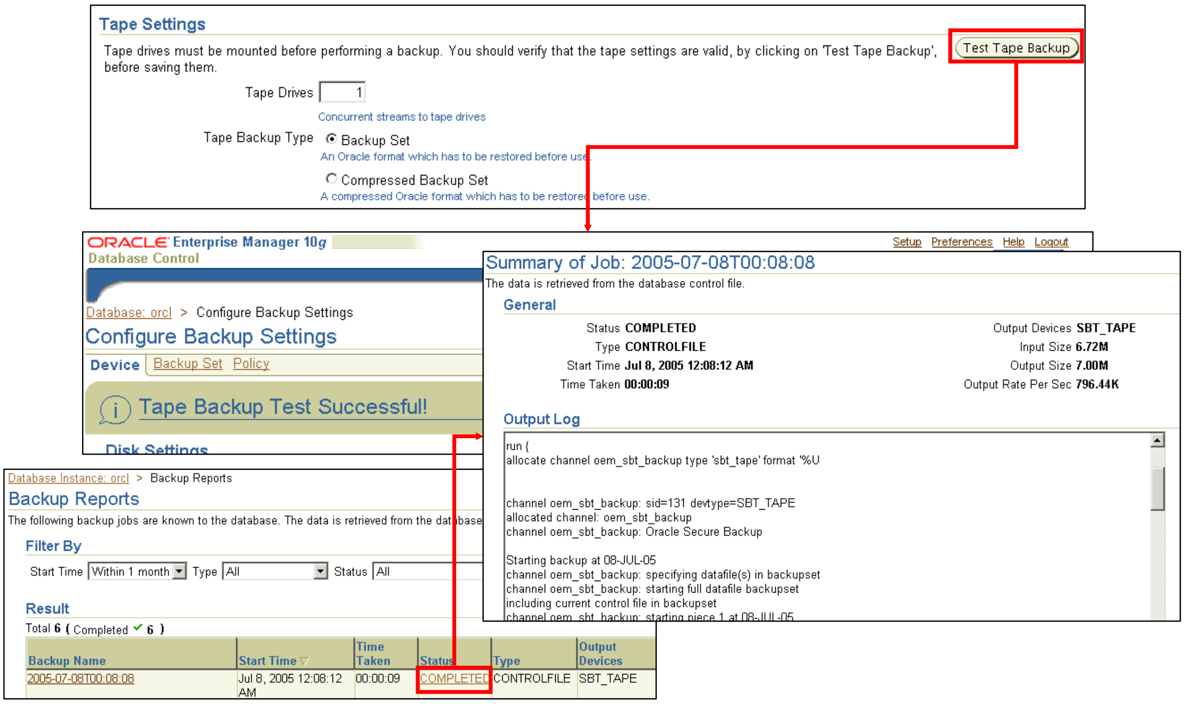
You can also use the following example to create a database storage selector by using the `obtool` command-line interface:

```
mkssel -c * -d * -i * -h EDRSR14P1 -r vt1 ssel1
```

This example creates a Database Backup Storage Selector that is valid for any Oracle database located on the `EDRSR14P1` host. This object is called `ssel1`, and uses the `vt1` tape drive for backing up data.

Note: For more information about how to manage Database Backup Storage Selectors, refer to the *Oracle Secure Backup Administrator's Guide*.

Testing Your Tape Drives



Testing Your Tape Drives

After you register Oracle Secure Backup to be used by RMAN through EM, you can open the Configure Backup Settings page to test that everything is set up correctly. In the Tape Settings section, click Test Tape Backup. This creates a backup of the control file, issues the `RESTORE VALIDATE CONTROLFILE` RMAN command, and deletes the control file copy from tape.

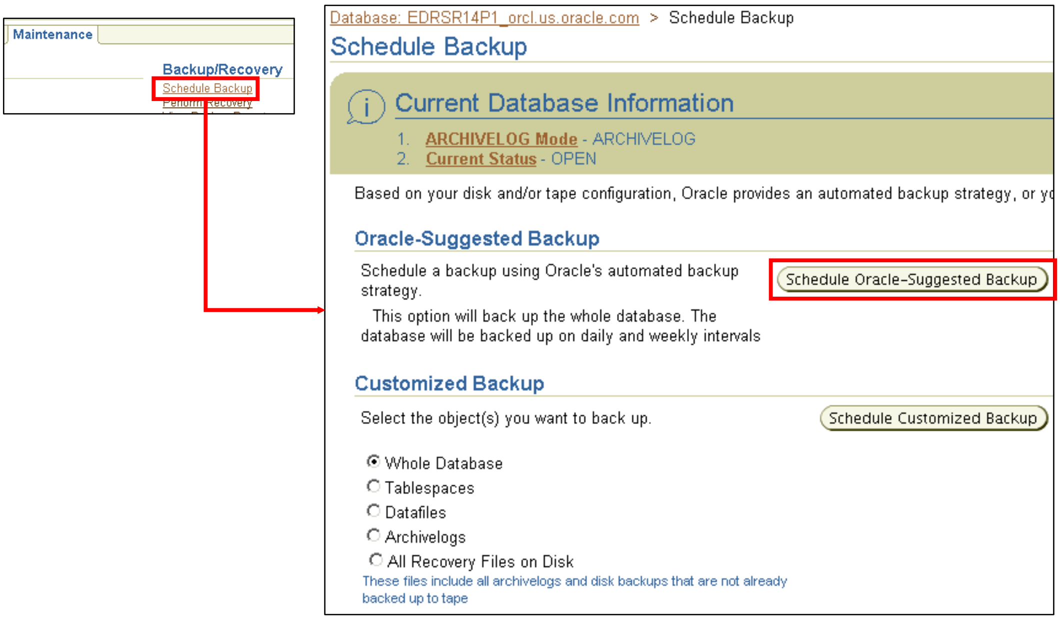
After this is done, you are taken back to the Configure Backup Settings page, where you can see the Tape Backup Test Successful message.

You can then look at the backup report. On the Maintenance page, click the Backup Report link in the Backup/Recovery section. Then, on the Backup Report page, locate the corresponding report, and click its corresponding Status. You are directed to the Summary page, where you can see the detail log information.

Note: The following is a script example that is automatically executed by RMAN to test your tape drive.

```
run { allocate channel oem_sbt_backup type 'sbt_tape' format '%U';
backup as BACKUPSET current controlfile tag '12152004064001';
restore controlfile validate from tag '12152004064001';
release channel oem_sbt_backup;}
allocate channel for maintenance type 'sbt_tape' ;
delete noprompt backuppiece tag '12152004064001';
```

Scheduling Backups by Using EM Database Control



F-33

Scheduling Backups by Using EM Database Control

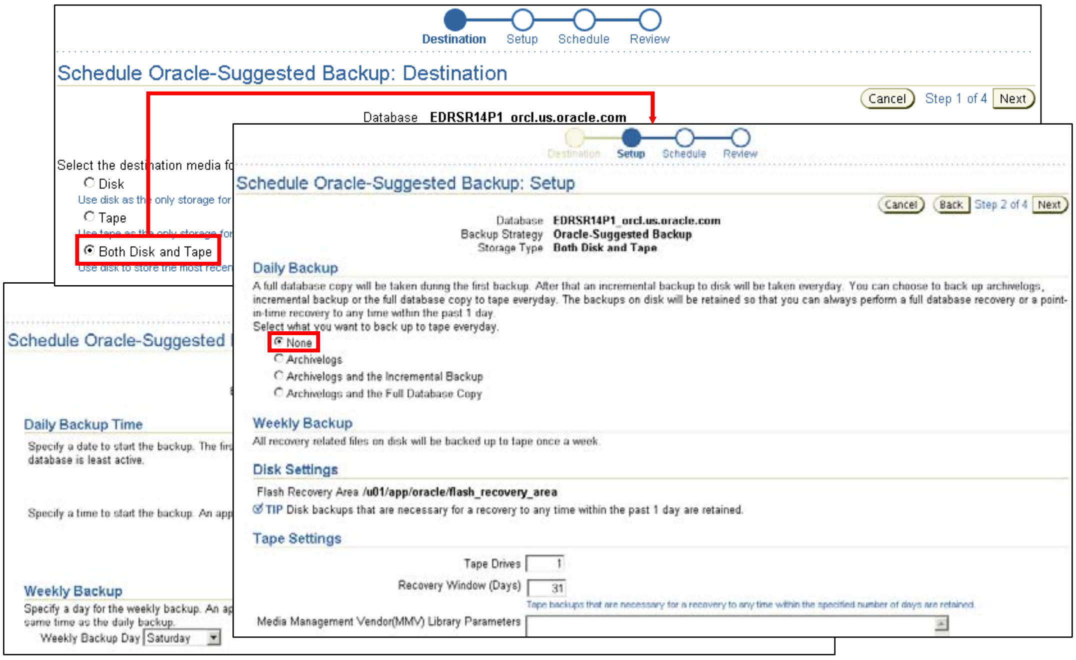
Using EM Database Control, you can schedule backups to either disks or tapes, or to both.

To schedule a backup, click the Schedule Backup link on the Maintenance tabbed page.

On the Schedule Backup page, you can choose either the Oracle-Suggested Backup strategy or Customized Backup.

In the slide example, the Oracle-suggested strategy is used by clicking Schedule Oracle-Suggested Backup.

Oracle-Suggested Strategy for Backups



ORACLE

Oracle-Suggested Strategy for Backups

On the Schedule Oracle-Suggested Backup: Destination page, you can select the destination media for your backup. In the slide example, Both Disk and Tape is selected. The idea is to generate a daily backup of the database to disk, and once a week to back up the flash recovery area to tape. The default Oracle-suggested strategy is to use incremental RMAN backups daily to disk.

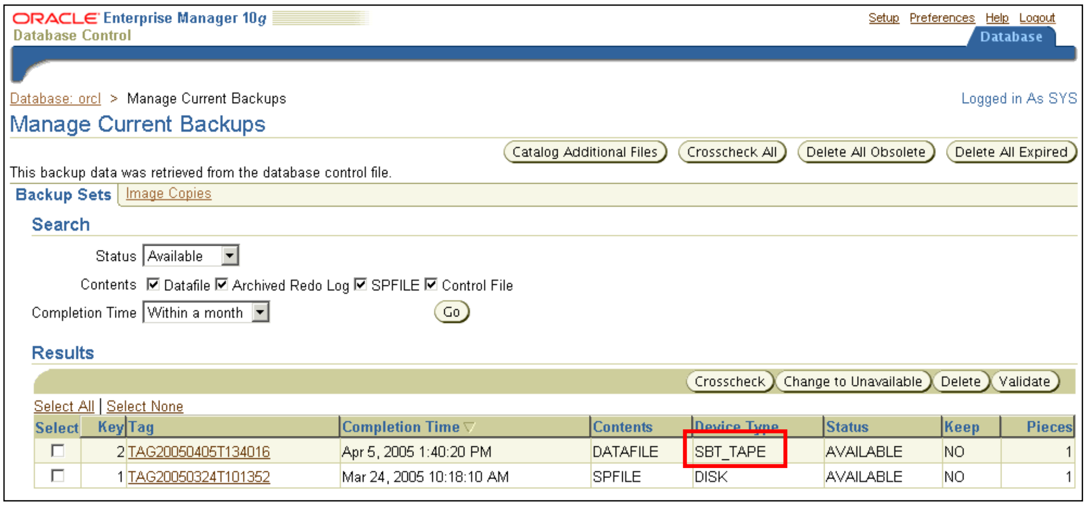
Click Next to display the Schedule Oracle-Suggested Backup: Setup page, where you can determine what needs to be backed up to tape daily. In the example, you indicate that you do not want to back up data to tape daily by selecting None in the Daily Backup section.

As shown in the example, "all recovery-related files on disk will be backed up to tape once a week," and "disk backups that are necessary for a recovery to any time within the past 1 day are retained."

In addition, you can specify your tape settings, such as the Recovery Window, the number of Tape Drives, and the Library Parameters.

Click Next to access the Schedule Oracle-Suggested Backup: Schedule page. On this page, you can define the Daily Backup Time as well as the Weekly Backup Time. Click Next to review your job and then click Submit Job to submit your job.

Managing Tape Backups



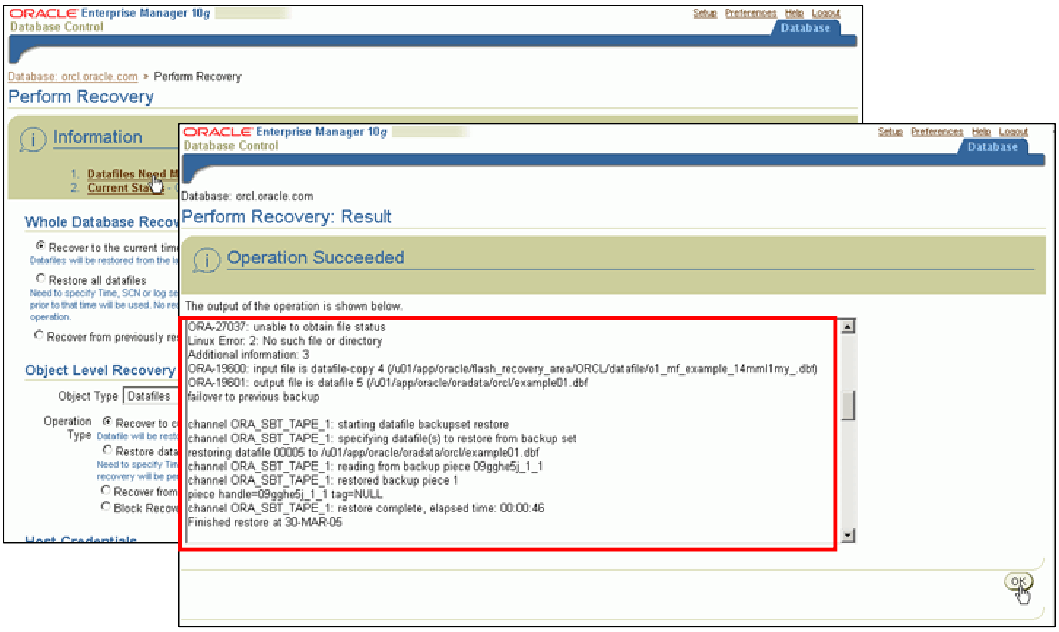
Managing Tape Backups

Use the Manage Current Backups page to search for and display a list of backup sets or backup copies and to perform management operations on selected copies, sets, or files. You can access this page from the Maintenance tabbed page.

As you can see in the slide, this page shows you both disk backups and tape backups.

Use the Search section to find backup sets or copies by using Status filters to isolate specific objects. You can then use the available functions on the Manage Current Backups page to manage the files or sets displayed in the Results table.

Performing Database Recovery by Using Tape Backups



ORACLE

Performing Database Recovery by Using Tape Backups

You can access the Perform Recovery page from the Maintenance tabbed page. Using the Perform Recovery page, you can perform various kinds of database recovery. You can recover the whole database, a particular data file, or a tablespace.

In the background, RMAN requests the necessary files from previous backups. If those files are stored on tape, Oracle Secure Backup automatically determines which tape to use. If those tapes are not immediately available (off-site), RMAN waits for the resources. This wait time is defined by the resource wait time parameter of your backup storage selector that defaults to one hour.

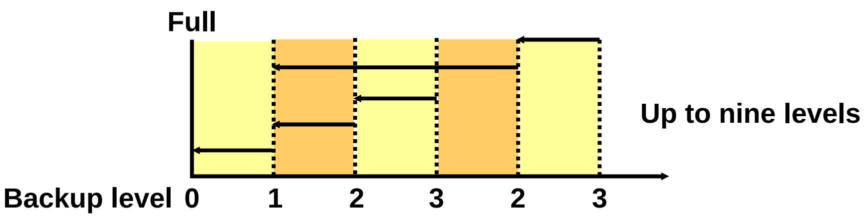
When you need to perform recovery of your database, following a data file incident, RMAN automatically selects the most appropriate backup to restore. This means that RMAN may decide to fall back to a tape backup created by Oracle Secure Backup. This operation is totally transparent and is automatically done by RMAN.

The screenshot (given in the slide) illustrates this situation where the needed data file to be restored was inadvertently deleted from the flash recovery area. As you can see, RMAN automatically switches from a previous backup that was generated by Oracle Secure Backup.

Note: RMAN recovers the data file or database, whereas Oracle Secure Backup just restores the necessary files if they are located on tape.

Backing Up File System Files with Oracle Secure Backup

- Two ways of backing up data
  - On-demand backups
  - Scheduled backups
- Two types of backup
  - Full: All specified files
  - Incremental: Only files that have changed since the last lower backup



Backing Up File System Files with Oracle Secure Backup

You can back up file system files in two different ways:

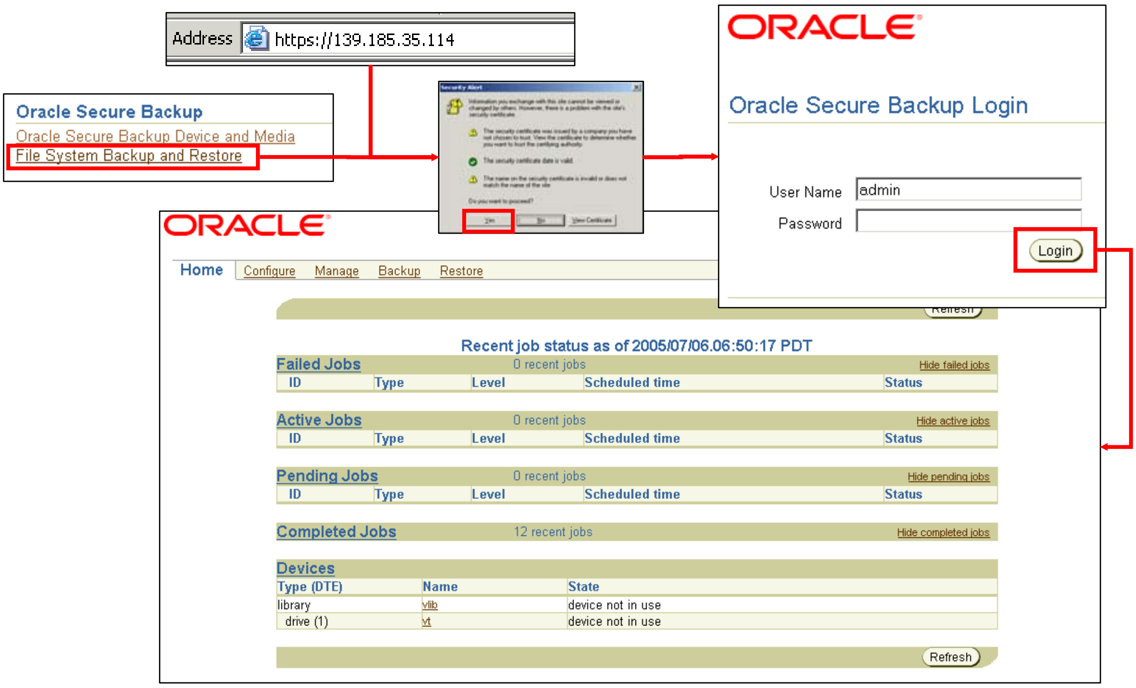
- By creating on-demand (ad hoc or one-time only) backup jobs, and submitting them to the Oracle Secure Backup scheduler
- By scheduling backup jobs to run at predetermined times. The Oracle Secure Backup scheduler automatically initiates such jobs upon a day and time that you specify.

Using Oracle Secure Backup, you create two types of backup:

- **Full backups:** A full backup backs up all specified files, regardless of when they were last backed up. This option is the same as backup level 0. You can also perform full backups in such a manner that it does not affect the full or incremental backup schedule. This is useful when you want to create an archive for off-site storage without disturbing your schedule of incremental backups.
- **Incremental backups:** There are nine different incremental backup levels. In each level, Oracle Secure Backup backs up only those files that have changed since the last backup at a lower (numerical) backup level. You can also ask Oracle Secure Backup to back up only those files that have been modified since the last backup, regardless of its backup level. This option is the same as backup level 10, and is called “incr.”

Note: Oracle Secure Backup does not support the incr backup level in conjunction with some platforms, including certain NAS devices. Notably, this includes Network Appliance filers.

Oracle Secure Backup Web Tool



Oracle Secure Backup Web Tool

Oracle Secure Backup invokes Apache to start the GUI tool. The Apache Web server is started in the background during the installation process.

To start Oracle Secure Backup by using a Web browser:

- Ensure that:
  - Service daemon `observiced` is running on the machine
  - Oracle Secure Backup Web server `obhttpd` is running
- Invoke a Web browser on any machine that can connect to the secure HTTPS port (usually port 443) on your administrative server
- In the browser's URL or Location field, enter: `https://`*`administrative-server-name`*

You can also access the Web tool directly from the EM Maintenance page. When the Security Alert box appears, click Yes.

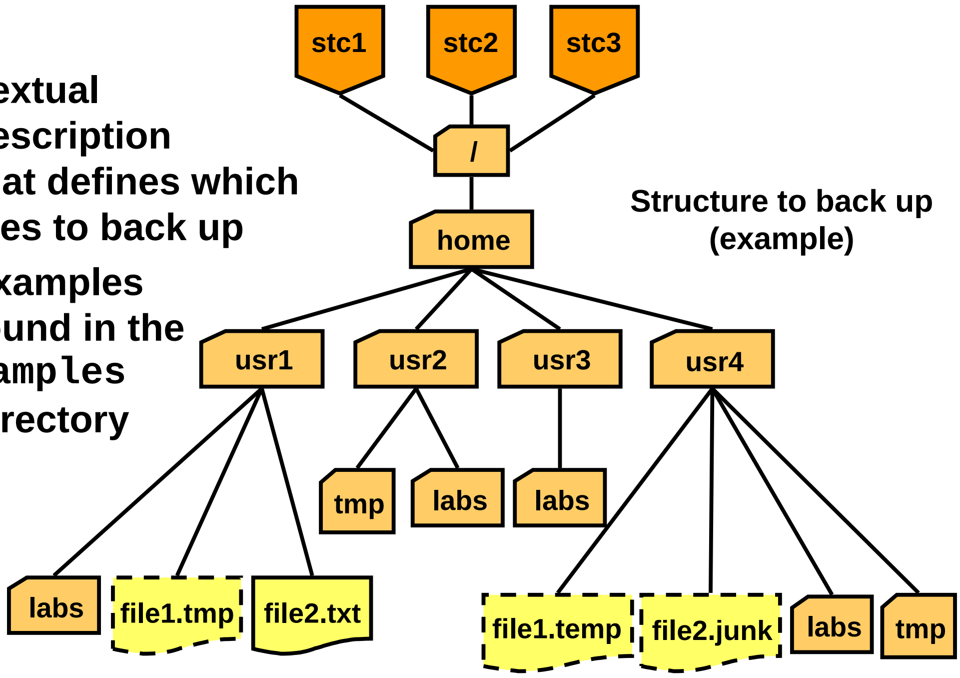
When the Oracle Secure Backup login page appears, enter `admin` in the User Name field. This is the default username created during installation. Leave the Password field empty, and click Login.

The Oracle Secure Backup Web tool is best to handle the following operations:

- If you want to add client hosts to your Oracle Secure Backup configuration
- To manage Oracle Secure Backup daemons
- To manage additional Oracle Secure Backup users along with their class names and e-mail addresses

Oracle Secure Backup Data Set Scripts

- Textual description that defines which files to back up
- Examples found in the `samples` directory



F-39

Oracle Secure Backup Data Set Scripts

With Oracle Secure Backup, you need to define data sets to describe the list of files that you want to back up.

A data set is a textual description that indicates to Oracle Secure Backup what files to back up.
To enable this, data sets employ a lightweight language. With it, Oracle Secure Backup provides you great flexibility in how you build and organize the definitions of the files you want to protect.

The graphic in the slide illustrates the files that you can find on three different hosts. Using the data set script defined in the next slide, you can back up the files (shown in this slide), except the ones corresponding to the dashed boxes.

To familiarize yourself with the data set language, you can find data set file examples in the `/usr/local/oracle/backup/samples` directory.

Note: Never back up files or directories matching `*.backup` and `*~`.

Data Set Script: Examples

```
# Dataset "common-exclusions":
exclude name tmp
exclude name *.tmp
exclude name *.temp
```

```
exclude name *~
include path /home/usr1
include path /home/usr2
include host stc1
include host stc2
include host stc3 {
 include dataset common-exclusions
 include path /home/usr3
  before backup optional "/etc/local/nfy '/usr3 begin'"
  after backup optional "/etc/local/nfy '/usr3 end'"
 include path /home/usr4 {
  exclude name *.junk
 }
}
```

ORACLE

Data Set Script: Examples

The slide shows you two data set description files that can be used to back up the data shown in the previous slide.

The first script is used to exclude directories and files starting with `tmp`, `*.tmp`, and `*.temp`.

The second script is used to back up the following data on hosts `stc1`, `stc2`, and `stc3`:

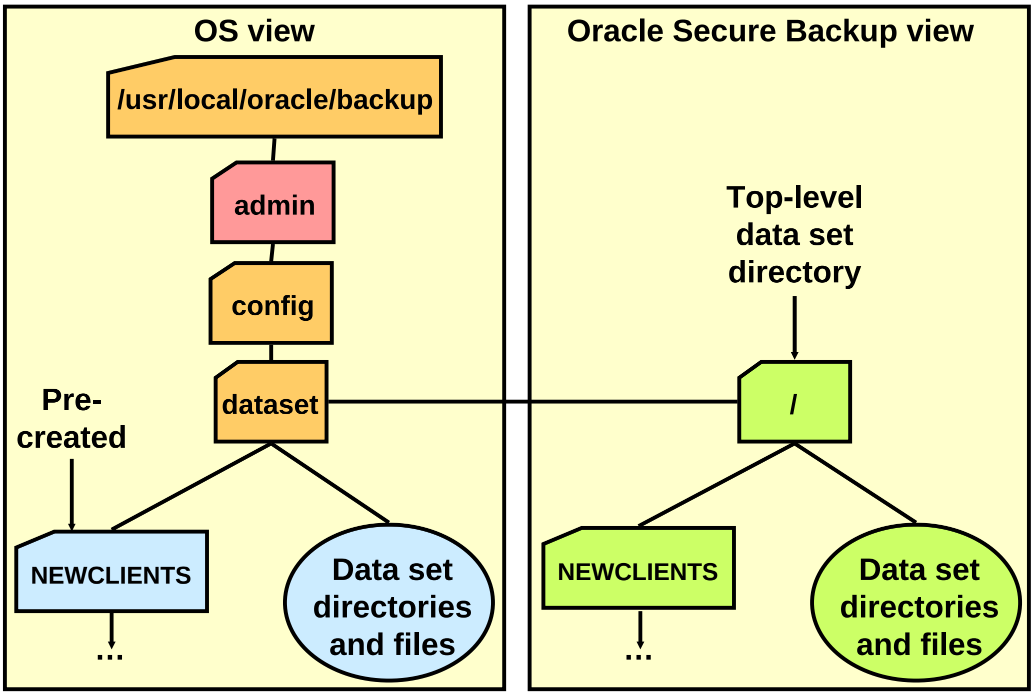
- On `stc1` and `stc2`: `/home/usr1` and `/home/usr2`, except files starting with `*~`
- On `stc3`: `/home/usr1`, `/home/usr2`, `/home/usr3`, and `/home/usr4`, except files starting with `*~`, `tmp`, `*.tmp`, `*.temp`, and `*.junc` only for `/home/usr4`

When Oracle Secure Backup starts backing up data in `/home/usr3` on `stc3`, it also executes the `/etc/local/nfy` executable. The same executable is also executed when Oracle Secure Backup finishes its backup of `/home/usr3`.

When performing a normal (nondatabase) backup, you may want to skip files that would be included in a database backup. Examples of such files include the database files themselves, control files, redo logs, flashback logs, and so on. To exclude these files, specify the `exclude oracle files` directive in your data set.

Note: For more information about the data set language, refer to the *Oracle Secure Backup Administrator's Guide*.

Data Set Organization



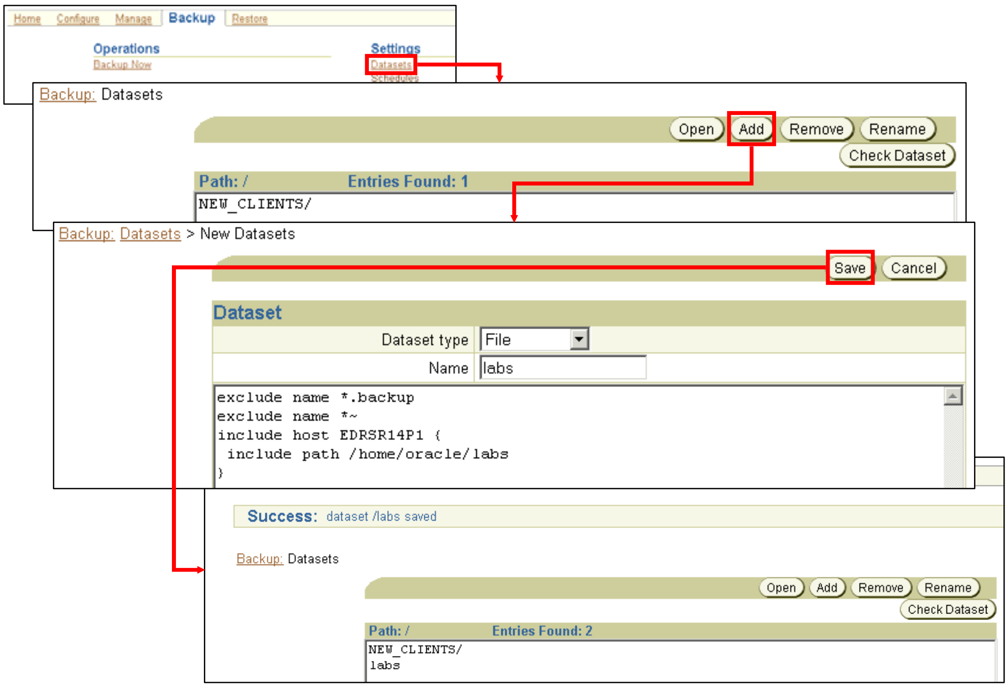
Data Set Organization

As shown in the slide, data set description files are hierarchically organized into a directory structure.

From the administrative server point of view, the data set description files and directories are stored in the `/usr/local/oracle/admin/config/dataset` file system directory. As shown on the left part of the illustration, the `NEWCLIENTS` directory is automatically created during installation. This directory can be used to store your future data set description files.

Using either `obtool` or the Oracle Secure Backup Web interface, you have access to special commands that enable you to manage data set description files and directories. Therefore, from an Oracle Secure Backup perspective, you can create your own data set directories and description files, and organize them into a tree-like structure. This is shown on the right part of the illustration.

Creating Data Sets Using the Web Interface



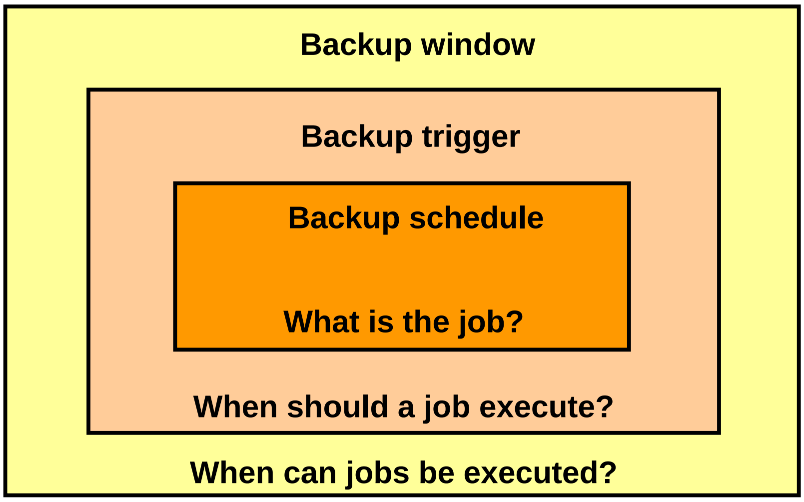
Creating Data Sets by Using the Web Interface

Use the Oracle Secure Backup Web interface to create a data set by performing the following steps:

1. On the home page, click the Backup tab in the menu bar.
2. From the Backup menu, click Datasets in the submenu under Settings. The Datasets page appears. Data set directories appear in the Path box with a slash as the last character in the name.
3. Click the Add button to create a new data set. When you create a new data set description, the initial contents of the data set is defined by a data set template.
4. Select File or Directory from the “Dataset type” list. You can create data set directories to organize your data definitions. By default, a data set file is created in the `/usr/local/oracle/backup/admin/dataset/NEW_CLIENTS` directory.
5. In the Name field, enter a name for the data set.
6. Update the data set statements displayed in the template file to define your backup data. See the “Data Set Script: Examples” section for more information.
7. Click the Save button to accept your entries and return to the Datasets page.

If your data set has errors, a message appears in the Status section. As you can see in the slide, you can check, edit, rename, and remove data sets.

File System Files: Backup Concepts



File System Files: Backup Concepts

The slide illustrates the important concepts relating to backing up file system files by using Oracle Secure Backup:

- A backup window defines a time range within which Oracle Secure Backup performs scheduled backup jobs. You must have at least one backup window in order for scheduled backup jobs to run. However, a backup window is not associated with any particular scheduled backup jobs. A default backup window is always created, and is identified as `daily 00:00-24:00`.
- A backup trigger is a calendar-based time at which a particular scheduled backup becomes eligible to run. One particular scheduled backup can be associated with more than one backup trigger.
- A backup schedule basically tells Oracle Secure Backup what data to back up, and how to back up that data.

Oracle Secure Backup Jobs

- Backups using data sets:
  - Data set jobs: One for each data set request
  - Backup jobs: One for each impacted host for each data set job
- File system file restores:
  - Restore jobs: One for each needed backup image
- RMAN jobs
- For each job, Oracle Secure Backup maintains:
  - A log
  - A running transcript

Oracle Secure Backup Jobs

Oracle Secure Backup creates jobs in response to the work that you ask it to do. It assigns each job a name, called a job identifier, that is unique among all jobs within the administrative domain. Several events cause Oracle Secure Backup to create new jobs:

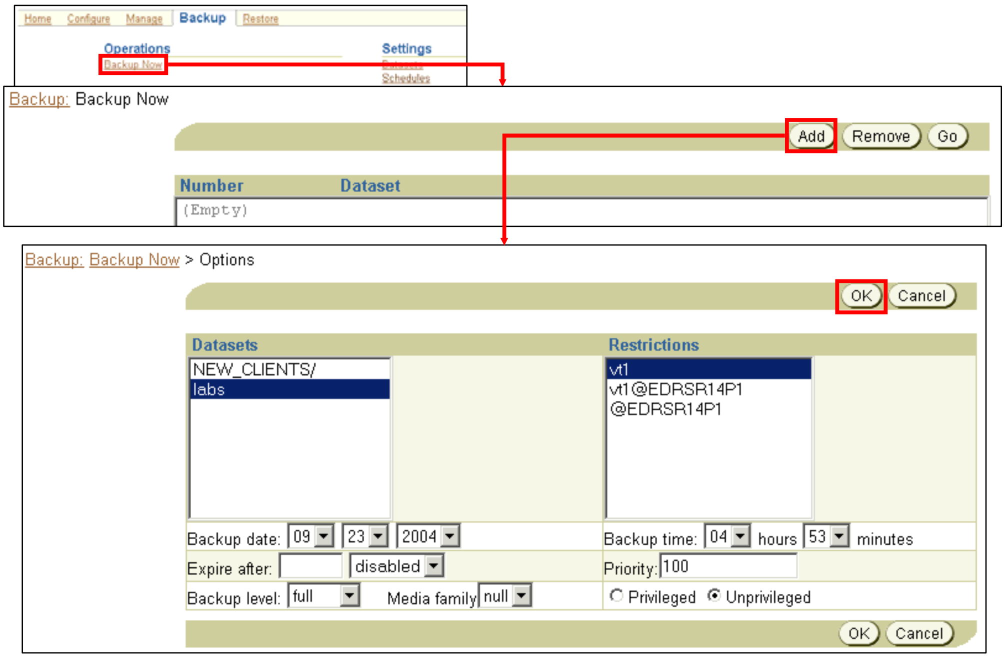
- Oracle Secure Backup creates a *data set job* for each scheduled backup request, or each time you explicitly request a backup using a data set. An example of such a job identifier is `admin/233`.
- At the scheduled start time for a data set job, Oracle Secure Backup creates one subordinate *backup job* for each host it includes. An example of such a job identifier is `admin/233.1`.
- Each time you explicitly request that Oracle Secure Backup restore data, Oracle Secure Backup creates a *restore job* for each backup image that must be read to effect the restore.
- RMAN creates an Oracle Secure Backup job with the `Oracle Secure Backup` type, instead of the `dataset` type. Rather than using the data set name, the RMAN job type contains the database name.

Oracle Secure Backup Jobs (continued)

Oracle Secure Backup keeps a log for each job. This log describes high-level events, such as the creation, dispatch, and completion times of the job.

Oracle Secure Backup also maintains a running transcript for each job. The transcript describes the details of the job's operation. Oracle Secure Backup creates this transcript when dispatching the job for the first time, and updates it as the job progresses. When a job requires operator assistance, Oracle Secure Backup prompts for assistance using the transcript.

Creating On-Demand Backup Requests

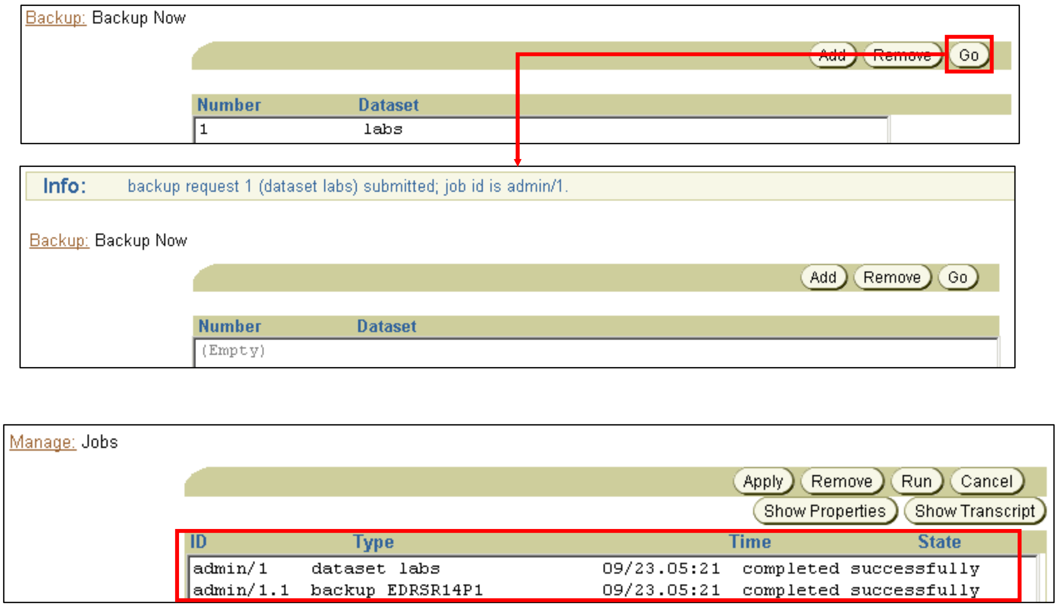


Creating On-Demand Backup Requests

To create an on-demand backup request with the Web interface, perform the following steps:

1. On the Backup tabbed page, click Backup Now. The Backup Now page appears.
2. To create a new backup, click the Add button. The Options page appears.
3. Select one or more data sets from the Datasets box.
4. Optionally, select a future date and time for the backup to run from the "Backup date" and "Backup time" drop-down lists. If you leave these fields unchanged, Oracle Secure Backup considers your backup job immediately "runnable."
5. Optionally, enter an expiration time in the "Expire after" field.
6. Select a backup level from the "Backup level" drop-down list. Your choices are: full (default), 1 to 9, incr, and offsite.
7. From the "Media family" drop-down list, select a media family to which the data of this backup should be assigned.
8. Optionally, select one or more device restrictions from the Restrictions box.
9. Optionally, change the priority (1–100) of the backup job in the Priority field. The lower this value, the greater the priority assigned to the job by the scheduler.
10. Click OK to accept your selections.

Sending Backup Requests to the Scheduler



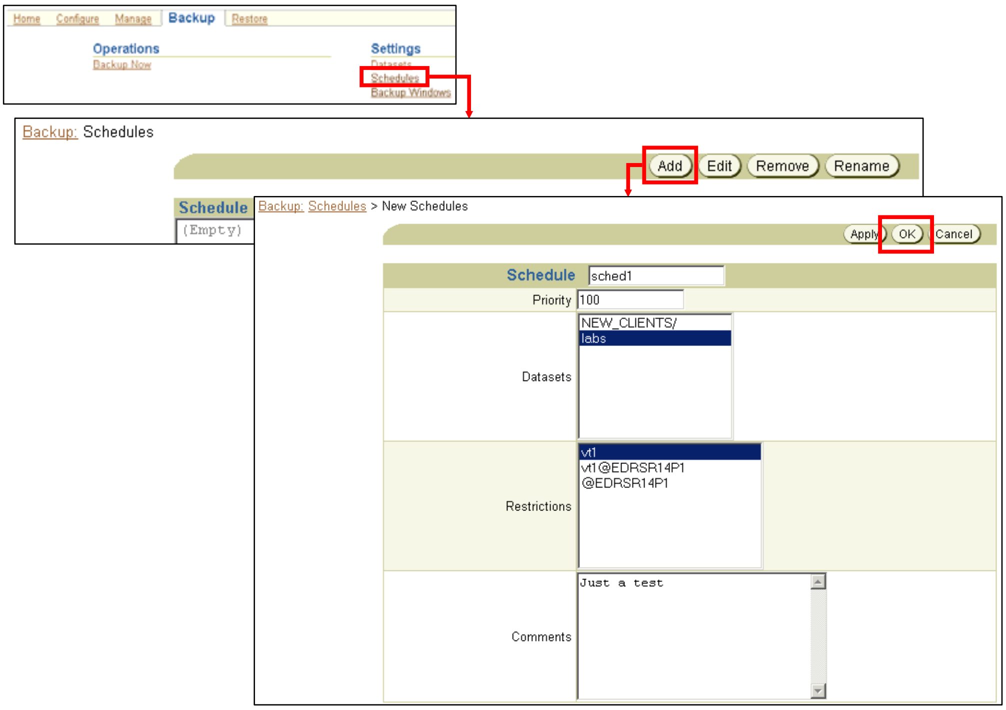
F-47

Sending Backup Requests to the Scheduler

To send backup requests to the scheduler by using the Oracle Secure Backup Web interface, perform the following steps:

1. On the Backup menu, click Backup Now in the submenu under Operations. The Backup Now page appears.
2. Click the Go button. Oracle Secure Backup sends each backup request that appears in the Number/Dataset central panel to the scheduler. A message appears in the status section for each request acknowledged by the scheduler.
   Oracle Secure Backup deletes each backup request upon its acceptance by the scheduler. As a result, the Number/Dataset central panel is empty upon completion of the Go operation.
3. To view the status of your job, access the Manage page, and click the Jobs link. On the Jobs page, you can see the output of your job as illustrated in the slide.

Creating Backup Schedules



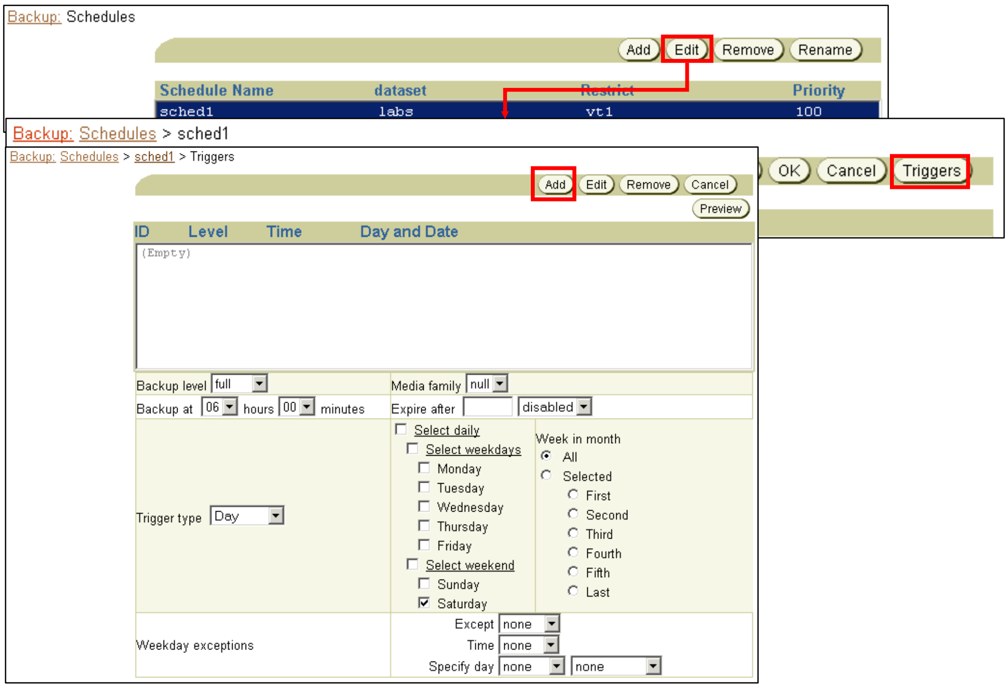
ORACLE

Creating Backup Schedules

A backup schedule tells Oracle Secure Backup what data to back up, and how to back up the data. Perform the following steps to create a schedule by using the Oracle Secure Backup Web interface:

1. On the Backup menu, click Schedules in the submenu under Settings. The Schedules page appears. Backup schedules appear in the “Schedule name” box in the central panel.
2. Click the Add button to add a new schedule. The New Schedules page appears.
3. Enter a name for the schedule in the Schedule field.
4. Enter a priority number for the backup job in the Priority field.
5. In the Datasets box, select one or more data sets that you want to include in the backup job.
6. Optionally, select a restriction in the Restrictions box. You can restrict scheduled backups to specific devices.
7. Optionally, enter any information that you want to store with the backup schedule in the Comments field.
8. Click OK to save your changes and return to the Schedules page.

Creating Backup Triggers

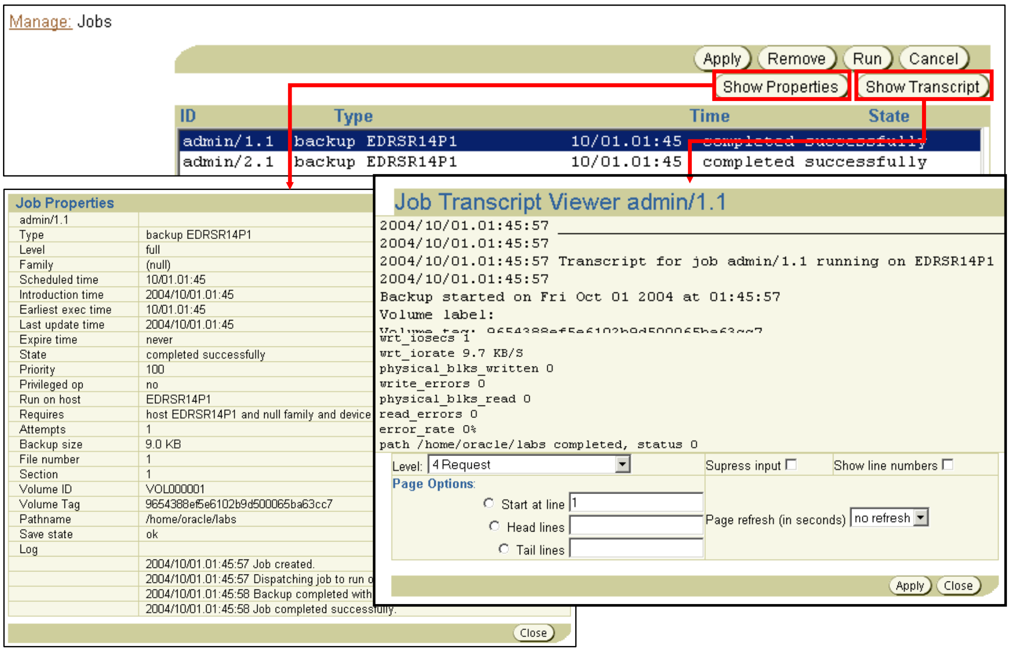


Creating Backup Triggers

A trigger is a calendar-based time at which a scheduled backup becomes eligible to run. Perform the following steps to create triggers by using the Oracle Secure Backup Web interface:

1. Go to the Backup Schedules page and select the schedule for which you want to add a trigger. Click Edit.
2. On the corresponding schedule page, click Triggers. The Triggers page appears with the default Day in the "Trigger type" field.
3. Using the "Trigger type" field, select a time representation that you want to use to define when to perform the backup job.
4. After this is done, complete the needed information, and click Add to accept your entries and add the trigger.

Viewing Job Properties and Transcripts



Viewing Job Properties and Transcripts

Perform the following steps to view a job's properties by using the Oracle Secure Backup Web interface:

1. On the Manage page, click the Jobs link in the Maintenance section. You are directed to the Jobs page. Select a job ID from the central panel of the Jobs page.
2. Click the Show Properties button. The Job Properties page appears showing the characteristics of the selected job.

Perform the following steps to view a job's transcript by using the Oracle Secure Backup Web interface:

1. Select a job from the job management table in the central panel of the Jobs page.
2. Click Show Transcripts. A transcript page appears.
3. Scroll down the page to view more information. At the end of the page, you can modify the transcript-viewing criteria.
4. Optionally, click the "Start at line" box and enter a line number at which you want the transcript view messages to start.
5. Optionally, select the "Suppress input" check box to suppress input requests. When a request for input is recognized, Oracle Secure Backup prompts for a response.
6. Click Apply to accept your changes, if any, and redisplay the transcript.

Restoring File System Files with Oracle Secure Backup

Two ways for restoring data

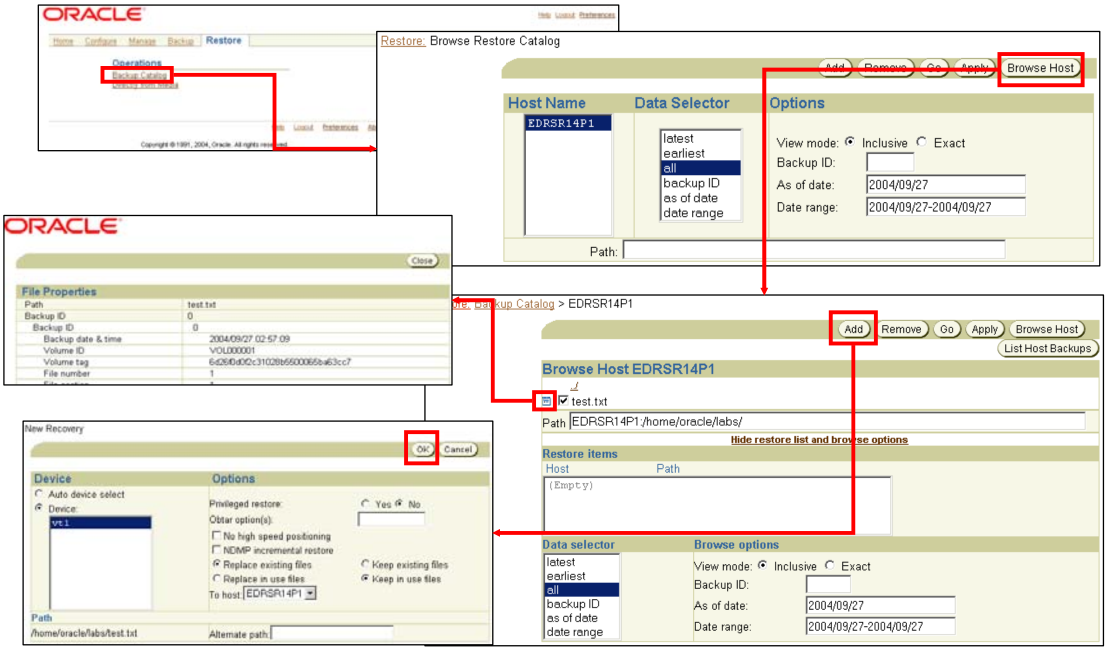
- Catalog-based restore: Based on catalog backups history
- Raw restore: Based on your memory

Restoring File System Files with Oracle Secure Backup

With Oracle Secure Backup, you can restore data in two different ways:

- By browsing backup catalogs for the file system objects of interest. After you have located their names and selected the instances to restore, you may direct Oracle Secure Backup to perform the restore. This is called catalog-based restore.
- By knowing the names of the file system objects of interest and the secondary storage location (volume ID and archive file number) in which they are stored. This is called raw restore.

Creating a Catalog-Based Restore Request

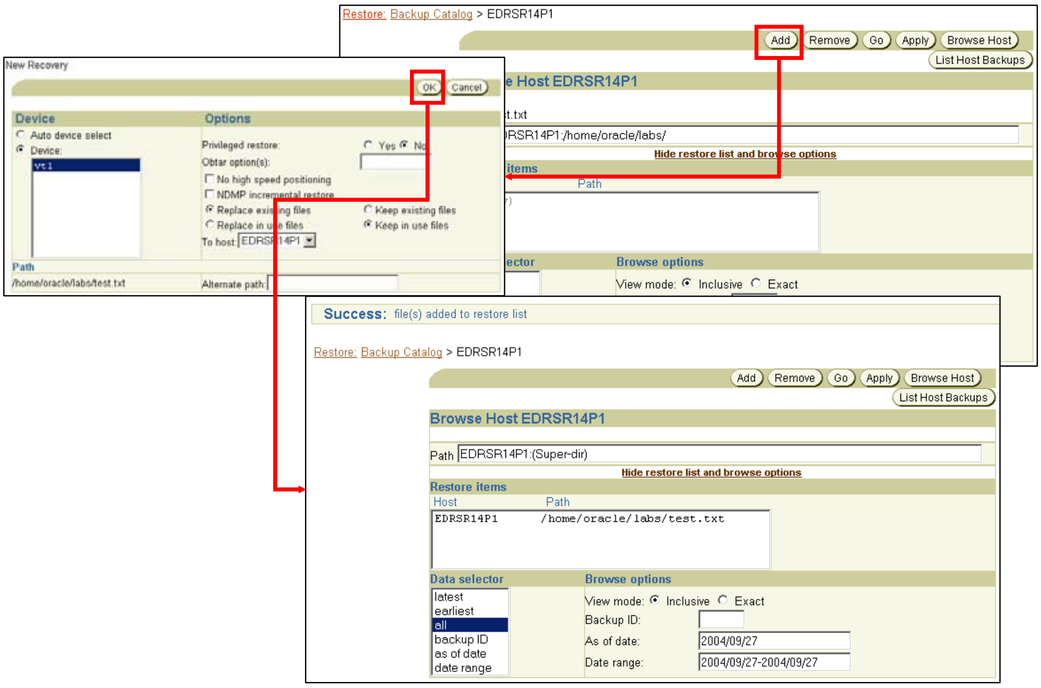


Creating a Catalog-Based Restore Request

To browse a backup catalog for data restore, perform the following steps:

1. On the home page, click the Restore tab. The Restore tabbed page appears.
2. On the Restore tabbed page, click the Backup Catalog link in the Operations section.
3. On the Browse Restore Catalog page that appears, select the client from which the data was originally saved in the Host Name list.
4. Select one or more data selectors from the Data Selector list.
5. Click Browse Host. The Browse Host page appears, with the selected directory displayed.
6. Click a directory name to make it your current directory and view its contents. You can repeat this operation many times to find the data you want to restore.
7. Select the check box next to the name of each file system file you want to restore. Doing so requests that Oracle Secure Backup restore each instance of the file identified by the data selector. To learn the identity of those instances, view the object’s properties page by clicking the adjacent Properties button.
8. Click the Add button. The New Recovery page appears.

Creating a Catalog-Based Restore Request



F-53

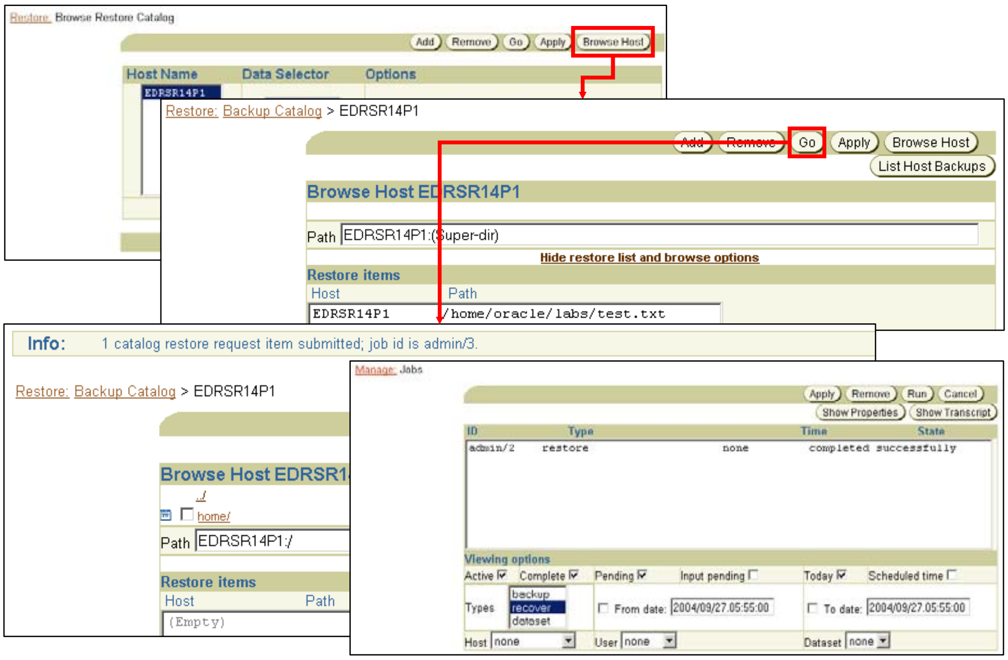
Creating a Catalog-Based Restore Request (continued)

9. Optionally, enter an alternate path name for each file or directory to restore. The original path name of each object you previously selected appears in the lower-left portion of this page. To its right is a text box in which you may enter the alternate path name. If you leave this blank, Oracle Secure Backup restores the data using its original name.
10. Optionally, click the Device option button and select a tape drive to use to perform the restore. By default, Oracle Secure Backup automatically selects the best drive to use.
11. Select “NDMP incremental restore” to direct certain NAS data servers to apply incremental restore rules. Normally, recoveries are additive: each file and directory restored from a full or an incremental backup is added to its destination directory. When you select NDMP incremental restore, NAS data servers that implement this feature restore each directory to its exact state as of the last incremental backup image applied during the restore job. Files that were deleted before the last incremental backup are deleted by the NAS data service upon restore of that incremental backup.

Creating a Catalog-Based Restore Request (continued)

12. Select “Replace existing files” to overwrite any existing files with those restored from the backup image. Alternatively, select “Keep existing files” to keep any existing files instead of overwriting them with files from the backup image.
13. Click OK. Oracle Secure Backup displays the Browse Host page. The restore request you just made appears in the “Restore items” list.

Sending Catalog-Based Restore Requests to the Scheduler



ORACLE

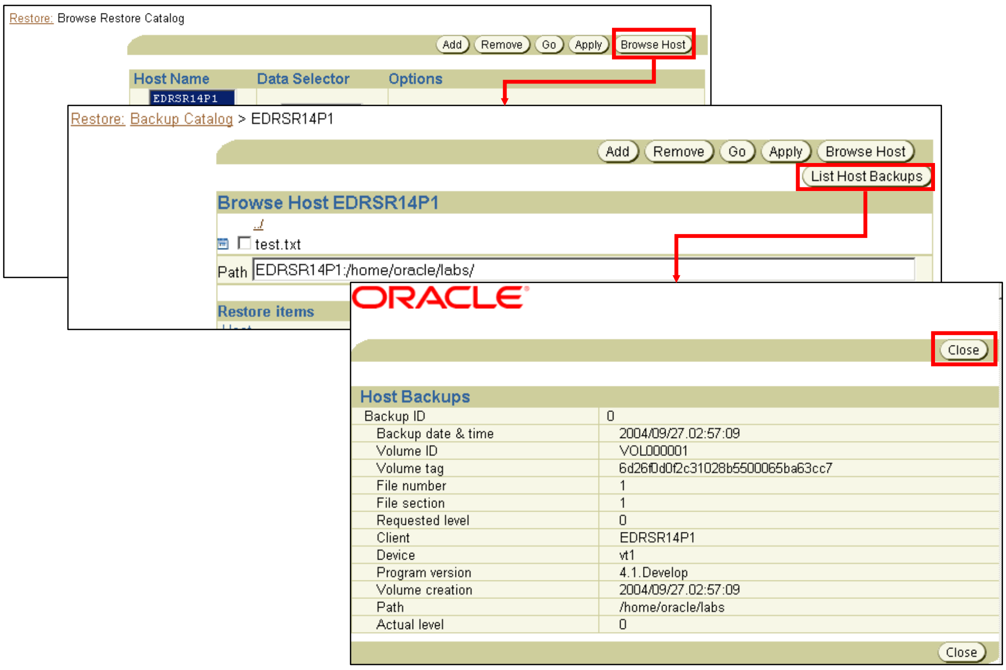
F-55

Sending Catalog-Based Restore Requests to the Scheduler

Perform the following steps to send catalog-based restore requests to the scheduler by using the Oracle Secure Backup Web interface:

1. On the Browse Restore Catalog page, select any host from the Host Name list.
2. Click Browse Host. Oracle Secure Backup displays the Browse Host page.
3. Click Go. The Web tool sends each restore request that appears in the “Restore items” list to the scheduler. A message appears in the status area for each request acknowledged by the scheduler. It might say, for example, `2 catalog restore request items submitted; job id is admin/2`. Oracle Secure Backup deletes each restore request upon its acceptance by the scheduler. As a result, the “Restore items” list box is empty upon completion of the Go operation.
4. To view the status of your job, go to the Manage page, and click the Jobs link. On the Jobs page, select “recover” in the Types field, and click Apply. You can see the output of your job.

Listing All Backups of a Client



Listing All Backups of a Client

Perform the following steps to list all backups of a client by using the Oracle Secure Backup Web interface:

1. On the Browse Restore Catalog page, select any host from the Host Name list.
2. Click Browse Host. Oracle Secure Backup displays the Browse Host page.
3. Click the List Host Backups button. A properties page appears. Click the Close button when you have finished viewing this window.

Summary

In this lesson, you should have learned how to:

- Describe the Oracle Secure Backup architecture and how it benefits your environment
- Discuss basic Oracle Secure Backup media management concepts
- Install and configure Oracle Secure Backup
- Use RMAN and Oracle Secure Backup to back up and restore the Oracle database
- Use Oracle Secure Backup to back up and restore file system files

ORACLE

Miscellaneous Topics

Appendix Overview

BFT
ROWID
TTG

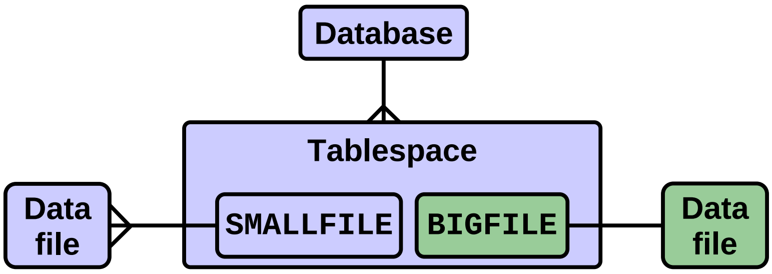
This appendix assists you to:

- Use bigfile tablespaces for very large databases (VLDB)
- Describe the row IDs for bigfile tablespaces
- Use temporary tablespace groups (TTG) for VLDB

G-2

Bigfile Tablespaces: Overview

- A bigfile tablespace contains a single file.
- The maximum file size ranges from 8 TB through 128 TB.
- Tablespaces are logically equivalent to data files.



Bigfile Tablespaces: Overview

A bigfile tablespace (BFT) is a tablespace containing a single file that has a very large size. The addressing scheme allows up to four billon blocks in a single data file, and the maximum file size can be 8 TB–128 TB depending on the Oracle block size.

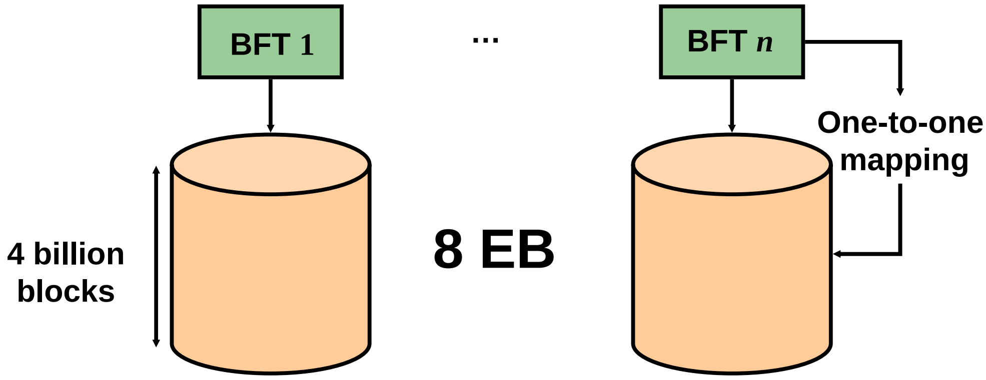
To distinguish a BFT from the traditional tablespace that can contain multiple, relatively small files, the traditional tablespace is referred to as a "smallfile" tablespace. An Oracle database can contain both bigfile and smallfile tablespaces.

The BFT concept eliminates the need for adding new data files to a tablespace. This simplifies manual or automatic management of the disk space (using Oracle Managed Files (OMF) or Automated Storage Management (ASM)) and provides data file transparency. The graphic in the slide shows the entity-relationship diagram of the Oracle database space management architecture. The one-to-many relationship between tablespaces and data files complicates the architecture and can create difficulties in managing disk space utilization whenever one tablespace is associated with hundreds of data files.

The BFT concept makes the notion of tablespaces logically equivalent to data files. **All operations traditionally performed on data files can be performed on tablespaces.**

Benefits of Bigfile Tablespaces

- Significantly increase the storage capacity
- Simplify data file management for large databases by making tablespaces the main units of disk space administration



Benefits of Bigfile Tablespaces

The purpose of using BFTs is to significantly increase the storage capacity of Oracle databases and, at the same time, simplify management of data files in large databases. This feature enables an Oracle database to contain up to eight exabytes (8,000,000 TB) of data. This allows you to store data in much larger files and, by doing so, to decrease the number of files in large databases. It also simplifies database management by providing data file transparency and making tablespaces the main units of disk space administration and backup and recovery. Calculate the maximum amount of data "`M`" that can be stored in the Oracle database by using the formula: `M = D * F * B`, where "`D`" is the maximum number of data files in the database, "`F`" is the maximum number of blocks per data file, and "`B`" is the maximum block size.

Availability of 64-bit operating systems that can handle much larger files and technologies that result in 500-GB hard drives within five years are good reasons to use BFTs.

Note: 1 PB = 1,024 TB ; 1 EB = 1,024 PB = 1,048,576 TB = 2^{60} bytes

Bigfile Tablespace: Usage Model

- BFTs are supported only for locally managed tablespaces using Automatic Segment Space Management.
- Use BFTs with logical volume managers or Automatic Storage Management.
- OMF provides complete data file transparency.

Database Block Size	Recommended Maximum Number of Extents
2 KB	100,000
4 KB	200,000
8 KB	400,000
16 KB	800,000

ORACLE

Bigfile Tablespace: Usage Model

BFTs are supported only for locally managed tablespaces with bitmapped segments, as well as locally managed `UNDO` and `TEMPORARY` tablespaces. (This is mainly because dictionary-managed tablespaces cannot address operations involving high space management activity as well as locally managed tablespaces.) Use BFTs with a logical volume manager or Automated Storage Management that supports striping, mirroring, and dynamically extensible logical volumes. You should avoid creating a BFT on a system that does not support striping because of negative implications for parallel executions.

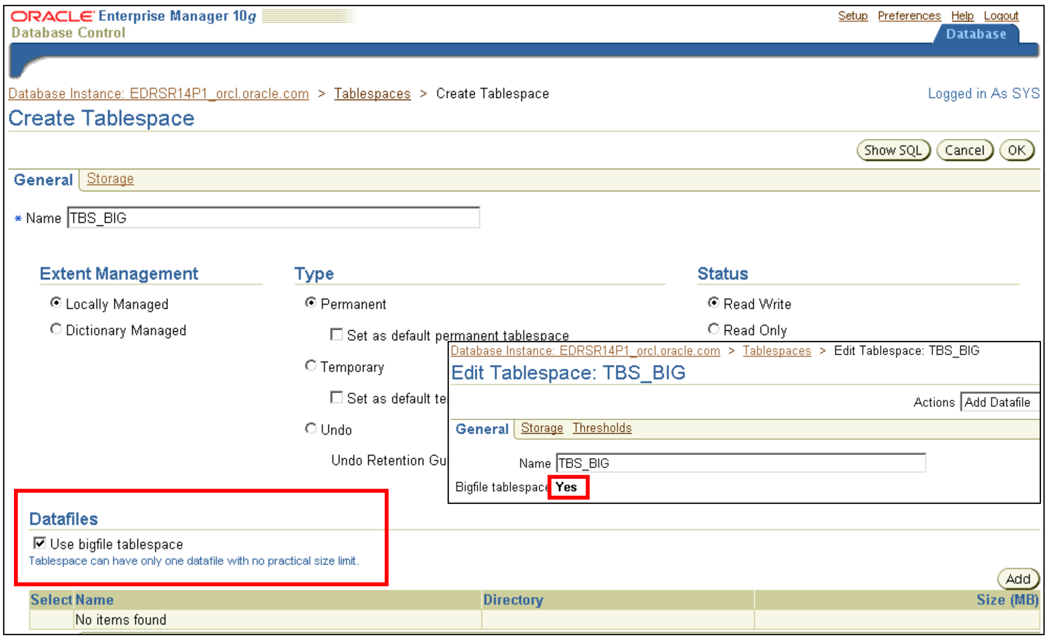
Using BFTs with OMF provides more benefits because of the higher degree of data file transparency. When using bigfile tablespaces, you should think about the extent size before creating such a tablespace. Although the default allocation policy is `AUTOALLOCATE`, you may want to change that default to `UNIFORM` with a large extent size when the file has a size in terabytes. Otherwise, `AUTOALLOCATE` is probably the best choice. The table in the slide gives you recommendations regarding the maximum number of extents depending on the block size.

Bigfile Tablespace: Usage Model (continued)

These figures are not a hard limit, but if more extents are created, there may be a performance penalty under high concurrency and during DDL operations involving high space management activity.

Note: Using BFTs on platforms that do not support large files can dramatically limit the tablespace's capacity.

Creating Bigfile Tablespaces

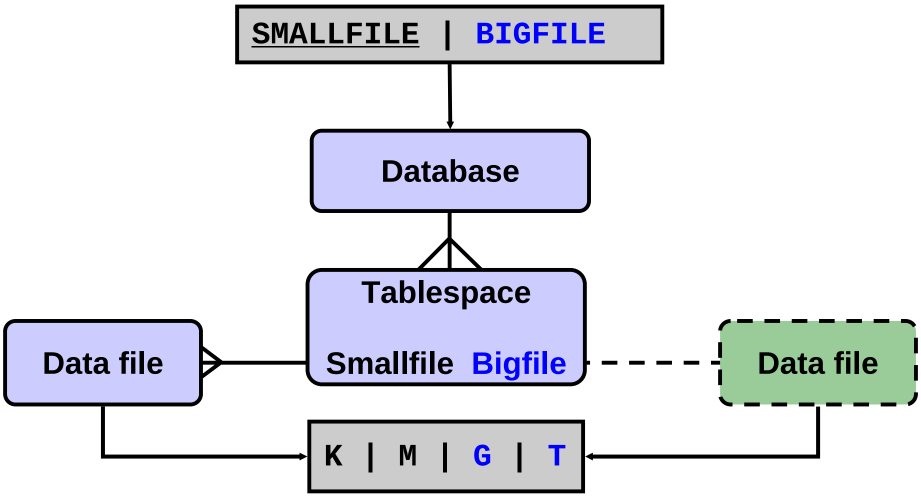


Creating Bigfile Tablespaces

You can use Database Control to create bigfile tablespaces. In Enterprise Manager, select Administration > Tablespaces. Click Create. On the Create Tablespace page, specify the tablespace name, and select the “Use bigfile tablespace” option in the Datafiles section.

Note: You can also determine whether a particular tablespace is a bigfile tablespace by looking at its corresponding Edit Tablespace page. On the General tabbed page, there is the “Bigfile tablespace” flag.

SQL Statement Clauses



SQL Statement Clauses

It is expected that, in most cases, you do not have to explicitly specify the tablespace type, and a default setting is used. The default tablespace type is a persistent database property stored in the data dictionary. You can set it by using the `CREATE DATABASE` command and change it by using the `ALTER DATABASE` command. If the parameter is not set by one of these commands, the default tablespace type for Oracle Database 10*g* is `SMALLFILE`. The default tablespace type setting is applied to all tablespaces being created unless it is explicitly overridden. Two keywords, `BIGFILE` and `SMALLFILE`, are used to override the default tablespace type, when creating a particular tablespace. These keywords can be used in the `DATAFILE` clause of all commands that create tablespaces.

In the `SIZE`, `MAXSIZE`, and `AUTOEXTEND` clauses, you can specify size in kilobytes "K," megabytes "M," gigabytes "G," and terabytes " T."

BFTs and SQL Statements: Examples

```
CREATE DATABASE
SET DEFAULT BIGFILE TABLESPACE
DATAFILE '/u0/data/system.dbf' SIZE 200M
SYSAUX DATAFILE '/u0/data/sysaux.dbf' SIZE 300M
SMALLFILE DEFAULT TEMPORARY TABLESPACE stemp_tbs
TEMPFILE '/u3/data/stemp_tbs1.dbf' SIZE 60M
SMALLFILE UNDO TABLESPACE sundo_tbs
DATAFILE '/u2/data/sundo_tbs1.dbf' SIZE 100M;
```
1

```
ALTER DATABASE SET DEFAULT BIGFILE TABLESPACE;
```
2

```
CREATE BIGFILE UNDO TABLESPACE bundo_tbs
DATAFILE '/u1/data/bundo_tbs.dbf' SIZE 1G;
```
3

```
ALTER TABLESPACE users RESIZE 2G;
```
4

```
ALTER TABLESPACE users AUTOEXTEND ON ;
```
5

ORACLE

G-9

BFTs and SQL Statements: Examples

- The tablespace type for SYSTEM and SYSAUX tablespaces is always the same as the default tablespace type at the time of creation of the database. The first statement creates a new database and sets the default tablespace type to BIGFILE. Then the statement uses the SMALLFILE keyword to override the database's default setting for the UNDO and DEFAULT TEMPORARY tablespaces.
- The second statement is used to dynamically change the default tablespace type. The new setting takes effect immediately after the statement gets executed. The setting defines the default type of the new tablespace being created but has no effect on existing tablespaces. In the example, the new default is set to BIGFILE.
- The third statement creates an UNDO tablespace as a BIGFILE tablespace.
- You can use the fourth statement to resize the unique data file contained inside the BIGFILE USERS tablespace.
- The last statement can be used to enable automatic file extension at the tablespace level. This is possible only for BIGFILE tablespaces.

Note: For more syntax information, see the *Oracle Database SQL Reference* guide.

Data Dictionary Additions To Support VLDB

```
SELECT property_value
FROM database_properties
WHERE property_name='DEFAULT_TBS_TYPE';
```

```
SELECT tablespace_name, bigfile
FROM DBA_TABLESPACES;
```

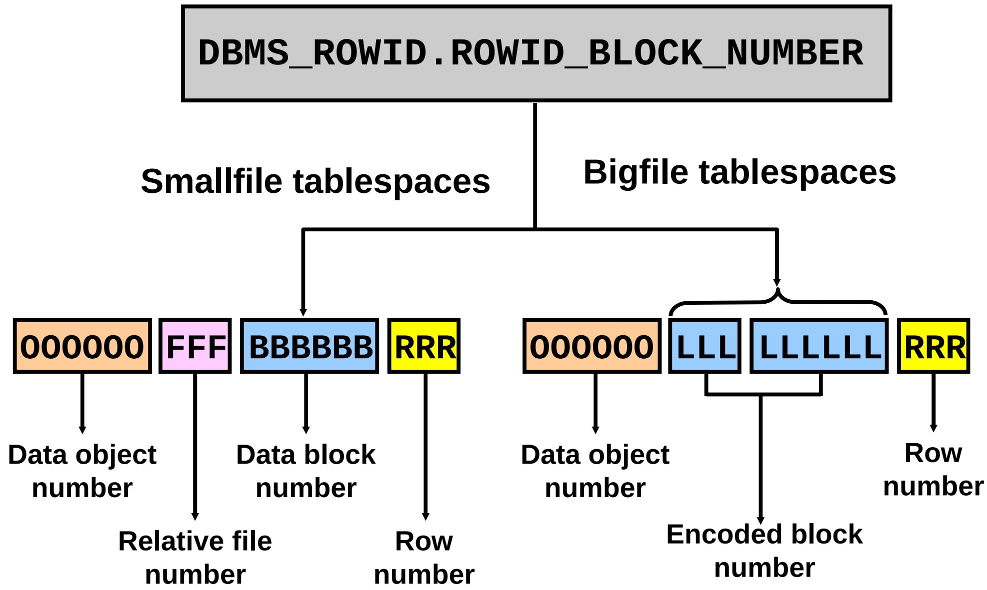
```
SELECT name, bigfile FROM V$TABLESPACE;
```


Data Dictionary Additions to Support VLDB

- `DATABASE_PROPERTIES` is a dictionary view that contains different database properties. A new row is added to this table to specify the default tablespace type for the database: `BIGFILE` or `SMALLFILE`.
- `DBA_TABLESPACES` displays information about all tablespaces in the database. A new column is added to this view to indicate whether a particular tablespace is bigfile (`YES`) or smallfile (`NO`). The same column is also added to `USER_TABLESPACES`.
- `V$TABLESPACE` contains information from the control file about all tablespaces in the database. A new column is added to this view to indicate whether a particular tablespace is bigfile (`YES`) or smallfile (`NO`).

Extended ROWID Format and BFTs

BFT
> ROWID
TTG



Extended ROWID Format and BFTs

The description of the extended ROWID format, for both previous releases and smallfile tablespaces, has a four-piece format, OOOOOOFFFBBBBBBRRR:

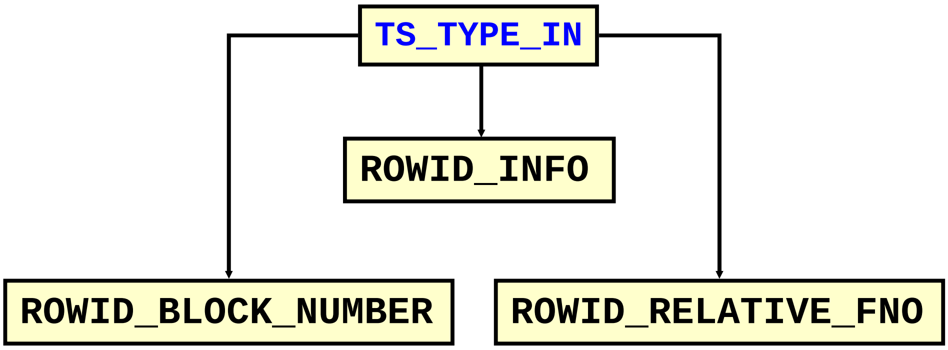
- OOOOOO is the data object number that identifies the database segment.
- FFF is the tablespace-relative data file number of the data file that contains the row.
- BBBBBB is the data block that contains the row. In smallfile tablespaces, block numbers are relative to their data file rather than their tablespace. Therefore, two rows with identical block numbers could reside in two different data files of the same tablespace.
- RRR is the slot number identifying the row inside a particular block.

In a bigfile tablespace, there is only one file that always has a relative file number equal to 1024. Therefore, there is no need to include the file number in row IDs, and both FFF and BBBBBB pieces are used to denote the block number. The concatenation of these two fields represents the "encoded block number," which can be much bigger compared to row IDs from traditional smallfile tablespaces. For BFTs, block numbers are relative to their tablespaces and are unique within a tablespace.

Extended ROWID Format and BFTs (continued)

With BFTs, the only supported way of getting components of extended row IDs is to use the DBMS_ROWID package. It is not recommended that you use any other means of extracting ROWID components. This implies that, in previous releases, user applications that do not use the DBMS_ROWID package to extract ROWID components are not able to recognize and correctly interpret row IDs from BFTs.

VLDB Support: DBMS_ROWID Package




```
SELECT DBMS_ROWID.ROWID_RELATIVE_FNO(ROWID,'BIGFILE')
FROM  employees;
```


VLDB Support: DBMS_ROWID Package

Using the DBMS_ROWID package, you can create row IDs and get components of existing row IDs. Because row IDs have different formats for bigfile and smallfile tablespaces, some functions and procedures of this package are changed to take into account the tablespace type when interpreting row IDs. The TS_TYPE_IN input parameter describes the type of tablespace to which a particular row belongs. The permissible values for this parameter are BIGFILE and SMALLFILE.

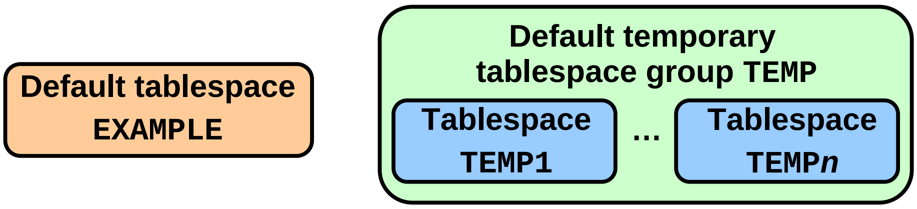
As shown, this parameter is added to the following procedures: ROWID_INFO, ROWID_BLOCK_NUMBER, and ROWID_RELATIVE_FNO.

Note: The only supported way of constructing an external or internal ROWID string corresponding to a BFT row is to use the ROWID_CREATE function with the RELATIVE_FNO argument set to 1024.

Temporary Tablespace Group (TTG): Overview

BFT
ROWID
> TTG

- Groups multiple temporary tablespaces
- Characteristics:
  – At least one temporary tablespace
  – Same namespace as tablespaces
  – Created implicitly on first assignment
  – No explicit deletion



Temporary Tablespace Group (TTG): Overview

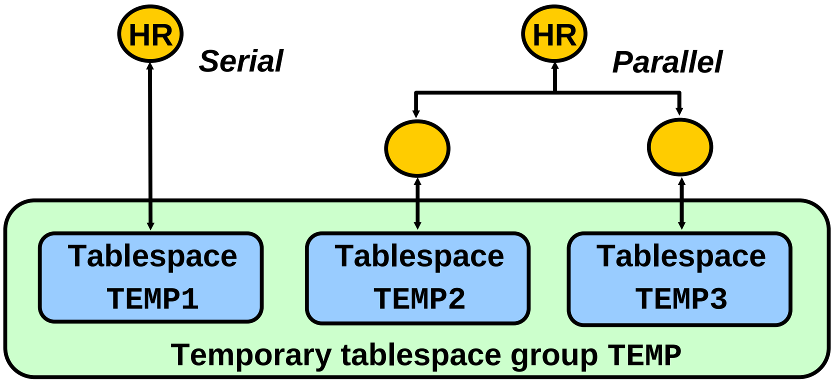
You can think of a temporary tablespace group as a shortcut for a list of temporary tablespaces. A temporary tablespace group consists of only temporary tablespaces and has the following properties:

- It contains at least one temporary tablespace. There is no explicit limit on how many tablespaces are contained in a group.
- It has the same namespace as tablespaces. It is not possible for a tablespace and a temporary tablespace group to have the same name.
- A temporary tablespace group name can appear wherever a temporary tablespace name appears (for example, while assigning a default temporary tablespace for the database, or assigning a temporary tablespace for a user).
- It is not explicitly created. It is created implicitly when the first temporary tablespace is assigned to it, and it is deleted when the last temporary tablespace is removed from the group.

Temporary Tablespace Group: Benefits

Enables the use of multiple temporary tablespaces:

- **For the same user in multiple sessions**
- **For slave processes in one parallel operation**
- **For configuration at database level**



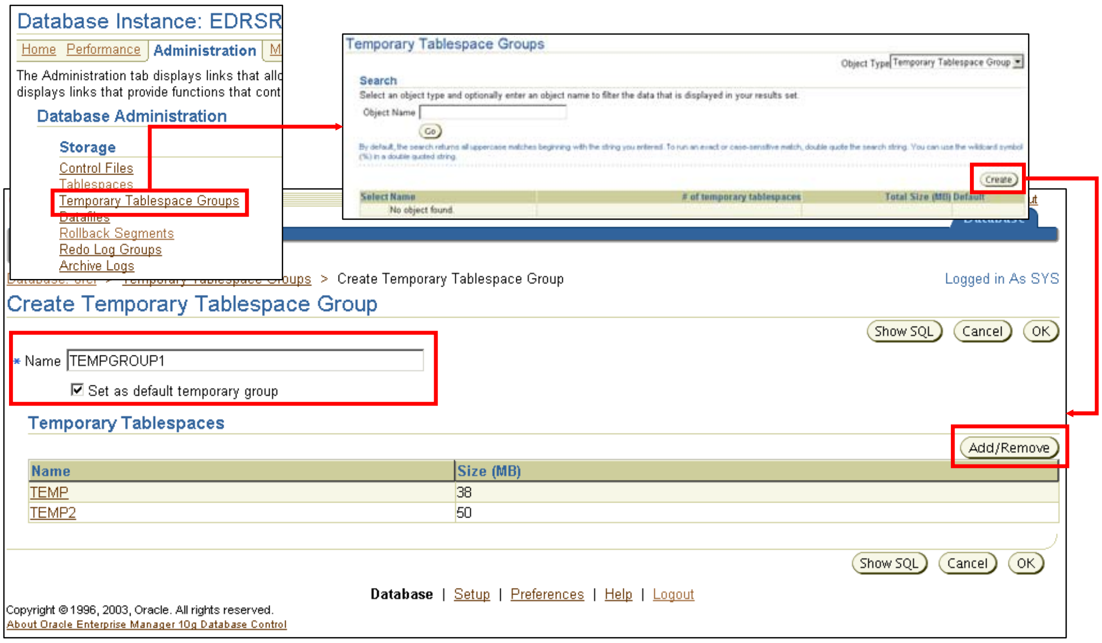
Temporary Tablespace Group: Benefits

This feature has the following benefits:

- Enables one particular user to use multiple temporary tablespaces in different sessions at the same time
- Enables the slave processes in a single parallel operation to use multiple temporary tablespaces
- Enables multiple default temporary tablespaces to be specified at the database level

Therefore, you can now define more than one default temporary tablespace, and a single SQL operation can use more than one temporary tablespace for sorting. This prevents large tablespace operations from running out of temporary space. This is especially relevant with the introduction of bigfile tablespaces.

Creating and Maintaining Temporary Tablespace Groups



ORACLE

Creating and Maintaining Temporary Tablespace Groups

You can create and maintain temporary tablespace groups by using Database Control. Select Administration > Temporary Tablespace Groups. This displays the Temporary Tablespace Groups page, where you can see a list of existing tablespace groups. On this page, you can view and edit existing tablespace groups.

When you click the Create button, the Create Temporary Tablespace Group page is displayed. Enter the name and specify whether or not you want this group to be set as the default temporary group. You can do this by selecting the “Set as default temporary group” option. After selecting this option, you need to add existing temporary tablespaces to the group. Click the Add/Remove button, and select the temporary tablespaces that belong to the group. Then, click the OK button to create the TTG.

When you edit a TTG, also use the Add/Remove button, and then click Apply.

Note: If you remove all temporary tablespaces from a temporary tablespace group, then the group is also removed implicitly.

Temporary Tablespace Group: SQL Examples

```
CREATE TEMPORARY TABLESPACE temp1 TEMPFILE 'tmp1.f'
SIZE 100M TABLESPACE GROUP group1;
```
1

```
CREATE TEMPORARY TABLESPACE temp2 TEMPFILE 'tmp2.f'
SIZE 200M TABLESPACE GROUP group2;
```
2

```
CREATE TEMPORARY TABLESPACE temp3 TEMPFILE 'tmp3.f'
SIZE 50M TABLESPACE GROUP '';
```
3

Temporary Tablespace Group: SQL Examples

The first and the second SQL statements shown in the slide implicitly result in the creation of two temporary tablespace groups (`GROUP1` and `GROUP2`) that contain one temporary tablespace each: `TEMP1` and `TEMP2`, respectively.

The third statement creates the temporary tablespace `TEMP3`. This tablespace does not belong to any group.

Note: The use of `''` indicates the lack of a group. This is exactly equivalent to the following statement:

```
CREATE TEMPORARY TABLESPACE temp3 TEMPFILE 'tmp3.f' SIZE 50M;
```

Temporary Tablespace Group: SQL Examples

```
ALTER TABLESPACE temp3 TABLESPACE GROUP group2;
```
1

```
ALTER TABLESPACE temp2 TABLESPACE GROUP '';
```
2

```
ALTER TABLESPACE temp1 TABLESPACE GROUP group2;
```
3

```
ALTER DATABASE DEFAULT TEMPORARY TABLESPACE group2;
```
4

```
CREATE USER hr IDENTIFIED BY hr DEFAULT
TABLESPACE TS1 TEMPORARY TABLESPACE group2;
```
5

```
ALTER USER hr TEMPORARY TABLESPACE group2;
```
6

ORACLE

Temporary Tablespace Group: SQL Examples (continued)

These examples give you an idea of the various uses of temporary tablespace groups. They are described in order:

- The first statement adds the TEMP3 tablespace to the GROUP2 group, which now has the TEMP2 (from the previous example) and TEMP3 tablespaces. If GROUP2 does not exist, then it is created.
- The second statement removes the TEMP2 tablespace from the GROUP2 group, which now contains only the TEMP3 tablespace.
- The third statement moves the TEMP1 tablespace from GROUP1 to GROUP2. GROUP1 is implicitly deleted because TEMP1 was the only tablespace in it.
- The fourth statement sets all the tablespaces in the GROUP2 tablespace group as the default temporary tablespaces for the database. All database users that do not have temporary tablespaces specified can create temporary segments in either TEMP1 or TEMP3.
- The fifth statement creates the HR user with the temporary tablespace group GROUP2.
- The last statement alters the HR user to use the GROUP2 tablespace group.

Temporary Tablespace Group: SQL Examples (continued)

Note: An implication of a tablespace being listed as a default temporary tablespace is that it cannot be dropped unless it is first excluded from the list of default temporary tablespaces. Extending this concept, if a tablespace group is specified as the default temporary tablespace for the database, none of the tablespaces in that group can be dropped.

Summary

BFT
ROWID
TTG

In this appendix, you should have learned how to:

- Use bigfile tablespaces for very large databases (VLDB)
- Describe the row IDs for bigfile tablespaces
- Use temporary tablespace groups (TTG) for VLDB

ORACLE

G-20

Next Steps: Continuing Your Education

Where Do You Go from Here?

“To stay competitive in the tech industry, never stop learning. Always be on the lookout for better ways of doing things and new technologies. Our industry does not reward people who let themselves stagnate”

–John Hall, Senior Vice President, Oracle University

Here are a few resources to help you with continuing your education.

ORACLE

Continuing Education Resources

The resources to learn more about administering Oracle Database 10*g* include:

- Oracle University Web site
- Oracle University Knowledge Center
- Oracle Technology Network:
  - Oracle by Example
  - Oracle Magazine
- Technical support: Oracle *Meta*Link

H-3

Oracle University

Learn Oracle from Oracle! No one knows Oracle technology better than Oracle University.

- **Worldwide education services**
- **Consistently high customer satisfaction**
- **Learn with the format that best suits *your* needs:**
  - **Instructor-Led Inclass Training**
  - **Live Web Class**
  - **Self-Study CD-ROMs**

Oracle University
http:// www.oracle.com/education

ORACLE

H-4

Oracle University

Oracle University is the world's largest corporate educator with education centers around the globe and has one of the highest customer satisfaction ratings in the industry (over 95%). Oracle University instructors are experts on Oracle technology and can help you get the most from your software.

Continuing Your Education

- **Grid technology specialty courses**
  - **Oracle Enterprise Manager 10*g* Grid Control**
  - **Oracle Database 10*g*: Real Application Clusters**
  - **Oracle Database 10*g*: Implement Streams**
  - **Oracle Database 10*g*: Data Guard Administration**
- **Other specialty courses**
  - **Oracle Database 10*g*: Performance Tuning**
  - **Oracle Database 10*g*: Security**
  - **Oracle Database 10*g*: Security**
  - **Oracle Database 10*g*: Implement and Administer a Data Warehouse**
  - **Oracle Spatial 10*g*: Fundamentals**

ORACLE

H-5

Continuing Your Education

After completing the “Oracle Database 10*g*: Administration Workshop II” course, you can continue with specialty courses. Consult Oracle University’s Web site for an up-to-date list of all courses.

Other specialty courses include:
- Oracle Spatial 10*g*: Advanced
- Oracle HTML DB 2.0: Develop Applications
- Oracle Database 10*g*: Develop XML Applications in PL/SQL

Oracle University Knowledge Center

Extend your learning with the Knowledge Center to gain access to thousands of hours of training on everything from fundamental SQL to advanced database topics. Topics of interest include:

- **Oracle Database 10*g*: Manage Jobs with the Scheduler**
- **Oracle Database 10*g*: Maximize Performance—General Enhancements**
- **OCA and OCP preparation material**

LEARN ORACLE FROM ORACLE | Oracle University

http://ilearning.oracle.com

ORACLE

Oracle University Knowledge Center

Oracle University Knowledge Center contains thousands of hours of content on a variety of topics. This content can be accessed 24/7 via the Web and is a great way to refresh your memory on things that you may not have worked with for a while or to learn about new concepts.

Additional content for the Oracle University Knowledge Center is being developed continuously, so make sure to check back often to see what is new.

Oracle Technology Network

Oracle Technology Network is a *free* resource with information about the core Oracle software products, including database, Application Server, Collaboration Suite, and development tools. You can have access to:

- **Technology centers**
- **Discussion forums**
- **Software downloads**
- **Online documentation**
- **Oracle by Example**
- **Code samples**

and much more!

ORACLE Technology NETWORK

http://www.oracle.com/technology

ORACLE

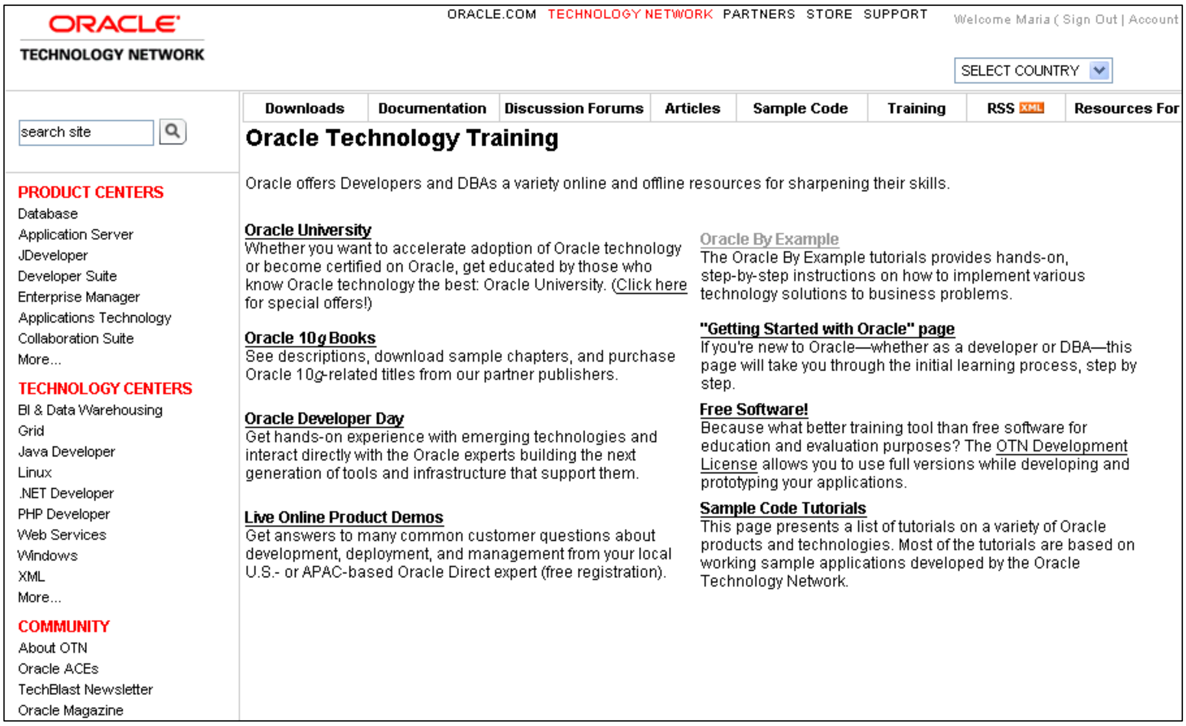
H-7

Oracle Technology Network

Oracle Technology Network (OTN) hosts the latest news about Oracle technology and products. Additionally, OTN provides peer-to-peer forums, white papers, security bulletins, and other vital information for the Oracle professional.

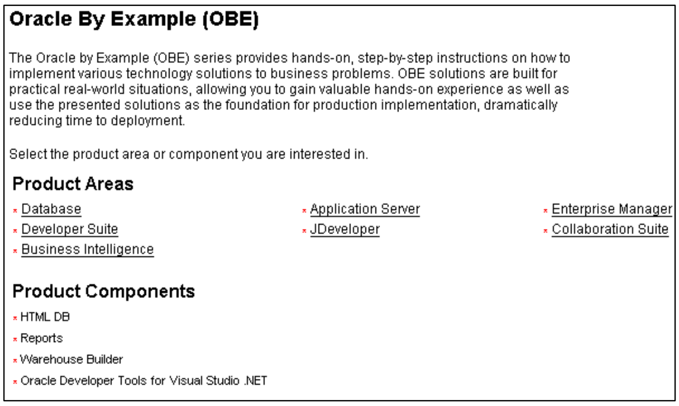
In addition to tips, tricks, and techniques for getting the most out of your Oracle software, you can download that software from OTN. Remember: All software downloads are free, and each comes with a development license that allows you to use full versions of the products only when developing and making prototypes for your applications.

Oracle Technology Training



Oracle by Example

- **What is an OBE?**
  A set of hands-on, step-by-step instructions
- **Where can I find them?**
  http://www.oracle.com//technology/obe
- **What is available?**
  More than 100 database OBEs



ORACLE

H-9

Oracle by Example

The Oracle by Example (OBE) series provides hands-on, step-by-step instructions on how to use various new features of Oracle products. OBEs help to reduce the time spent on learning a new product capability and enhance the users' understanding of how the feature can be implemented in their environment. Currently, OBEs are available for the Oracle database, Oracle Application Server, and Oracle Collaboration Suite. OBEs can be accessed at http://www.oracle.com/technology/obe.

Oracle Magazine

- Free subscription
- Oracle Magazine Archives

  http://www.oracle.com/technology/oramag/index.html

ORACLE
MAGAZINE
Oracle Magazine Archives

ORACLE

H-10

Oracle Magazine

Among the many different types of resources to which you have access from OTN is Oracle Magazine. You can receive your free subscription also by mail.

Oracle Applications Community

Oracle Technology Network is a resource for Oracle Applications users and implementers. You can have access to:

- **Discussion Forums**
- **User Groups**
- **Online Chat**
- **Documentation**
- **Training**
- **Upgrade Information**

and much more!

http://www.oracle.com/technology/community/apps/index.html

Technical Support: Oracle *Meta*Link

Access to Oracle *Meta*Link is included as part of your annual support maintenance fees. In addition to the most up-to-date technical information available, *Meta*Link gives you access to:

- **Service requests (SRs)**
- **Certification matrices**
- **Technical forums monitored by Oracle experts**
- **Software patches**
- **Bug reports**

MetaLink

http://metalink.oracle.com

H-12

Oracle *Meta*Link

Oracle *Meta*Link is your gateway to Oracle’s Support resources. Here, you find answers to the most common issues facing Oracle administrators and developers, as well as resources to solve many of those issues.

Like Oracle Technology Network, *Meta*Link includes the most recent headlines about issues that affect the Oracle professional.

Thank You!

We hope your experience with Oracle University has been enjoyable. We welcome your feedback on how we can improve to better meet your needs:

- **End-of-course evaluations**
- **Oracle University Office of Customer Satisfaction**
- **Oracle Education Services**

We hope to see you in class again soon.

ORACLE

Thank You!

Oracle University's mission is to enhance the adoption of Oracle technology. Our goal is to partner with you, providing information that is pertinent, timely, and relevant to your needs.

Please take a minute to complete the end-of-course evaluation and let us know how we can serve you better. In the U.S., feel free to e-mail our office of customer satisfaction at:

`customersat_us@oracle.com`

If you have questions about continuing your Oracle education, need help finding a class, or want to arrange for on-site training at your company, contact Oracle Education Services for assistance. In the U.S., dial 800.529.0165. For contact numbers outside the U.S., visit the following Web site:

http://www.oracle.com/education/index.html?contact.html

Thanks again and hope to see you in another class!

Index

A

B

D

E

F

G

O

P

R

R

R

S

S