Oracle8*i*

Backup and Recovery Guide

Release 2 (8.1.6)

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Oracle8*i* Backup and Recovery Guide, Release 2 (8.1.6)

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Primary Author: Connie Dialeris, Joyce Fee, Lance Ashdown

Contributing Authors: Greg Pongracz, Francisco Sanchez, Steve Wertheimer

Contributors: Richard Anderson, Don Beusee, Bill Bridge, Sandra Cheevers, Mike Cusson, Rick Frank, John Frazzini, Tim Berry-Hart, Wei Hu, Mike Johnson, Joy Kundu, Gordon Larimer, Bill Lee, Juan Loaiza, Diana Lorentz, Eric Magrath, Alok Pareek, Lyn Pratt, Thomas Pystynen, Daniel Semler, Slartibartfast, Bob Thome, Ron Weiss.

Graphic Designer: Valarie Moore

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Preface

Welcome to the world of Oracle backup and recovery. This guide includes the conceptual and task-oriented information you need to:

- Understand what backup and recovery is and how it works.
- Perform backup, restore, and recovery procedures using operating system (O/S) commands.

The *Oracle8i Backup and Recovery Guide* contains information that describes the features and functionality of the Oracle8*i* Standard Edition and the Oracle8*i* Enterprise Edition products. The Standard Edition and Enterprise Edition have the same basic features, but several advanced features are available only with the Enterprise Edition, and some of these are optional.

See Also:

- *Oracle8i Recovery Manager User's Guide and Reference* for concepts, procedures, and reference material related to the Recovery Manager utility
- *Oracle8i Standby Database Concepts and Administration* for information about the standby database
- *Getting to Know Oracle8i* for information for the differences between Oracle8*i* Standard Edition and the Oracle8*i* Enterprise Edition and the features and options that are available to you

What's New in Oracle8*i*?

This section describes new features in Oracle8*i*.

Release 8.1.6

Oracle release 8.1.6 contains a number of improvements that provide more robust protections against the following types of data corruption:

- Logical corruptions. Logical data corruptions are typically caused by software bugs and are difficult to repair because these corruptions are in the redo stream. You can prevent most logical corruptions by enabling block checking, which can detect and roll back changes that corrupt the database. Block checking is improved in these ways:
  - Oracle checks more block types, such as rollback blocks, transaction table blocks, and segment headers.
  - Block checking is more efficient, checking more blocks without increasing system overhead.
  - Block checking is always turned on for the SYSTEM tablespace, regardless of the setting of the DB_BLOCK_CHECKING initialization parameter.
- Memory corruptions. If block checking is turned on, then DBW*n* performs block checking immediately before writing a block to disk. This check enables Oracle to catch some memory corruptions and automatically repair corrupted blocks.
- Physical data corruptions caused by disks or storage systems. Typically, Oracle detects these corruptions through a checksum. Oracle release 8.1.6 always performs a checksum in the SYSTEM tablespace, regardless of the DB_BLOCK_CHECKSUM parameter setting.

  If the checksum fails when Oracle reads the control file or redo logs, then Oracle rereads the data from either a different log or the same member in situations where previous Oracle releases would not reread. Consequently, Oracle has a second chance to find a good copy of the data and repair any physical data corruption.

Release 8.1.5

The following backup and recovery features are new in release 8.1.5:

- You can temporarily suspend and then resume database operations without shutting down the database (see "Making Backups in SUSPEND Mode" on page 4-9).

- You can use transportable tablespaces to perform tablespace point-in-time recovery (TSPITR) (see "Performing TSPITR Using Transportable Tablespaces" on page 7-25).
- The LOG_ARCHIVE_DEST_*n* (where *n* is an integer from 1 to 5) initialization parameter allows you to archive to up to 5 locations (see "Archiving Redo Logs to Multiple Locations" on page 2-21).

Structure

This book contains the following parts and chapters.

Part / Chapter	Contents
PART 1	**Developing a Backup and Recovery Strategy**
Chapter 1, "What Is Backup and Recovery?"	Offers a general overview of backup and recovery concepts and methods.
Chapter 2, "Managing Data Structures"	Describes how to manage control files, online redo logs, and archived redo logs for backup and recovery.
Chapter 3, "Developing a Backup and Recovery Strategy"	Provides guidelines for developing a backup and recovery strategy.
PART 2	**Using Operating System Commands for Backup and Recovery**
Chapter 4, "Performing Operating System Backups"	Provides step-by-step instructions for performing operating system backups.
Chapter 5, "Performing Media Recovery"	Provides step-by-step instructions for performing media restore and recovery using operating system and SQL*Plus commands.
Chapter 6, "Media Recovery Scenarios"	Describes the procedures for performing media recovery in several common scenarios.
Chapter 7, "Performing Operating System Tablespace Point-in-Time Recovery"	Provides planning guidelines and step-by-step instructions for manually performing tablespace point-in-time recovery.

Changes to This Book

The following aspects of this manual are new in release 8.1.6:

- In release 8.1.5, all the backup and recovery documentation was located in the *Oracle8i Backup and Recovery Guide*. In release 8.1.6, this documentation is divided into the following books:

- *Oracle8i Backup and Recovery Guide*
- *Oracle8i Recovery Manager User's Guide and Reference*
- *Oracle8i Standby Database Concepts and Administration*

Audience

This guide is for database administrators (DBAs) who administer the backup, restore, and recovery operations of an Oracle database system using operating system commands.

Knowledge Assumed of the Reader

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

Conventions

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

Text

This section explains the conventions used within the text:

UPPERCASE Characters

Uppercase text is used to call attention to tablespace names, initialization parameters, and SQL keywords.

For example, "If you create a private rollback segment, the name must be included in the ROLLBACK_SEGMENTS parameter of the initialization parameter file. You can view this information by issuing a SHOW PARAMETER statement in SQL*Plus."

Italicized Characters

Italicized words within text are book titles, new vocabulary, emphasized words, or variables in SQL or Recovery Manager syntax.

For example, "An *archived redo log* is an online redo log that has been copied offline. You *must* run your database in ARCHIVELOG mode to enable this feature. If you are using Recovery Manager, you can specify an archived redo log in a **backup** command by using the **archivelog like** *'/oracle/archive/arc_*'* subclause."

Bold Characters

Bold words within text are Recovery Manager keywords.

For example, "Use the Recovery Manager **backup** command to back up your database."

`Monospaced` Characters

Filenames, directories, and operating system commands appear in a monospaced font. Also, monospaced characters in text preceding a code example indicates a filename or keyword used in the sample code.

For example, "If you do not want to use a command such as the UNIX `cp` to perform the backup of `/oracle/dbs/df1.f`, then you can execute an RMAN job as follows:

```
run {
     allocate channel c1 type disk;
     backup datafile '/oracle/dbs/df1.f';
}
```

Recovery Manager Syntax Diagrams and Notation

For information about Recovery Manager syntax conventions, see the *Oracle8i Recovery Manager User's Guide and Reference*.

Code Examples

SQL, SQL*Plus, and Recovery Manager commands and statements appear separated from the text of paragraphs in a monospaced font. For example:

```
INSERT INTO emp (empno, ename) VALUES (1000, 'SMITH');
ALTER TABLESPACE users ADD DATAFILE 'users2.ora' SIZE 50K;
run {
     allocate channel ch1 type disk;
     backup database;
```

```
}
```

When you run RMAN from the command line, the command prompt appears as `RMAN>`. When you issue commands from the SQL*Plus command line, the prompt appears as `SQL>`. These prompts are displayed in the code examples only when they are necessary to prevent confusion.

You can execute SQL, SQL*Plus, and RMAN commands in different environments on different platforms. As much as possible, this guide attempts to provide generic documentation, that is, documentation that is not specific to any operating system or interface. Nevertheless, it is sometimes necessary for illustrative purposes to show how the syntax works at the operating system level. In these cases, this book uses examples from a UNIX command-line interface and employs the % symbol to indicate the operating system prompt. For example:

```
% rman target / rcvcat rman/rman@inst2
RMAN> startup
```

How to Use This Guide

Every reader of this guide is presumed to have read:

- The beginning of the *Oracle8i Concepts* manual, which provides an overview of the concepts and terminology related to Oracle and a foundation for the more detailed information in this guide. The rest of the *Oracle8i Concepts* manual explains the Oracle architecture and features in detail.
- The chapters in the *Oracle8i Administrator's Guide* that deal with managing the control file, online redo logs, and archived redo logs.

You will often need to refer to the following reference guides:

- *Oracle8i SQL Reference*
- *Oracle8i Reference*

Your Comments Are Welcome

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Part I

Developing a Backup and Recovery Strategy

1

What Is Backup and Recovery?

This chapter introduces database concepts that are fundamental to backup and recovery. It is intended as a general overview. Subsequent chapters explore backup and recovery concepts in greater detail.

This chapter includes the following topics:

What Is Backup and Recovery?

A *backup* is a copy of data. This copy can include important parts of your database such as the control file and datafiles. A backup is a safeguard against unexpected data loss and application errors; if you lose the original data, then you can use the backup to reconstruct it.

Backups are divided into *physical backups* and *logical backups*. Physical backups, which are the primary concern of this guide, are copies of physical database files. In contrast, logical backups contain data that you extract using the Oracle Export utility and store in a binary file. You can use logical backups to supplement physical backups. You can make physical backups using either the Oracle8*i* Recovery Manager utility or operating system utilities.

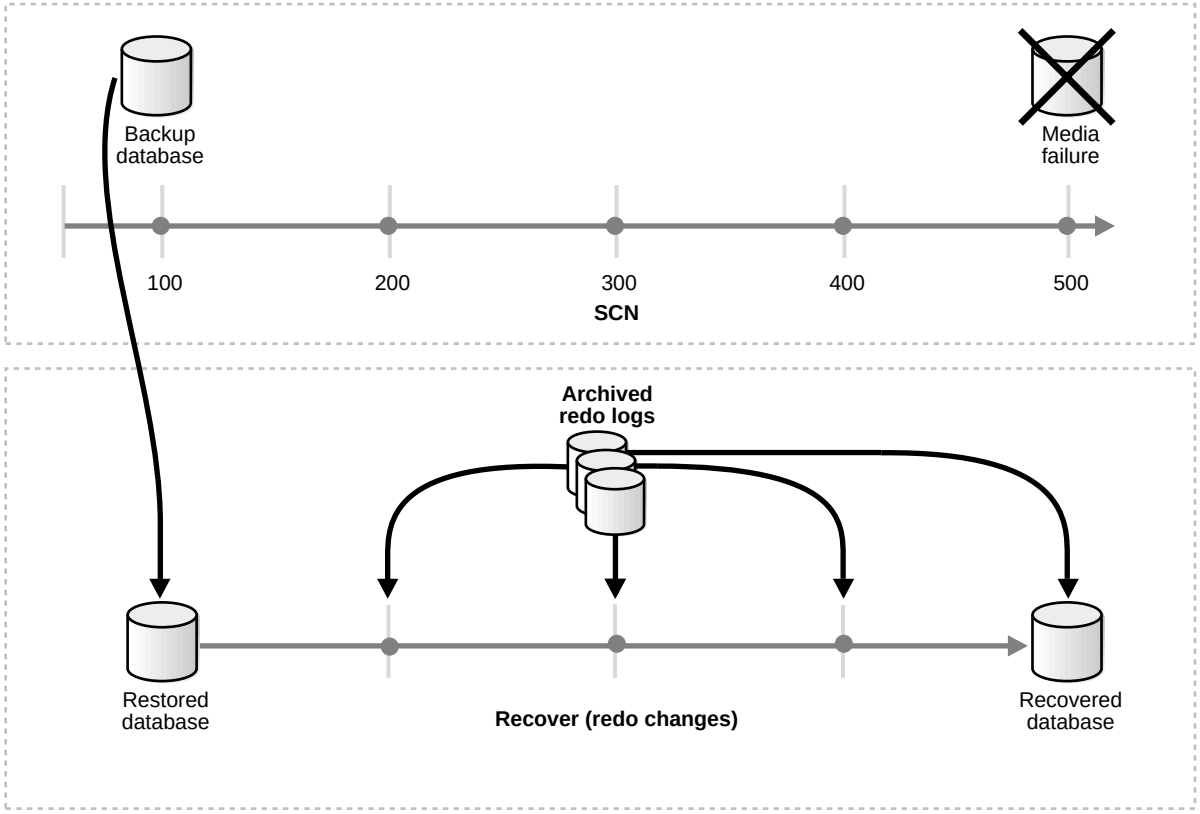
To *restore* a physical backup is to reconstruct it and make it available to the Oracle database server. To *recover* a restored datafile is to update it using *redo records*, that is, records of changes made to the database after the backup was taken. If you use Recovery Manager (RMAN), then you can also recover restored datafiles using *incremental backups*, which are backups of a datafile that contain only blocks that changed after the last backup.

Oracle performs *crash recovery* and *instance recovery* automatically after an instance failure. Instance recovery is an automatic procedure that involves two distinct operations: *rolling forward* the backup to a more current time by applying online redo records and *rolling back* all changes made in uncommitted transactions to their original state.

In contrast to instance recovery, *media recovery* requires you to issue recovery commands. If you use SQL*Plus, then you can issue the RECOVER or ALTER DATABASE RECOVER statements to apply the archived logs. If you use RMAN, then you issue the **recover** command to apply archived redo logs or incremental backups to the datafiles.

Figure 1–1 illustrates the basic principle of backing up, restoring, and performing media recovery on a database:

Figure 1–1 Restoring and Recovering a Database



Recovery in general refers to the various operations involved in restoring, rolling forward, and rolling back a backup. *Backup and recovery* in general refers to the various strategies and operations involved in protecting your database against data loss and reconstructing the data should that loss occur.

See Also:

- Chapter 1 of the *Oracle8i Recovery Manager User's Guide and Reference* for an overview of Recovery Manager features.
- Chapter 4, "Performing Operating System Backups" to learn how to make backups.
- Chapter 5, "Performing Media Recovery" to learn how to perform media recovery using SQL*Plus.
- *Oracle8i Designing and Tuning for Performance* to learn about instance recovery and how to tune performance.

How Oracle Keeps Records of Database Transactions

To understand the basics of backup and recovery, you need to understand how Oracle records changes to a database. Every time a change is made, Oracle generates a record of both the changed and original value in the *redo log buffer* in memory. This record is called a redo record. Oracle records both committed and uncommitted changes in redo log buffers.

Oracle frequently writes the redo log buffers to the on-disk *online redo log*. The online redo log contains at least two online redo log files. Oracle writes to these logs in a circular fashion: first it writes to one log file, then switches to the next available file when the current log is full, then back to the other file, and so forth.

Depending on whether Oracle runs in ARCHIVELOG or NOARCHIVELOG mode, the system begins *archiving* the redo information in the non-current online redo log file by copying the file to specified locations on disk. The online and archived redo logs are crucial for recovery because they contain records of all changes to the database.

See Also:

- *Oracle8i Concepts* for an overview of the online and archived redo logs
- *Oracle8i Administrator's Guide* to learn the basics of administering these data structures
- Chapter 2, "Managing Data Structures" to learn how to manage these structures for backup and recovery.

Backup and Recovery Operations

A physical backup is a copy of a datafile, tablespace, or database made at a specific time. If you make periodic backups of a database, then you can perform media recovery using these backups. During media recovery, you apply redo records or incremental backups to a restored backup to bring the database forward in time. If

the backup is a *consistent backup*, then you can also restore the backup without performing recovery.

Oracle enables you to restore an older backup and apply partial redo data, thereby recovering the database to a specified non-current time or SCN. This type of recovery is called *incomplete recovery*. You must open your database with a RESETLOGS operation after performing incomplete recovery in order to reset the online redo logs.

An example helps illustrate the concept of media recovery. Assume that you make a backup of your database at noon. Starting at noon, one change to the database is made every second. The redo logs switch three times over the next hour, and because the database runs in ARCHIVELOG mode, these redo logs are archived to disk. At 1:00 p.m., your disk drive fails. Fortunately, you can restore your noon whole database backup onto a functional disk drive and, using the archived redo logs to recover the database to 1:00 p.m., apply the changes so that the database is back to its pre-failure state.

> **See Also:** "Making Consistent Whole Database Backups" on page 4-4 to learn how to make consistent backups using operating system methods, and Chapter 5, "Performing Media Recovery" to learn how to perform media recovery using SQL*Plus.

Elementary Backup and Recovery Strategy

Although backup and recovery operations can sometimes be complicated, the basic principles for developing an effective strategy are simple:

1. Maintain multiple identical copies of your online redo logs on different disks.
2. Archive your redo logs to multiple locations or make frequent backups of your archived redo logs.
3. Maintain multiple, concurrent copies of your control file using Oracle multiplexing in conjunction with operating system mirroring (see "Control Files" on page 1-7).
4. Take frequent backups of your datafiles and control file and store them in a safe place on more than one media.

Most backup and recovery techniques are variations on these principles. So long as you have backups of your datafiles, control files, and archived redo logs in safe storage, then even if a fire were to completely destroy your hardware, you can recreate your original database.

A sophisticated and effective disaster prevention technique is to maintain a standby database, which is an exact replicate of your production database that you can update automatically with archived redo logs propagated through a Net8 connection.

See Also:

- Chapter 3, "Developing a Backup and Recovery Strategy" to learn more about developing a backup and recovery strategy
- *Oracle8i Standby Database Concepts and Administration* to learn how to manage a standby database
- Chapter 2, "Managing Data Structures" to learn more about managing important data structures such as the online redo logs

Which Data Structures Are Important for Backup and Recovery?

Before you can begin thinking seriously about backup and recovery strategy, you need to understand the physical data structures that are relevant for backup and recovery operations. This section addresses the following topics:

- Datafiles
- Control Files
- Rollback Segments
- Online Redo Log Files
- Archived Redo Log Files

This manual covers these topics in more detail in subsequent chapters.

See Also: *Oracle8i Concepts* for a complete overview of the Oracle8*i* architecture, and *Oracle8i Administrator's Guide* to learn how to manage these data structures.

Datafiles

Every Oracle database has one or more physical *datafiles*. A database's datafiles, which belong to logical structures called *tablespaces*, contain the database data. The datafile is divided into smaller units called *data blocks*. The data of logical database structures such as tables and indexes is physically located in the blocks of the datafiles allocated for a database.

The first block of every datafile is the header. The header includes important control information such as file size, block size, tablespace, creation timestamp, and

checkpoint SCN (see "System Change Number (SCN)" on page 1-10). Whenever you open a database, Oracle checks the datafile header information against the information stored in the control file to determine whether recovery is necessary.

The Use of Datafiles

Oracle reads the data in a datafile during normal operation and stores it in the in-memory buffer cache. For example, assume that a user wants to access some data in a table. If the requested information is not already in the buffer cache, Oracle reads it from the appropriate datafiles and stores it in memory.

The background process DBW*n*, known as the *database writer* or *db writer*, writes modified buffers to disk. Typically, a time lapse occurs between the time when an Oracle server process changes a block in the buffer cache and the time when DBW*n* writes it to disk. The more data that accumulates in memory without being written to disk, the longer the instance recovery time, because a crash or media failure forces Oracle to apply redo data from the current online log to recover those changes. Minimizing this time, known as the *mean time to recover (MTTR)*, is an important aspect of backup and recovery strategy.

> **See Also:** *Oracle8i Designing and Tuning for Performance* for more information on parameters that you can use to influence the MTTR.

Control Files

Every Oracle database has a *control file*. A control file is an extremely important binary file that contains the operating system filenames of all other files constituting the database. It also contains consistency information that is used during recovery, such as:

- The database name.
- The timestamp of database creation.
- The names of the database's datafiles and online and archived redo log files.
- The *checkpoint*, that is, a record indicating the point in the redo log such that all database changes prior to this point have been saved in the datafiles.
- Information on backups (when using the Recovery Manager utility).

When *multiplexing* the control file, you configure Oracle to write multiple copies of it in order to protect it against loss. If your operating system supports disk *mirroring*, you can also mirror the control file, that is, configure the operating system to write a copy of the control file to multiple disks.

> **See Also:** "Maintaining Multiple Control Files" on page 2-6 for more information about multiplexing and mirroring the control file, and *Oracle8i Administrator's Guide* for general information about managing the control file.

The Use of Control Files

Every time you mount an Oracle database, its control file is used to identify the datafiles and online redo log files that must be opened for database operation. If the physical makeup of the database changes, for example, a new datafile or redo log file is created, then Oracle modifies the database's control file to reflect the change.

The control file also contains crucial checkpoint information. The checkpoint records the highest SCN of all changes to blocks such that all data blocks with changes below that SCN have been written to disk by DBW*n*. The control file also contains a record of the checkpoint SCN contained in the header of each datafile in the database. Whenever a discrepancy occurs between the SCN that is actually in a datafile header and the datafile header SCN listed in the control file, Oracle requires media recovery.

The control file is absolutely crucial for database operation. Back up the control file whenever the set of files that makes up the database changes. Examples of structural changes include adding, dropping, or altering datafiles or tablespaces and adding or dropping online redo logs.

> **See Also:** "Backing Up the Control File After Structural Changes" on page 2-5 to learn how to back up the control file.

Rollback Segments

Every database contains one or more *rollback segments*, which are logical structures contained in datafiles. Whenever a transaction modifies a data block, a rollback segment records the state of the information before it changed.

The Use of Rollback Segments

Oracle uses rollback segments for a variety of operations. In general, the rollback segments of a database store the old values of data changed by uncommitted transactions. For example, if DBW*n* writes an uncommitted change to a data block and a session accesses the block in a query, then a rollback segment is used to display the pre-change value to the user.

Oracle can use the information in a rollback segment during database recovery to undo any uncommitted changes applied from the redo log to the datafiles, putting the data into a consistent state.

Online Redo Log Files

Every Oracle database has a set of two or more *online redo log files*. Oracle assigns every redo log file a unique *log sequence number* to identify it. The set of redo log files for a database is collectively known as the database's *redo log*. Oracle uses the redo log to record all changes made to the database.

Oracle records every change in a *redo record*, which is an entry in the redo buffer describing what has changed. For example, assume a user updates a column value in a payroll table from 5 to 7. Oracle records the change to the datafile block (new value of 7) and rollback segment (old value of 5) in a redo record. Because the redo log stores every change to the database, the redo record for this transaction actually contains three parts:

- The change to the transaction table of the rollback segment.
- The change to the rollback segment data block.
- The change to the payroll table data block.

Each atomic change in a redo record is called a *change vector*. A redo record is composed of all the change vectors involved in a change. For example, if you update all the values in a multi-column row in a table, then Oracle generates a redo record containing change vectors for all the changed blocks corresponding to each updated value.

If you then *commit* the update, Oracle generates another redo record and assigns the change an SCN. In this way, the system maintains a careful watch over everything that occurs in the database.

Circular Use of Redo Log Files

The log writer background process (LGWR) writes to online redo log files in a circular fashion: when it fills the *current online redo log*, LGWR writes to the next available *inactive redo log*. LGWR cycles through the online redo log files in the database, writing over old redo data. Filled redo log files are available for reuse depending on whether archiving is enabled:

- If archiving is disabled, a filled online redo log is available after the changes recorded in the log have been saved to the datafiles.

- If archiving is enabled, a filled online redo log is available after the changes have been saved to the datafiles and the file has been archived.

System Change Number (SCN)

The *system change number (SCN)* is an ever-increasing internal timestamp that uniquely identifies a committed version of the database. Every time a user commits a transaction, Oracle records a new SCN. You can obtain SCNs in a number of ways, for example, from the alert log. You can then use the SCN as an identifier for purposes of recovery. For example, you can perform an incomplete recovery of a database up to SCN 1030.

Oracle uses SCNs in control files, datafile headers, and redo records. Every redo log file has both a log sequence number and *low* and *high* SCN. The low SCN records the lowest SCN recorded in the log file, while the high SCN records the highest SCN in the log file.

The Use of Online Redo Logs

Redo logs are crucial for recovery. For example, suppose that a power outage prevents Oracle from permanently writing modified data to the datafiles. In this situation, you can use an old version of the datafiles combined with the changes recorded in the online and archived redo logs to reconstruct what was lost.

To protect against redo log failure, Oracle allows the redo log to be *multiplexed*. When Oracle multiplexes the online redo log, it maintains two or more copies of the redo log on different disks. Note that you should not back up the online redo log files, nor should you ever need to restore them; you keep redo logs by archiving them.

See Also:

- "Managing the Online Redo Logs" on page 2-10 for more information on managing the online redo log for backup and recovery
- *Oracle8i Administrator's Guide* for more information on managing the online redo log for backup and recovery
- "Avoiding the Backup of Online Redo Logs" on page 3-10 to learn why backing up redo logs is dangerous.

Archived Redo Log Files

An *archived redo log* is an online redo log that Oracle has filled with redo entries, rendered inactive, and copied to one or more destinations specified in the parameter file. You can run Oracle in either of two archive modes:

ARCHIVELOG	Oracle archives the filled online redo log files before reusing them in the cycle.
NOARCHIVELOG	Oracle does not archive the filled online redo log files before reusing them in the cycle.

Running the database in ARCHIVELOG mode has the following consequences:

- You can completely recover the database from both instance and media failure.
- You can perform a *hot backup*, that is, a backup made while the database is open and available for use.
- You can transmit and apply archived redo logs to a *standby database*, which is an exact replica of your primary database.
- You have more recovery options, for example, you can perform incomplete recovery and tablespace point-in-time recovery (TSPITR).
- You have to perform additional administrative operations to store the archived redo logs.
- You require extra disk space to store the archived logs.

Running the database in NOARCHIVELOG mode has the following consequences:

- You can only back up the database while it is completely closed after a clean shutdown.
- Typically, your only media recovery option is to restore the whole database. You lose all changes made after the last whole database backup.
- Because no archived redo log is created, no additional administration is necessary.

Note: The *only* time you can recover a database while operating in NOARCHIVELOG mode is when you have not already overwritten the online log files that were current at the time of the most recent backup.

See Also: "Managing the Archived Redo Logs" on page 2-14 for more information on archiving redo logs, and *Oracle8i Standby Database Concepts and Administration* for more information about the standby database option.

Understanding Basic Backup Strategy

A physical backup is a copy of a datafile, control file, or archived redo log that you store as a safeguard against data loss. When thinking about a backup strategy, consider these questions:

Why Are Backups Important?

Imagine the magnitude of lost revenue—not to mention the degree of customer dissatisfaction—if the production database of a catalog company, express delivery service, bank, or airline suddenly becomes unavailable, even for just 5 or 10 minutes. Alternatively, imagine that you lose important payroll datafiles due to a hard disk crash and cannot restore or recover them because you do not have a backup. Depending on the size and value of the lost information, the results can be devastating.

By making frequent backups, you ensure that you can restore at least some of your lost data. If you run you database in ARCHIVELOG mode, then you can apply redo to restored backups in order to reconstruct all lost changes.

What Types of Failures Can Occur?

You can lose or corrupt data in a variety of ways; you should consider these various possibilities when developing your backup strategy. The most common types of failures causing data loss are:

Statement failure	A logical failure in the handling of a statement in an Oracle program.
Process failure	A failure in a user process accessing Oracle, for example, an abnormal disconnection or process termination.

Instance failure	A problem that prevents an Oracle instance, that is, the SGA and background processes, from continuing to function.
User or application error	A user or application problem that results in the loss of data. For example, a user can accidentally delete data from a payroll table.
Media failure	A physical problem that arises when Oracle tries to write or read a file that is required to operate the database. A common example is a disk head crash that causes the loss of all data on a disk drive.

See Also: "Planning Your Response to Non-Media Failures" on page 3-12 and "Planning Your Response to Media Failures" on page 3-15 to learn about the most common type of failures affecting the database.

What Type of Backup Should You Make?

When developing your backup strategy, you need to know which types of backups you can perform. In each type of physical backup you either back up a file or group of files. This section defines and describes:

- Whole Database Backups
- Tablespace Backups
- Datafile Backups
- Control File Backups

Logical backups, also known as *exports*, are described in detail in *Oracle8i Utilities*.

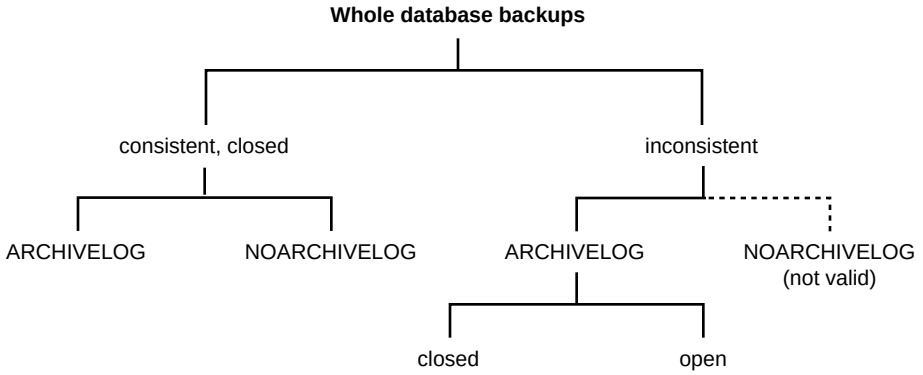
Whole Database Backups

A whole database backup should include backups of the control file along with all datafiles. Whole database backups are the most common type of backup.

Whole database backups do not require you to operate the database in a specific archiving mode. Before performing whole database backups, however, be aware of the implications of backing up in ARCHIVELOG and NOARCHIVELOG modes (see "Choosing the Database Archiving Mode" on page 2-17).

Figure 1–1 illustrates the various options available to you when performing whole database backups:

Figure 1–2 Whole Database Backup Options



Whole database backups can be consistent or inconsistent. Whether or not the backup is consistent determines whether you need to apply redo logs after restoring the backup.

See Also:

- "How Often Should You Make Backups?" on page 1-23 to learn about the difference between consistent and inconsistent backups
- Chapter 4, "Performing Operating System Backups" for detailed procedures for backing up a database using operating system commands
- *Oracle8i Recovery Manager User's Guide and Reference* for detailed procedures for backing up a database using RMAN commands

Tablespace Backups

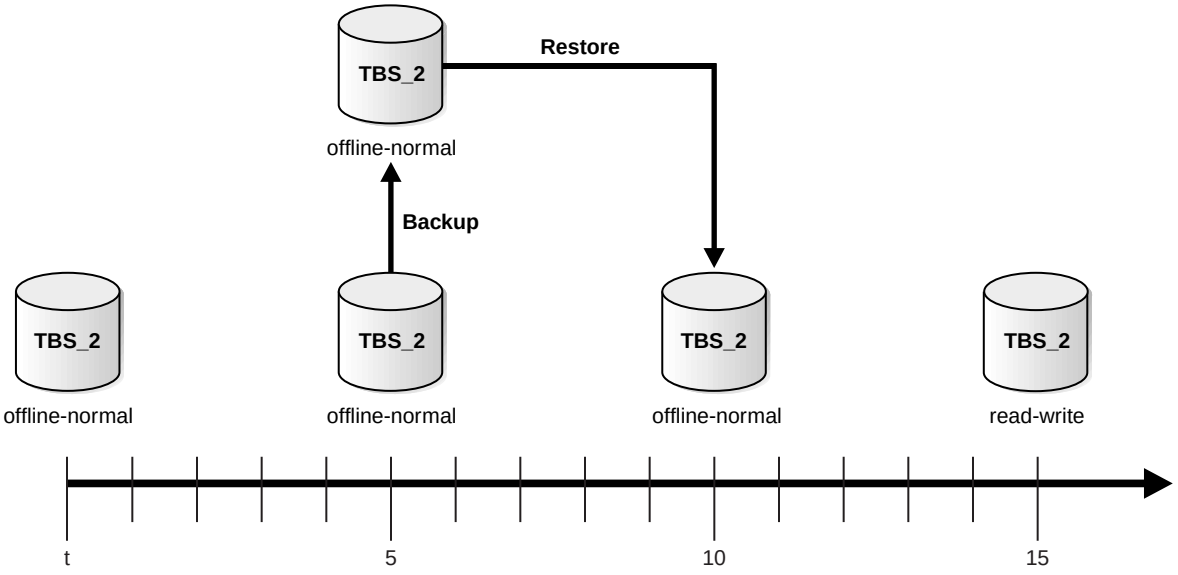
A tablespace backup is a backup of the datafiles that constitute the tablespace. For example, if tablespace TBS_2 contains datafiles 2, 3, and 4, then a backup of tablespace TBS_2 backs up these three datafiles.

Tablespace backups, whether online or offline, are only valid if the database is operating in ARCHIVELOG mode. The reason is that redo is required to make the restored tablespace consistent with the other tablespaces in the database.

The only time a tablespace backup is valid for a database running in NOARCHIVELOG mode is when the tablespace is currently read-only or offline-normal. These cases are exceptions because no redo is required to recover them. For example, take the scenario depicted in Figure 1–3:

1. You take tablespace TBS_2 offline normal at some time during day *t*.
2. You make a backup of TBS_2 at day *t + 5*.
3. You restore tablespace TBS_2 at day *t + 10* using the backup made at day *t + 5*.
4. You make tablespace TBS_2 read-write at day *t* + 15.

Figure 1–3 Tablespace Backups in NOARCHIVELOG Mode



Because there were necessarily no changes to the offline tablespace between *t + 5* and *t + 10*, Oracle does not require media recovery. If you make the tablespace read-write at *t + 15* and then subsequently attempt to restore the *t + 5* backup, however, Oracle requires media recovery for the changes after *t + 15*. Consequently, you are only be able to open the database if all necessary redo is located in the online redo logs.

Datafile Backups

A datafile backup is a backup of a single datafile. Datafile backups, which are not as common as tablespace backups, are valid in ARCHIVELOG databases.

The only time a datafile backup is valid for a database in NOARCHIVELOG mode is if every datafile in a tablespace is backed up. You cannot restore the database unless all datafiles are backed up. The datafiles must be read-only or offline-normal.

Control File Backups

If the database is mounted, you can make a binary backup up your control file using the ALTER DATABASE statement. You can also back up the control file to a trace file. Note that trace file backups have one major disadvantage: they have no record of any previous backups made with the old control file.

> **See Also:** "Backing Up the Control File After Structural Changes" on page 2-5 to learn how to make control file backups using SQL*Plus, and "Performing Control File Backups" on page 4-13 to learn how to make control file backups using SQL commands.

Should You Make Consistent or Inconsistent Backups?

You can use RMAN or operating system commands to make an *inconsistent* or a *consistent backup*. An inconsistent backup is a backup of one or more database files that you make while the database is open or after the database has been shut down abnormally. A consistent backup is a backup of one or more database files that you make after the database has been closed cleanly. Unlike an inconsistent backup, a consistent backup does not require instance recovery after it is restored.

Whether you make consistent or inconsistent backups depends on a number of factors. If your database must be open and available all the time, then inconsistent backups are your only option. If there are recurring periods of minimal use, then you may decide to take regular consistent backups of the whole database and supplement them with online backups of often-used tablespaces.

Consistent Backups

A consistent backup of a database or part of a database is a backup in which all read-write datafiles and control files have been checkpointed with respect to the same SCN. In addition, all the online, read-write datafiles are not *fuzzy*, that is, do not contain changes beyond the SCN in the header. Oracle determines whether a restore backup is consistent by checking all the datafile headers against the datafile header information contained in the control file.

Oracle makes the control files and datafiles consistent during a database checkpoint. The only tablespaces in a consistent backup that are allowed to have older SCNs are read-only and offline normal tablespaces, which are still consistent with the other

datafiles in the backup because no changes have been made to these tablespaces and so no recovery is required. If the offline datafile's checkpoint SCN matches the offline-SCN in the control file, then Oracle know the datafile needs no redo.

The important point is that you can open the database after restoring a consistent whole database backup *without applying redo logs* because the data is already consistent: no action is required to make the data in the restored datafiles correct. Consequently, you can restore a year-old consistent backup of your database without performing media recovery and without Oracle performing instance recovery.

> **WARNING: Only use a backup control file created during a consistent whole database backup if you are restoring the whole database backup and do not intend to perform recovery. If you intend to perform recovery and have a current control file, do not restore an older control file—unless performing point-in-time recovery to a time when the database structure was different from the current structure.**

The only way to make a consistent whole database backup is to shut down the database using the NORMAL or IMMEDIATE options and make the backup while the database is closed. If a database is not shut down cleanly, for example, an instance fails or you issue a SHUTDOWN ABORT statement, the database's datafiles are always inconsistent—unless you opened the database in read-only mode. Instance recovery will be required at open time.

A consistent whole database backup is the only valid backup option for databases running in NOARCHIVELOG mode, because otherwise redo will need to be applied to create consistency—and in NOARCHIVELOG mode Oracle overwrites redo records without archiving them first.

To make a consistent database backup current or to take it to a non-current point in time, perform media recovery. If you use a current control file for recovery, Oracle starts media recovery beginning at the lowest checkpoint SCN in the datafile headers. If you use a backup control file, then Oracle starts media recovery using the lowest of the following: the control file SCN and the lowest SCN in the datafile headers.

To perform media recovery either apply archived redo logs or, if you are using Recovery Manager, apply incremental backups and / or archived logs. All redo data is located in the archived and online redo logs.

Inconsistent Backups

An inconsistent backup s a backup in which all read-write datafiles and control files have not been checkpointed with respect to the same SCN. For example, one read-write datafile header may contain an SCN of 100 while others contain an SCN of 95. Oracle cannot open the database until these SCNs are consistent, that is, until all changes recorded in the online redo logs have been made to the datafiles.

If your database must be up and running 24 hours a day, 7 days a week, then you have no choice but to perform inconsistent backups of a whole database. For example, a backup of an offline tablespace in an open database is inconsistent with other tablespaces because portions of the database are being modified and written to disk while the backup of the tablespace is progressing. The datafile headers for the online and offline datafiles may contain inconsistent SCNs. You must run your database in ARCHIVELOG mode to make open backups.

If you run the database in ARCHIVELOG mode, then you can construct a whole database backup using backups of datafiles taken at different times. For example, if your database contains seven tablespaces, and you back up the control file as well as a different tablespace each night, in a week you will back up all tablespaces in the database as well as the control file. You can consider this backup as a whole database backup.

Inconsistent Closed Backups You have the option of making inconsistent closed backups if a database is backed up after a system crash or SHUTDOWN ABORT. This type of backup is valid if the database is running in ARCHIVELOG mode, because both online and archived redo logs are available to make the backup consistent.

Note: Oracle recommends that you do not make inconsistent, closed database backups in NOARCHIVELOG mode.

If you run your database in NOARCHIVELOG mode, only back it up when you have closed it cleanly using the IMMEDIATE or NORMAL options. Inconsistent whole database backups of databases running in NOARCHIVELOG mode are usable *only if* the redo logs containing the changes made prior to the backup are available when you restore it—an unlikely occurrence.

The reason that NOARCHIVELOG inconsistent backups are not recommended is that the datafile headers of the backed up files contain different SCNs (a normal shutdown guarantees the consistency of these SCNs), and because the database is in NOARCHIVELOG mode, no archived redo logs are available to apply the lost

changes. For this reason, RMAN does not allow you to back up a database that has been running in NOARCHIVELOG mode and shut down abnormally because the backup is not usable for recovery.

The moral is: *if you run your database in NOARCHIVELOG mode, always have a backup that is usable without performing any recovery.* This aim is defeated if you need to apply redo from logs to recover a backup. If you need redo data to make a database consistent, operate in ARCHIVELOG mode.

Archiving Unarchived Redo Log Files After open or inconsistent closed backups, always guarantee that you have the redo necessary to recover the backup by archiving the unarchived redo logs. When the database is open, issue the following SQL statement to force Oracle to switch out of the current log and archive it as well as all other unarchived logs:

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

When the database is mounted, open, or closed, issue the following SQL statement to force Oracle to archive all non-current redo logs:

```
SQL> ALTER SYSTEM ARCHIVE LOG ALL;
```

When the database is mounted, open, or closed, issue the following SQL statement to archive a specified log group, where *integer* is the number of the group:

```
SQL> ALTER SYSTEM ARCHIVE LOG GROUP integer;
```

Backing Up the Archived Logs and the Control File After open or inconsistent closed backups, back up all archived redo logs produced since the backup began. This operation ensures that you can use the backup and also allows you to delete the original archived logs from disk. If you do not have all archived redo logs produced during the backup, you cannot recover the backup because you do not have all the redo records necessary to make it consistent.

Also, make a binary backup up your control file using the ALTER DATABASE statement.

> **See Also:** "Performing Control File Backups" on page 4-13 for more information about backing up the control file using SQL statements.

> **See Also:** "Backing Up Online Tablespaces and Datafiles" on page 4-5 to learn how to make online backups using operating system methods, and *Oracle8i Recovery Manager User's Guide and Reference* to learn how to use RMAN to make backups.

What Is a Redundancy Set?

The set of files needed to recover from the failure of a database file—a datafile, control file, or online redo log—is called the *redundancy set*. The golden rule of backup and recovery is: *the set of disks or other media that contain the redundancy set should be separate from the disks that contain the datafiles, online redo logs, and control files.* This strategy ensures that the failure of a disk that contains a datafile does not also cause the loss of the backups or redo logs needed to recover the datafile.

> **See Also:** "Obeying the Golden Rule of Backup and Recovery" on page 3-2 to learn more the redundancy set and how to maintain it.

Which Backup Method Should You Use?

In Oracle8*i*, you have a choice between these basic methods for making backups:

- Use the Recovery Manager (RMAN), which is a utility that establishes a connection with a server session and manages the movement for data for backup and recovery operations.

  > **Note:** RMAN is only compatible with Oracle databases of release 8.0 or higher. Use the Enterprise Backup Manager (EBU) for Oracle7 databases.

- Back up your database manually by executing commands specific to your operating system.
- Use the Oracle Export utility to make logical backups. The utility writes data from an Oracle database to operating system files in a proprietary format. You can later import this data into a database.

Table 1–1 describes the version and system requirements for the these methods:

Table 1–1 Requirements for Different Backup Methods

Backup Method	Type	Version Available	Requirements
Recovery Manager (RMAN)	Physical	Oracle version 8.0 and higher	Media manager (if backing up to tape)
Operating System	Physical	All versions	Operating system backup utility (for example, UNIX dd)
Export	Logical	All versions	N / A
Enterprise Backup Utility (EBU)	Physical	Oracle7 only	Media manager

Note: Logical backups are not a substitute for whole database physical backups. You should consider logical backups as an additional tool within your overall backup and recovery strategy.

See Also: *Oracle8i Recovery Manager User's Guide and Reference* for an overview of Recovery Manager features.

Making Recovery Manager Backups and Image Copies

RMAN is a powerful and versatile program that allows you to make a *backup* or *image copy* of your data. When you specify files or archived logs using the RMAN **backup** command, RMAN creates a *backup set* as output.

A backup set is one or more datafiles, control files, or archived redo logs that are written in an RMAN-specific format; it requires you to use the RMAN **restore** command for recovery operations. In contrast, when you use the **copy** command to create an *image copy* of a file, you do not need to invoke RMAN to restore or recover it.

See Also: *Oracle8i Recovery Manager User's Guide and Reference* for an introduction to RMAN as well as instructions for making backups and copies.

Making Operating System Backups

If you do not want to use RMAN, you can use operating system commands such as the UNIX cp command to make backups. You can also automate backup operations by writing scripts.

You can make a backup of the whole database at once or supplement a whole database backup with backups of individual tablespaces, datafiles, control files, and archived logs. You can use operating system commands to perform these backups.

> **See Also:** Chapter 4, "Performing Operating System Backups" to learn how to make operating system backups.

Using the Export Utility for Supplemental Backup Protection

You can supplement physical backups by using the Export utility to make logical backups of your data. Logical backups store information about the schema objects created for a database. The Export utility writes data from a database into Oracle files in a proprietary format. You can then import this data into a database using the Import utility.

> **See Also:** To learn how to use the Export and Import utilities, see *Oracle8i Utilities*.

Feature Comparison of Backup Methods

Table 1–2 compares the features of the different backup methods:

Table 1–2 Feature Comparison of Backup Methods **(Page 1 of 2)**

Feature	Recovery Manager	Operating System	Export
Closed database backups	Supported. Requires instance to be mounted.	Supported.	Not supported.
Open database backups	Do not use BEGIN / END BACKUP statements.	Use BEGIN / END BACKUP statements.	Requires RBS to generate consistent backups.
Incremental backups	Supported.	Not supported.	Not supported.
Corrupt block detection	Supported. Identifies corrupt blocks and writes to V$BACKUP_ CORRUPTION or V$COPY_CORRUPTION.	Not supported.	Supported. Identifies corrupt blocks in the export log.

Table 1–2 Feature Comparison of Backup Methods **(Page 2 of 2)**

Feature	Recovery Manager	Operating System	Export
Automatic backup	Supported. Establishes the name and locations of all files to be backed up (whole database, tablespace, datafile or control file backup).	Not supported. Files to be backed up must be specified manually.	Supported. Performs either full, user, or table backups.
Backup catalogs	Supported. Backups are cataloged in the recovery catalog and in the control file, or just in the control file.	Not supported.	Not supported.
Backups to sequential media	Supported. Interfaces with a media manager. RMAN also supports proxy copy, a feature that allows the media manager to manage the transfer of data.	Supported. Backup to tape is manual or managed by a media manager.	Supported.
Backs up initialization parameter file and password files	Not supported.	Supported.	Not supported.
Operating system independent language	Supported (uses PL/SQL interface).	Not supported.	Supported.

How Often Should You Make Backups?

Tailor your backup strategy to the needs of your business. For example, if you can afford to lose data in the event of a disk failure, then you may not need to perform backups very often. The advantage of taking infrequent backups is that you free Oracle's resources for other operations. The disadvantage is that you may end up losing data or increasing recovery time.

In a different scenario, if your database must be available twenty-four hours a day, seven days a week, then you should make online backups of your database frequently. In this case, you may decide to take daily hot backups, *multiplex* (that is, have multiple copies of) your online redo logs, and archive your redo logs to several different locations. You can even maintain a standby database in a different city that is a constantly updated replica of your original database.

See Also: Chapter 3, "Developing a Backup and Recovery Strategy" to learn important considerations for an effective backup strategy.

Understanding Basic Recovery Strategy

Basic media recovery involves two parts: restoring a physical backup and updating it with database changes. The most important aspect of recovery is making sure that all datafiles are consistent with respect to the same SCN. Oracle has integrity checks that prevent you from opening the database until all datafiles are consistent with one another.

When preparing a recovery strategy, make sure you understand the answers to these questions:

- What Is Media Recovery?
- Which Recovery Method Should You Use?

What Is Media Recovery?

Media recovery uses redo records or (if you use RMAN) incremental backups to recover restored datafiles either to the present or to a specified non-current time. When performing media recovery, you can recover the whole database, a tablespace, or a datafile. In any case, you always use a restored backup to perform the recovery.

This section contains the follow topics:

- Complete Recovery
- Incomplete Recovery
- Opening the Database with the RESETLOGS Option

Complete Recovery

Complete recovery involves using redo data or incremental backups combined with a backup of a database, tablespace, or datafile to update it to the most current point in time. It is called *complete* because Oracle applies *all* of the redo changes to the backup. Typically, you perform media recovery after a media failure damages datafiles or the control file.

Requirements for Complete Recovery You can perform complete recovery on a database, tablespace, or datafile. If you are performing complete recovery on the whole database, then you must:

- Mount the database.
- Ensure that all datafiles you want to recover are online.
- Restore a backup of the whole database or the files you want to recover.
- Apply online or archived redo logs, or a combination of the two.

If you are performing complete recovery on a tablespace or datafile, then you must:

- Take the tablespace or datafile to be recovered offline if the database is open.
- Restore a backup of the datafiles you want to recover.
- Apply online or archived redo logs, or a combination of the two.

> **See Also:** "Performing Complete Media Recovery" on page 5-19 to learn how to perform complete media recovery using operating system methods, and *Oracle8i Recovery Manager User's Guide and Reference* to learn how to perform complete recovery with RMAN.

Incomplete Recovery

Incomplete recovery uses a backup to produce a non-current version of the database. In other words, you do not apply all of the redo records generated after the most recent backup. You usually perform incomplete recovery when:

- Media failure destroys some or all of the online redo logs.
- A user error causes data loss, for example, a user inadvertently drops a table.
- You cannot perform complete recovery because an archived redo log is missing.
- You lose your current control file and must use a backup control file to open the database.

To perform incomplete media recovery, you must restore all datafiles from backups created prior to the time to which you want to recover and then open the database with the RESETLOGS option when recovery completes. The RESETLOGS operation creates a new *incarnation* of the database—in other words, a database with a new stream of log sequence numbers.

Tablespace Point-in-Time Recovery The tablespace point-in-time recovery (TSPITR) feature enables you to recover one or more tablespaces to a point-in-time that is different from the rest of the database. TSPITR is most useful when you want to:

- Recover from an erroneous drop or truncate table operation.
- Recover a table that has become logically corrupted.
- Recover from an incorrect batch job or other DML statement that has affected only a subset of the database.
- Recover one independent schema to a point different from the rest of a physical database (in cases where there are multiple independent schemas in separate tablespaces of one physical database).
- Recover a tablespace on a very large database (VLDB) rather than restore the whole database from a backup and perform a complete database roll-forward (see "Planning for Tablespace Point-in-Time Recovery" on page 7-4 before making any decisions).

> **See Also:** Chapter 7, "Performing Operating System Tablespace Point-in-Time Recovery" to learn how to perform O/S TSPITR, and *Oracle8i Recovery Manager User's Guide and Reference* to learn how to perform TSPITR using RMAN.

Media Recovery Options Because you are not completely recovering the database to the most current time, you must tell Oracle when to terminate recovery. You can perform the following types of recovery.

Type of Recovery	Function
Time-based recovery	Recovers the data up to a specified point in time.
Cancel-based recovery	Recovers until you issue the CANCEL statement (not available when using Recovery Manager).
Change-based recovery	Recovers until the specified SCN.
Log sequence recovery	Recovers until the specified log sequence number (only available when using Recovery Manager).

> **See Also:** *Oracle8i Recovery Manager User's Guide and Reference* to learn how to perform incomplete recovery with RMAN, and "Performing Incomplete Media Recovery" on page 5-25 to learn how to perform incomplete media recovery using SQL*Plus.

Opening the Database with the RESETLOGS Option

Whenever you perform incomplete recovery or perform complete or incomplete recovery using a backup control file, you must reset the online redo logs when you open the database. The new version of the reset database is called a new *incarnation*. All archived redo logs generated after the point of the RESETLOGS on the old incarnation are invalid in the new incarnation.

> **See Also:** "Opening the Database After Media Recovery" on page 5-31 to learn how to restart the database in RESETLOGS mode.

Which Recovery Method Should You Use?

You have a choice between two basic methods for recovering physical files. You can:

- Use the RMAN utility to automate restore recovery.
- Restore backups using operating system utilities, and then recover your database manually by executing SQL / SQL*Plus statements.

Whichever method you choose, you can recover a database, tablespace, or datafile. Before performing media recovery, you need to determine which datafiles to recover. Often you can use the fixed view V$RECOVER_FILE.

> **See Also:** Chapter 5, "Performing Media Recovery" to learn how to perform operating system recovery, and *Oracle8i Recovery Manager User's Guide and Reference* to learn how to perform recovery with RMAN.

Recovering with SQL*Plus

If you do not use RMAN, follow these basic steps:

1. Restore backups of files permanently damaged by media failure. If you do not have a backup, it is sometimes possible to perform recovery if you have the necessary redo logs dating from the time when the datafiles were first created and the control file contains the name of the damaged file.

   If you cannot restore a datafile to its original location, relocate the restored datafile and change the location in the control file.
2. Restore any necessary archived redo log files.
3. use the SQL*Plus utility to restore and recover your files. You can execute:
   - The SQL*Plus RECOVER statement (recommended)

- The SQL ALTER DATABASE RECOVER statement

  See Also: *SQL*Plus User's Guide and Reference* to learn more about the RECOVER statement.

Recovering with RMAN

The basic RMAN recovery commands are **restore** and **recover**. Use RMAN to restore datafiles from backup sets or from image copies on disk, either to their current location or to a new location. You can also restore backup sets containing archived redo logs. Use the RMAN **recover** command to perform media recovery and apply incremental backups. RMAN completely automates the procedure for recovering and restoring your backups and copies.

2

Managing Data Structures

This chapter describes how to manage data structures that are crucial for successful backup and recovery. It includes the following topics:

- Overview of Backup and Recovery Data Structures
- Managing the Control File
- Managing the Online Redo Logs
- Managing the Archived Redo Logs

See Also:

- *Oracle8i Concepts* for a conceptual overview of these data structures
- *Oracle8i Administrator's Guide* for detailed administration information
- *Oracle8i Parallel Server Documentation Set: Oracle8i Parallel Server Concepts; Oracle8i Parallel Server Setup and Configuration Guide; Oracle8i Parallel Server Administration, Deployment, and Performance* if you are using Oracle with the Parallel Server

Overview of Backup and Recovery Data Structures

The single most useful strategy in backup and recovery is planning ahead. To prevent data loss, you must anticipate the various ways that data can be lost and develop your defense accordingly.

An important aspect of planning ahead is the intelligent management of database data structures. For example, what can you do to prevent a database crash if your control file become corrupted? What can you do to prevent the loss of archived redo logs if a disk failure occurs? Besides the datafiles, the data structures that are most important for developing a backup and recovery strategy are:

- Control files
- Online redo logs
- Archived redo logs (if you run in ARCHIVELOG mode)

If these structures become corrupted or unavailable, then you may find yourself unable to recover lost data.

If you have sufficient resources, then you can help protect yourself from data loss by following this basic data management strategy:

- Mirror datafiles at the operating system or hardware level.
- Maintain at least two current control files on different disks by Oracle multiplexing or operating system mirroring, or both at the same time. Operating system or hardware mirroring ensures that you can recover from any one media failure while the system is fully available.
- Maintain at least three online redo log groups with two members each. Place each member of the group on a different disk and on a different disk controller.
- Archive redo logs to multiple destinations and back them up frequently to different media. It is advisable to take multiple backups to multiple different media devices.

Note: This chapter assumes that you understand the function of the control file, online redo logs, and archived redo logs as well as the basics of how to administer them. If you do not, refer to the relevant chapters in *Oracle8i Concepts* and the *Oracle8i Administrator's Guide*.

Managing the Control File

The control file is a small binary file containing a record of the database schema. It is one of the most essential files in the database because it is necessary for the database to start and operate successfully. Oracle updates the control file continuously during database use, so it must be available for writing whenever the database is mounted. If for some reason the control file is not accessible, then the database cannot be mounted and recovery is difficult.

A control file contains information about the associated database that is required for the database to be accessed by an instance, both at startup and during normal operation. Only the Oracle database server can modify a control file's information; no user can edit a database's control file directly.

The control file has various properties that make it crucial for backup and recovery. For example, the control file:

- Identifies the database name (taken from either the name specified by the initialization parameter DB_NAME or the name used in the CREATE DATABASE statement).
- Records the names and locations of associated datafiles and online redo log files.
- Records the names and locations of archived redo logs.
- Stores checkpoint and log sequence information for all database files required for the synchronization of the database.
- Stores information on Recovery Manager backups (if you use Recovery Manager). The recovery catalog optionally used by RMAN obtains its essential information from the control file.
- Must be accessible for the database to be mounted, opened, and maintained.

This section addresses the following topics relating to control file management:

- Displaying Control File Information
- Backing Up the Control File After Structural Changes
- Maintaining Multiple Control Files
- Recovering from the Loss of Control Files

Displaying Control File Information

Your first step in managing the control file is learning how to gain information about it. The following data dictionary views contain useful information:

Views	Description
V$CONTROLFILE	Lists the control file filenames.
V$DATABASE	Indicates whether the control file is current or a backup, when the control file was created, and the last timestamp in the control file if it is a backup.

For example, the following query displays the database control files:

```
SELECT name FROM v$controlfile;

NAME
--------------------------------------------------------------------------------
/vobs/oracle/dbs/cf1.f
/vobs/oracle/dbs/cf2.f
2 rows selected.
```

To display the control file type, query the V$DATABASE view:

```
SELECT controlfile_type FROM v$database;

CONTROL
------------
BACKUP
```

The following useful statement displays all control files, datafiles, and online redo log files for the database:

```
SELECT member FROM v$logfile
UNION ALL
SELECT name FROM v$datafile
UNION ALL
SELECT name FROM v$controlfile;

MEMBER
--------------------------------------------------------------------------------
/vobs/oracle/dbs/rdo_log1.f
/vobs/oracle/dbs/rdo_log2.f
/vobs/oracle/dbs/tbs_01.f
/vobs/oracle/dbs/tbs_02.f
/vobs/oracle/dbs/tbs_11.f
/vobs/oracle/dbs/tbs_12.f
/vobs/oracle/dbs/tbs_21.f
```

```
/vobs/oracle/dbs/tbs_22.f
/vobs/oracle/dbs/tbs_13.f
/vobs/oracle/dbs/cf1.f
/vobs/oracle/dbs/cf2.f
11 rows selected.
```

> **See Also:** *Oracle8i Reference* for more information on the dynamic performance views.

Backing Up the Control File After Structural Changes

Each time that a user adds, renames, or drops a datafile or an online redo log file from the database, Oracle updates the control file to reflect this physical structure change. Oracle records these changes so that it can identify:

- The datafiles and online redo log files that it needs to open during database startup.
- The files that are required or available in case database recovery is necessary.

Therefore, if you make a change to your database's physical structure, *immediately* back up the control file. If you do not, and your control file is corrupted or destroyed, then the backup control file will not accurately reflect the state of the database at the time of the failure.

Generate a binary copy of the control file or back up to a text trace file (with the destination specified by the USER_DUMP_DEST initialization parameter). You can run the script in the text trace file to re-create the control file. Back up the control file after you issue any of the following statements:

- ALTER DATABASE [ADD | DROP] LOGFILE
- ALTER DATABASE [ADD | DROP] LOGFILE MEMBER
- ALTER DATABASE [ADD | DROP] LOGFILE GROUP
- ALTER DATABASE [ARCHIVELOG | NOARCHIVELOG]
- ALTER DATABASE RENAME FILE
- CREATE TABLESPACE
- ALTER TABLESPACE [ADD | RENAME] DATAFILE
- ALTER TABLESPACE [READ WRITE | READ ONLY]
- DROP TABLESPACE

To learn how to back up the control file, see "Performing Control File Backups" on page 4-13.

> **See Also:** *Oracle8i Administrator's Guide* for more information on managing the control file, and "Backing Up the Control File to a Trace File" on page 4-14 for a sample scenario involving editing a trace file.

Maintaining Multiple Control Files

As with online redo log files, Oracle allows you to *multiplex* control files, that is, configure Oracle to open and write to multiple, identical copies. Oracle writes the same data to each copy of the control file. You can also *mirror* them, that is, allow the operating system to write a copy of a control file to two or more physical disks. Oracle corporation recommends that you both multiplex and mirror the control files.

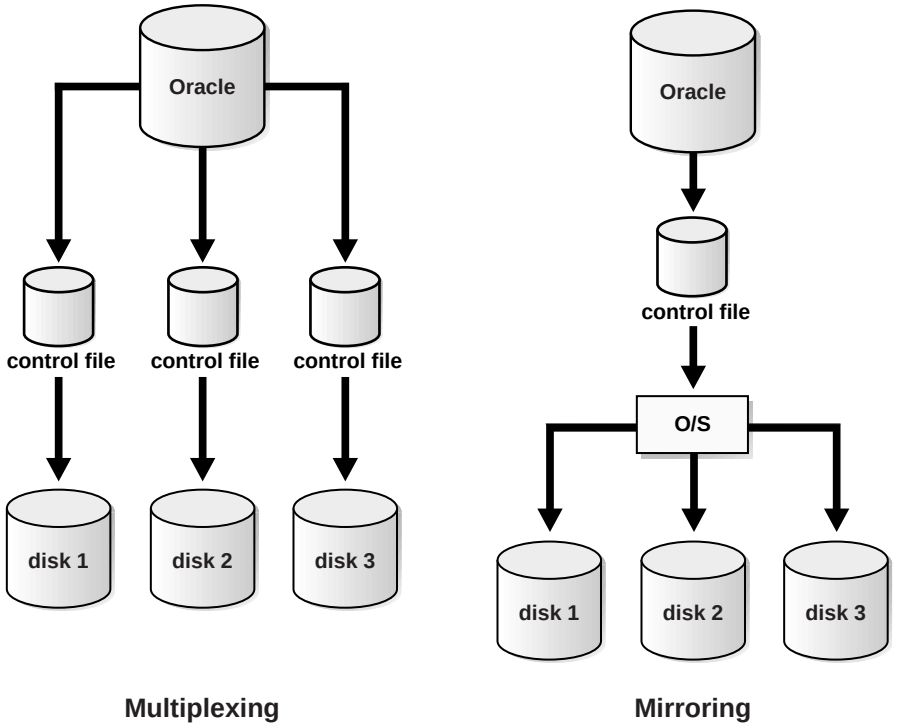
Mirroring at the operating system level is often better than multiplexing at the Oracle level because operating system mirroring usually tolerates failure of one of the mirrors, whereas Oracle multiplexing does not. With Oracle multiplexing, if any mirror fails, then the instance shuts down. The user then has to either:

- Repair the failed disk, copy a good control file into the old location, and restart.
- Copy a good control file to a new location and edit the CONTROL_FILES parameter of the initialization parameter file accordingly.

With operating system or hardware mirroring, you achieve the same redundancy that you do with multiplexing, but in many cases you do not have to pay with a loss in availability when a failure occurs.

The permanent loss of all copies of a database's control file is a serious problem. If any copy of a control file fails during database operation, then the instance aborts and media recovery is required. If you do not multiplex or mirror the control file, then recovery is more complex. Therefore, you should use multiplexed or mirrored control files with each database.

Figure 2–1 Multiplexing and Mirroring the Control File



Multiplexing the Control File

By storing multiple control files for a single database on different disks, you safeguard against a single point of failure. If a single disk containing a control file crashes, then the instance fails when Oracle attempts to access the damaged control file.

If the control file is multiplexed, other copies of the current control file are available on different disks. After repairing the bad disk, you can then copy a good control file to the old location and restart the instance easily without having to perform media recovery. If you cannot repair the disk, then you can edit the CONTROL_ FILES initialization parameter to specify a new location and copy the good control file copy to this location.

The only disadvantage of multiplexing control files is that operations that update the control files such as adding a datafile or checkpointing the database can take

slightly longer. This increase in performance overhead is usually insignificant, however, especially for operating systems that can perform multiple, concurrent writes. A slight performance loss does not justify using only a single control file.

> **Note:** Oracle strongly recommends that you maintain a minimum of two control files on different disks.

Note the following characteristics of multiplexed control files:

- At least two filenames are listed for the initialization parameter CONTROL_FILES in the database's parameter file.
- The first file listed in the CONTROL_FILES parameter is the only file read by the Oracle database server during database operation.
- If any of the control files becomes unavailable during database operation, then the instance becomes inoperable and aborts. Copy a good control file to the bad control file's location or, if media failure makes the disk inaccessible, copy a good control file to a new location and edit the initialization parameter file.

Mirroring the Control File

If your operating system supports disk mirroring, then the operating system allows for *mirrored disk storage*. Mirrored disk storage makes several physical disks look like a single disk to Oracle. Oracle writes the data once, then the operating system writes it to each of the underlying physical disks. Each file is a mirror, that is, an exact duplicate, of the others.

The advantage of disk mirroring is that if one of the disks becomes unavailable, then the other disk or disks can continue to function without interruption. Therefore, your control file is protected against a single point of failure. Note that if you store your control file on a mirrored disk system, then you only need Oracle to write one active copy of the control file.

Oracle recommends that you multiplex at least two copies of the control files on mirrored disks. This precaution allows transparent recovery of single failures, and retains fast recovery of the control file data in the case of double failure.

Recovering from the Loss of Control Files

Following are scenarios where you may need to recover or re-create the control file:

- The control file is corrupted or lost due to media failure. If you multiplex or mirror your control files on different disks, you significantly minimize this risk.
- You change the name of a database. Because the control file records the name of the database, you need to re-create it.

To recover from control file corruption using a current control file copy:

This procedure assumes that one of the control files specified in the CONTROL_FILES parameter is corrupted, the control file directory is still accessible, and you have a current multiplexed copy.

1. With the instance shut down, use an operating system command to overwrite the bad control file with a good copy:

   ```
   % cp '/disk2/copy/cf.f' '/disk1/oracle/dbs/cf.f';
   ```

2. Start SQL*Plus and mount or open the database:

   ```
   SQL> STARTUP MOUNT
   ```

To recover from permanent media failure using a current control file copy:

This procedure assumes that one of the control files specified in the CONTROL_FILES parameter is inaccessible due to a permanent media failure, and you have a current multiplexed or mirrored copy.

1. With the instance shut down, use an operating system command to copy the current copy of the control file to a new, accessible location:

   ```
   % cp '/disk2/copy/cf.f' '/disk3/copy/cf.f';
   ```

2. Edit the CONROL_FILES parameter in the initialization parameter file to replace the bad location with the new location:

   ```
   CONTROL_FILES = '/oracle/dbs/cf1.f','/disk3/copy/cf.f'
   ```

3. Start SQL*Plus and mount or open the database:

   ```
   SQL> STARTUP MOUNT
   ```

Managing the Online Redo Logs

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

WARNING: Oracle recommends that you do not back up a current online log, because if you restore that backup, the backup will appear at the end of the redo thread. Because additional redo may have been generated in the thread, when you attempt to execute recovery by supplying the redo log copy, recovery will erroneously detect the end of the redo thread and prematurely terminate, possibly corrupting the database.

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

Note: This manual describes how to configure and manage the online redo log when the Oracle Parallel Server is *not* used. Thus, the thread number can be assumed to be 1 in all discussions and examples of commands. For complete information about configuring the online redo log with the Oracle Parallel Server, see *Oracle8i Parallel Server Documentation Set: Oracle8i Parallel Server Concepts; Oracle8i Parallel Server Setup and Configuration Guide; Oracle8i Parallel Server Administration, Deployment, and Performance*.

See Also: *Oracle8i Concepts* for a conceptual overview of the online redo log, and *Oracle8i Administrator's Guide* for detailed information about managing the online redo logs.

Displaying Online Redo Log Information

The following data dictionary views contain useful information about the online redo logs:

Views	Description
V$LOG	Identifies the online redo log groups, the number of members per group, and which logs have been archived.
V$LOGFILE	Displays filenames and status information about the redo log group members.

For example, the following query displays which online redo log group requires archiving:

```
SELECT group#, sequence#, status, archived FROM v$log;

GROUP#     SEQUENCE#  STATUS           ARC
---------- ---------- ---------------- ---
         1         43 CURRENT          NO
         2         42 INACTIVE         YES
2 rows selected.
```

Table 2–1 displays status information that can be crucial in a recovery situation:

Table 2–1 Status Column of V$LOG

Status	Description
UNUSED	The online redo log has never been written to.
CURRENT	This is the current redo log and that it is active. The redo log can be open or closed.
ACTIVE	The log is active, that is, needed for instance recovery, but is not the current log.It may be in use for block recovery, and may or may not be archived.
CLEARING	The log is being recreated as an empty log after an ALTER DATABASE CLEAR LOGFILE command. After the log is cleared, the status changes to UNUSED.
CLEARING_CURRENT	The current log is being cleared of a closed thread. The log can stay in this status if there is some failure in the switch such as an I/O error writing the new log header.
INACTIVE	The log is no longer needed for instance recovery. It may be in use for media recovery, and may or may not be archived.

To display the members for each log group, query the V$LOGFILE view:

```
SELECT group#, member FROM v$logfile;

GROUP#     MEMBER
--------  ---------------------------------------------------------------------------
       1  /oracle/dbs/t1_log1.f
       2  /oracle/dbs/t1_log2.f
2 rows selected.
```

> **See Also:** *Oracle8i Reference* for more information on the data dictionary views.

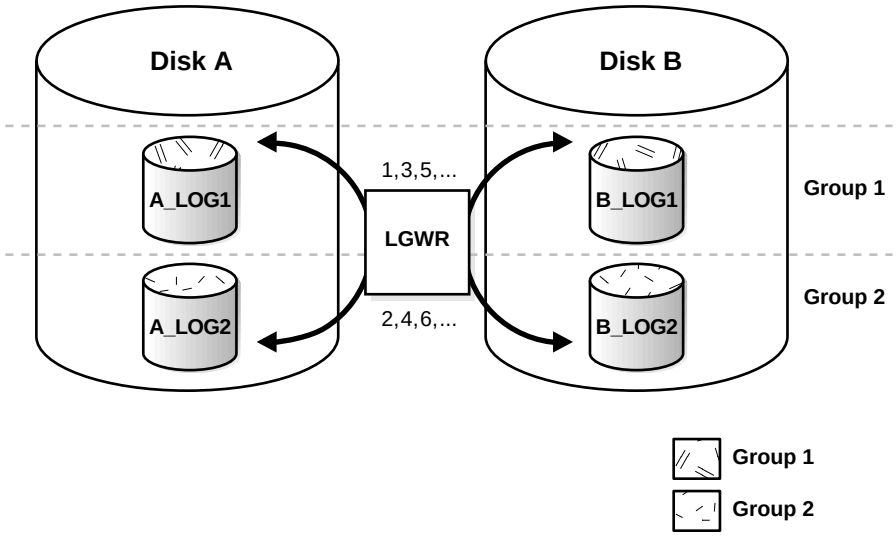
Multiplexing Online Redo Log Files

Oracle provides the capability to *multiplex* an instance's online redo log files to safeguard against damage. When multiplexing online redo log files, LGWR concurrently writes the same information to multiple identical online redo log files, thereby eliminating a single point of failure. You can also mirror redo logs at the operating system level, but in so doing you run the risk of operating system or hardware induced corruption. In most cases, multiplexing of online logs is best.

Oracle recommends multiplexing the online redo log on separate physical disks or possibly different file systems. If the file systems or disk subsystems support mirroring, this operation adds another level of redundancy. The online redo log is the source of your recovery data. Loss of all copies of an online log can mean the loss of committed transaction data.

WARNING: Oracle strongly recommends that you multiplex your redo log files or mirror them at the operating system level; the loss of the redo data can be catastrophic if recovery is required.

Figure 2–2 Multiplexed Online Redo Log Files



The corresponding online redo log files are called *groups*. Each online redo log file in a group is called a *member*. In Figure 2–2, files A_LOG1 and B_LOG1 are both members of Group 1; A_LOG2 and B_LOG2 are both members of Group 2, and so forth. Each member in a group must be the exact same size.

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

Responding to Online Redo Log Failure

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

If...	Then...
LGWR can successfully write to at least one member in a group	Writing proceeds as normal; LGWR simply writes to the available members of a group and ignores the unavailable members.
LGWR cannot access the next group at a log switch because the group needs to be archived	Database operation temporarily halts until the group becomes available, that is, until the group is archived.
All members of the next group are inaccessible to LGWR at a log switch because of disk failures	Oracle returns an error and the database instance shuts down. In this case, you may need to perform media recovery on the database from the loss of an online redo log file.
All members of the next group are inaccessible and the database checkpoint has moved beyond the lost redo log	Media recovery is not necessary because Oracle has saved the data recorded in the redo log to the datafiles. Simply drop the inaccessible redo log group.
You want to drop an unarchived redo log when in ARCHIVELOG mode	Issue ALTER DATABASE CLEAR UNARCHIVED LOG to disable archiving before the log can be dropped.
All members of group become inaccessible to LGWR while it is writing to them	Oracle returns an error and the database instance immediately shuts down. In this case, you may need to perform media recovery. If the media containing the log is not actually lost — for example, if the drive for the log was inadvertently turned off — media recovery may not be needed. In this case, you only need to turn the drive back on and let Oracle perform instance recovery.

See Also: *Oracle8i Administrator's Guide* for more information about configuring multiplexed online redo logs.

Managing the Archived Redo Logs

If you run your database in ARCHIVELOG mode, Oracle allows you to save filled groups of online redo log files, known as *archived redo logs*, to one or more offline destinations. *Archiving* is the operation of turning online redo logs into archived redo logs.

Use archived logs to:

- Recover a database.

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

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

If you enable archiving, LGWR is not allowed to re-use and hence overwrite an online redo log group until it has been archived. Therefore, the archived redo log contains a copy of every online redo group created since you enabled archiving. The best way to back up the contents of the current online log is always to archive it, then back up the archived log.

By archiving your online redo logs, you save a copy of every change made to the database since you enabled archiving. If you suffer a media failure, then you can recover the lost data by using the archived redo logs.

> **See Also:** *Oracle8i Administrator's Guide* for complete procedures for managing archived redo logs as well as for using the LogMiner, and *Oracle8i Standby Database Concepts and Administration* to learn how to manage a standby database.

This section contains the following topics:

- Displaying Archived Redo Log Information
- Choosing the Database Archiving Mode
- Setting the Archive Mode
- Archiving Redo Logs to Multiple Locations

Displaying Archived Redo Log Information

The following data dictionary views contain useful information about the archived redo logs:

Views	Description
V$DATABASE	Identifies whether the database is in ARCHIVELOG or NOARCHIVELOG mode.
V$ARCHIVED_LOG	Displays archived log information from the control file.
V$ARCHIVE_DEST	Describes the current instance, all archive destinations, and the current value, mode, and status of these destinations.
V$LOG	Displays all online redo log groups for the database and indicates which need to be archived.
V$LOG_HISTORY	Contains log history information such as which logs have been archived and the SCN range for each archived log.

For example, the following query displays which online redo log group requires archiving:

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

GROUP#     ARC
---------- ---
1          YES
2          NO
```

To see the current archiving mode, query the V$DATABASE view:

```
SELECT log_mode FROM sys.v$database;

LOG_MODE
------------
NOARCHIVELOG
```

The SQL*Plus statement ARCHIVE LOG LIST also shows archiving information for the connected instance:

```
ARCHIVE LOG LIST;

Database log mode                  ARCHIVELOG
Automatic archival                 ENABLED
Archive destination                /oracle/log
Oldest online log sequence         30
Next log sequence to archive       31
```

```
Current log sequence number             33
```

This display tells you all the necessary information regarding the archived redo log settings for the current instance:

- The database is currently operating in ARCHIVELOG mode.
- Automatic archiving is enabled.
- The destination of the archived redo log (operating system specific).
- The oldest filled online redo log group has a sequence number of 30.
- The next filled online redo log group to be archived has a sequence number of 31.
- The current online redo log file has a sequence number of 33.

You must archive all redo log groups with a sequence number equal to or greater than the *Next log sequence to archive*, yet less than the *Current log sequence number*. For example, the display above indicates that the online redo log groups with sequence numbers 31 and 32 need to be archived.

> **See Also:** *Oracle8i Reference* for more information on the data dictionary views.

Choosing the Database Archiving Mode

This section describes the issues you must consider when choosing to run your database in NOARCHIVELOG or ARCHIVELOG mode, and includes the following topics:

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

Running a Database in NOARCHIVELOG Mode

When you run your database in NOARCHIVELOG mode, you disable the archiving of the online redo log. The database's control file indicates that filled groups are not required to be archived. Therefore, after a filled group becomes inactive after a log switch, the group is available for reuse by LGWR.

Running your database in NOARCHIVELOG mode has the following consequences:

- You can only *restore* (not recover) the database to the point of the most recent full database backup. You cannot apply archived logs to the backup because there are no archived logs to be applied.
- You can only perform an operating system backup of the database when it is shut down cleanly.
- You can only restore a whole database backup and then open the database when the backup was taken while the database was closed cleanly. The only time you can restore an inconsistent backup is when the redo logs are undamaged and contain all redo generated since the backup was made.
- You cannot perform online tablespace backups. Furthermore, you cannot use online tablespace backups previously taken while the database operated in ARCHIVELOG mode.

See Also: "Backing Up a NOARCHIVELOG Database" on page 3-4

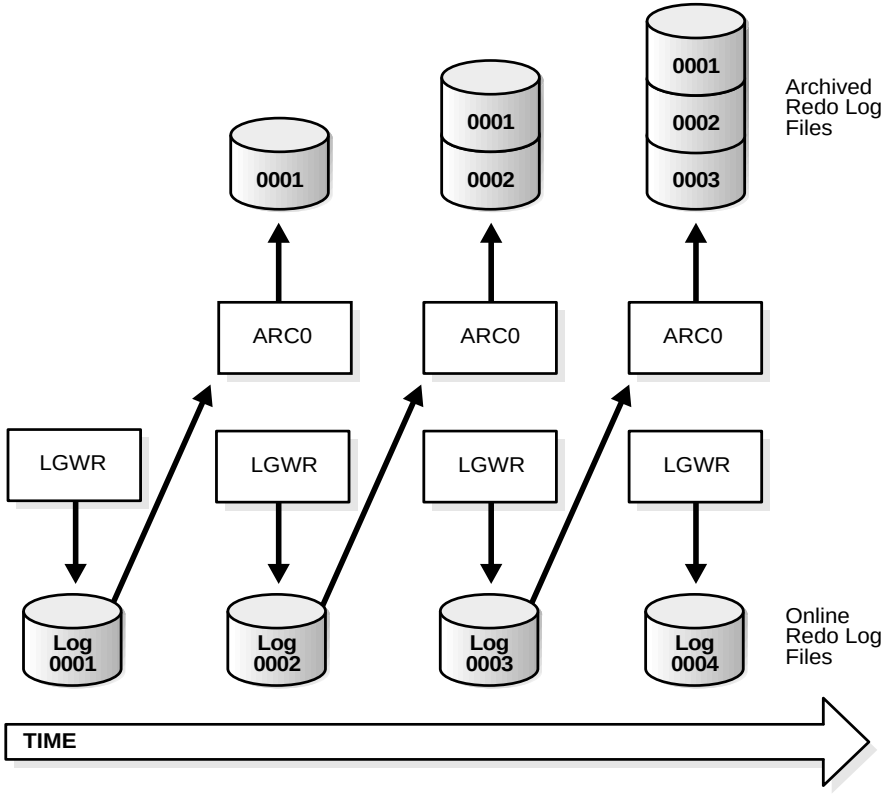
Running a Database in ARCHIVELOG Mode

When you run a database in ARCHIVELOG mode, Oracle requires the online redo log to be archived. You can either perform the archiving manually or enable automatic archiving.

In ARCHIVELOG mode, the database control file indicates that a group of filled online redo log files cannot be used by LGWR until the group is archived. A filled group is immediately available to ARC*n* after a log switch occurs. After the group has been successfully archived, Oracle can reuse the group.

Figure 2–3 illustrates the basic principle of archiving. LGWR writes to a log and then ARC*n* archives it. Each new write is assigned a new log sequence number, so the log sequence numbers increment by 1.

Figure 2–3 Online Redo Log File Use in ARCHIVELOG Mode



The archiving of filled groups has these advantages:

- A database backup in conjunction with all (possibly backed up) archived logs and the current online redo logs guarantees that you can recover all committed transactions.
- You can recover the database to a specified time, SCN, or log sequence number.
- You can take tablespace backups while the database is open.
- You can recover offline tablespaces while the database is open.
- You can keep a standby database current with its original database by continually applying the original's archived redo logs to the standby.

> **See Also:** *Oracle8i Administrator's Guide* to learn how to enable ARCHIVELOG mode and enable automatic archiving, and *Oracle8i Standby Database Concepts and Administration* for information about the managed recovery option for standby databases.

Setting the Archive Mode

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

```
ALTER DATABASE ARCHIVELOG;
```

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

1. Shut down the database instance.
2. Back up the database.
3. Restart the instance and mount but do not open the database.
4. Issue ALTER DATABASE ARCHIVELOG or ALTER DATABASE NOARCHIVELOG to switch the database's archiving mode.

Enabling Automatic Archiving

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

```
LOG_ARCHIVE_START=TRUE
```

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

To enable automatic archiving of filled online redo log groups without shutting down the current instance, use the SQL statement ALTER SYSTEM with the ARCHIVE LOG START parameter:

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

If you use the ALTER SYSTEM method, then you do not need to shut down and restart the instance to enable automatic archiving.

> **See Also:** *Oracle8i Administrator's Guide* for complete procedures for changing the archiving mode and enabling automatic archiving.

Archiving Redo Logs to Multiple Locations

You can specify a *single* destination or multiple destinations for the archived redo logs. Oracle recommends archiving your logs to different disks to guard against file corruption and media failure.

Specify the number of locations for your archived logs by setting either of two mutually exclusive sets of initialization parameters:

- LOG_ARCHIVE_DEST_*n* (where *n* is an integer from 1 to 5)
- LOG_ARCHIVE_DEST in conjunction with the optional initialization parameter LOG_ARCHIVE_DUPLEX_DEST

The first method is to use the LOG_ARCHIVE_DEST_*n* parameter to specify from one to five different destinations for archival. Each numerically-suffixed parameter uniquely identifies an individual destination, for example, LOG_ARCHIVE_DEST_1, LOG_ARCHIVE_DEST_2, etc. Use the LOCATION keyword to specify a pathname or the SERVICE keyword to specify a net service name (for use in conjunction with a standby database).

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

Note: You can also mirror your archived logs at the operating system level.

To set the archiving destination using LOG_ARCHIVE_DEST_*n*:

1. Edit the LOG_ARCHIVE_DEST_*n* parameter to specify from one to five archiving locations. For example, enter:

```
LOG_ARCHIVE_DEST_1 = 'LOCATION=/disk1/arc/'
LOG_ARCHIVE_DEST_2 = 'LOCATION=/disk2/arc/'
LOG_ARCHIVE_DEST_3 = 'LOCATION=/disk3/arc/'
```

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

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

For example, this setting results in the following files for log sequence numbers 100-102 on thread 1:

```
/disk1/arc/arch1_100.arc, /disk1/arc/arch1_101.arc, /disk1/arc/arch1_102.arc,
/disk2/arc/arch1_100.arc, /disk2/arc/arch1_101.arc, /disk2/arc/arch1_102.arc,
/disk3/arc/arch1_100.arc, /disk3/arc/arch1_101.arc, /disk3/arc/arch1_102.arc
```

3. If the database is open, start a SQL*Plus session and shut down the database. For example, enter:

```
SHUTDOWN IMMEDIATE
```

4. Mount or open the database to enable the settings. For example, enter:

```
STARTUP
```

To set archiving destinations with LOG_ARCHIVE_DEST and LOG_ARCHIVE_DUPLEX_DEST:

1. Edit the initialization parameter file, specifying destinations for the LOG_ARCHIVE_DEST and LOG_ARCHIVE_DUPLEX_DEST parameter. If the database is open, then you can also edit the parameter dynamically using the ALTER SYSTEM statement.

   For example, change the parameter to read:

```
LOG_ARCHIVE_DEST = '/disk1/arc'
LOG_ARCHIVE_DUPLEX_DEST_2 = '/disk2/arc'
```

2. Edit the LOG_ARCHIVE_FORMAT parameter, using `%S` to include the log sequence number as part of the filename and `%t` to include the thread number. Use capital letters (`%S` and `%T`) to pad the filename to the left with zeroes. If the database is open, you can alter the parameter using the ALTER SYSTEM statement.

   For example, enter:

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

   For example, this setting will result in the following files for log sequence numbers 300-302 on thread 1:

```
/disk1/arc/arch_1_300.arc, /disk1/arc/arch_1_301.arc, /disk1/arc/arch_1_302.arc,
/disk2/arc/arch_1_300.arc, /disk2/arc/arch_1_301.arc, /disk2/arc/arch_1_302.arc
```

3. If the database is open, start a SQL*Plus session and shut down the database. For example, enter:

```
SHUTDOWN IMMEDIATE
```

4. Mount or open the database to enable the settings in the initialization parameter file. For example, enter:

```
STARTUP
```

Oracle provides you with a number of useful archiving options. See the *Oracle8i Administrator's Guide* for a complete account of how to:

- Obtain status information for each archive destination. For example, you can determine whether there was a problem archiving to a specific destination.
- Specify archiving to a local disk or to either a local or remote standby database site.
- Specify the minimum number of destinations to which Oracle must successfully archive.
- Specify when and how often ARC*n* attempts to re-archive to a failed destination.
- Specify up to ten ARC*n* processes for each database instance to parallelize archiving operations.
- Use the LogMiner utility to analyze the contents of online and archived redo logs.

3

Developing a Backup and Recovery Strategy

This chapter offers guidelines and considerations for developing an effective backup and recovery strategy. It includes the following topics:

Developing a Backup Strategy

Before you create an Oracle database, decide how to protect the database against potential media failures. If you do not develop a backup strategy before creating your database, you may not be able to perform recovery if a disk failure damages the datafiles, online redo log files, or control files.

This section describes general guidelines that can help you decide when to perform database backups and which parts of a database you should back up. Of course, the specifics of your strategy depend on the constraints under which you are operating. No matter which backup strategy you implement, however, follow these guidelines whenever possible:

- Obeying the Golden Rule of Backup and Recovery
- Choosing the Database Archiving Mode
- Multiplexing Control Files, Online Redo Logs, and Archived Redo Logs
- Performing Backups Frequently and Regularly
- Performing Backups When You Make Structural Changes
- Backing Up Often-Used Tablespaces
- Performing Backups After Unrecoverable / Unlogged Operations
- Performing Whole Database Backups After Opening with the RESETLOGS Option
- Archiving Older Backups
- Knowing the Constraints for Distributed Database Backups
- Exporting Data for Added Protection and Flexibility
- Avoiding the Backup of Online Redo Logs

Obeying the Golden Rule of Backup and Recovery

The set of files needed to recover from the failure of any Oracle database file—a datafile, control file, or online redo log—is called the *redundancy set*. The redundancy set contains:

- The last backup of all the database files
- All archived redo logs generated after the last backup was taken

- A duplicate of the online redo log files generated by Oracle multiplexing, operating system mirroring, or both
- A duplicate of the current control file generated by Oracle multiplexing, operating system mirroring, or both
- Configuration files such as initialization parameter file, `tnsnames.ora`, and `listener.ora`

The golden rule of backup and recovery is: *the set of disks or other media that contain the redundancy set should be separate from the disks that contain the datafiles, online redo logs, and control files.* This strategy ensures that the failure of a disk that contains a datafile does not also cause the loss of the backups or redo logs needed to recover the datafile. Consequently, a minimal production-level database requires at least two disk drives: one to hold the files in the redundancy set and one to hold the main database files.

Always keep the redundancy set separated from the primary files in every way possible: on separate volumes, separate file systems, and separate RAID devices. These systems are very reliable, but they can and do fail. Keeping the redundancy set separate ensures that you can recover from a failure without losing committed transactions.

You can implement a system that follows the golden rule in several different ways. Oracle recommends following these guidelines:

- Multiplex the online redo log files and current control file at the Oracle level, not only at the operating system or hardware level. Multiplexing at the Oracle level has the advantage that an I/O failure or lost write should only corrupt one of the copies.
- Use operating system or hardware mirroring for at least the control file, because Oracle does not provide complete support for control file multiplexing: if one multiplexed copy of the control file fails, then Oracle shuts down.
- Use operating system or hardware mirroring for the primary datafiles if possible to avoid having to apply media recovery for simple disk failures.
- Keep at least one copy of the entire redundancy set—including the most recent backup—on hard disk. With disk prices steadily dropping, this strategy is economical for many installations.

  If the redundancy copy is generated by splitting a mirror, then it is not as good as a backup generated through operating system or RMAN commands because it relies on the mirroring subsystem for both the primary files *and* redundancy

set copy. The last real file backup, such as the last backup to tape, is the redundancy set copy. Therefore, keep archived redo logs starting with this copy.

- If your database is stored on a RAID device, then place the redundancy set on a set of devices that is not in the same RAID device.

Choosing the Database Archiving Mode

Before you create an Oracle database, decide how you plan to protect it against potential failures. Answer the following questions:

- **Is it acceptable to lose any data if a disk failure damages some of the files that constitute a database?** If not, run the database in ARCHIVELOG mode, ideally with a multiplexed online redo log, a multiplexed control file, and multiplexed archive redo logs. If you can afford to lose a limited amount of data, you can operate in NOARCHIVELOG mode and avoid the extra maintenance chores.
- **Will you need to recover to a non-current time?** If you need to perform incomplete recovery to correct an erroneous change to the database, run in ARCHIVELOG mode and perform control file backups whenever making structural changes. Incomplete recovery is helped by having a backup control file reflecting the database structure at the desired time.
- **Does the database need to be available at all times?** If so, do not operate the database in NOARCHIVELOG mode because the required whole database backups, taken while the database is shutdown, cannot be made frequently, if at all. Therefore, high-availability databases always operate in ARCHIVELOG mode to take advantage of open datafile backups.

Once you have answered these questions and have determined which mode to use, follow the guidelines for either:

- Backing Up a NOARCHIVELOG Database
- Backing Up an ARCHIVELOG Database

Backing Up a NOARCHIVELOG Database

If you operate your database in NOARCHIVELOG mode, Oracle does not archive filled groups of online redo log files. Therefore, the only protection against a disk failure is the most recent whole backup of the database. Follow these guidelines:

- Plan to make whole database backups regularly, according to the amount of work that you can afford to lose. For example, if you can afford to lose the amount of work accomplished in one week, make a consistent whole database backup once per week. If you can afford to lose only a day's work, make a

consistent whole database backup every day. For large databases with a high amount of activity, you usually cannot afford to lose work. In this case, you should operate the database in ARCHIVELOG mode.

- Whenever you alter the physical structure of a database operating in NOARCHIVELOG mode, immediately take a consistent whole database backup. A whole database backup fully reflects the new structure of the database.

Backing Up an ARCHIVELOG Database

If you run your database in ARCHIVELOG mode, ARC*n* archives groups of online redo log files. Therefore, the archived redo log coupled with the online redo log and datafile backups can protect the database from a disk failure, providing for complete recovery from a disk failure to the instant that the failure occurred (or, to the desired non-current time). Following are common backup strategies for a database operating in ARCHIVELOG mode:

- Perform a whole database backup of the entire database after you create it. This initial whole database backup is the foundation of your backups because it provides backups of all datafiles and the control file of the associated database.

  Note: When you perform this initial whole database backup, make sure that the database is in ARCHIVELOG mode first. Otherwise, the backup control files will contain the NOARCHIVELOG mode setting.

- Make open database or tablespace backups to keep your database backups up-to-date. Subsequent whole database backups are not required, and if a database must remain open at all times, whole database backups while the database is closed are not feasible.
- Make open or closed datafile backups to update backed up information for the database. Doing so supplements the initial whole database backup. In particular, back up the datafiles of extensively used tablespaces frequently to reduce database recovery time. If a more recent datafile backup restores a damaged datafile, you need to apply less redo data (or incremental backups) to the restored datafile to roll it forward to the time of the failure.

  Whether you should take open or closed datafile backups depends on the availability requirements of the data. Open datafile backups are the only choice if the data being backed up must always be available.

You can also use a datafile copy taken while the database is open and the tablespace is online to restore datafiles. You must apply the appropriate redo log files to these restored datafiles to make the data consistent and bring it forward to the specified point in time.

- Make a control file backup every time you make a structural change to the database. If you are operating in ARCHIVELOG mode and the database is open, use either RMAN or the ALTER DATABASE statement with the BACKUP CONTROLFILE option.

Multiplexing Control Files, Online Redo Logs, and Archived Redo Logs

The control file, online redo log, and archived redo log are crucial files for backup and recovery operations. The loss of any of these files can cause you to lose data irrevocably. You should maintain:

- At least two copies of the control file on different disks mounted under different disk controllers. You can either use Oracle to multiplex the copies or your operating system to mirror them.
- Two or more copies of your online redo log on different disks. The online redo data is crucial for instance, crash, and media recovery.
- Two or more copies of your archived redo log on different disks and, if possible, different media.

> **See Also:** Chapter 2, "Managing Data Structures" to learn how to integrate data structure management into your backup and recovery strategy, and *Oracle8i Concepts* for a thorough conceptual overview of all Oracle data structures.

Performing Backups Frequently and Regularly

Frequent backups are essential for any recovery scheme. Base the frequency of backups on the rate or frequency of database changes such as:

- Addition and deletion of tables.
- Insertions and deletions of rows in existing tables.
- Updates to data within tables.

If users generate a significant amount of DML, database backup frequency should be proportionally high. Alternatively, if a database is mainly read-only, and updates are issued only infrequently, you can back up the database less frequently.

Use either Recovery Manager or operating system methods to create backup scripts. RMAN scripts, which are stored in the recovery catalog, are an especially efficient method for performing routine, repetitive backup operations.

> **See Also:** *Oracle8i Recovery Manager User's Guide and Reference* to learn how to create, delete, replace, and print stored scripts.

Performing Backups When You Make Structural Changes

Administrators as well as users make changes to a database. If you make any of the following structural changes, then perform a backup of the appropriate portion of your database immediately before and after completing the alteration:

- Create or drop a tablespace.
- Add or rename a datafile in an existing tablespace.
- Add, rename, or drop an online redo log group or member.

The part of the database that you should back up depends on your archiving mode:

Mode	Action
ARCHIVELOG	Make a control file backup (using the ALTER DATABASE statement with the BACKUP CONTROLFILE option) before and after a structural alteration. Of course, you can back up other parts of the database as well.
NOARCHIVELOG	Make a consistent whole database backup immediately before and after the modification.

Backing Up Often-Used Tablespaces

Many administrators find that regular whole database backups are not in themselves sufficient for a robust backup strategy. If you run in ARCHIVELOG mode, then you can back up the datafiles of an individual tablespace or even a single datafile. This option is useful if a portion of a database is used more extensively than others, for example, the SYSTEM tablespace and tablespaces that contain rollback segments.

By making more frequent backups of the extensively used datafiles of a database, you avoid a long recovery time. For example, you may make a whole database backup once a week on Sunday. If your database experiences heavy traffic during the week, a media failure on Friday can force you to apply a tremendous amount of redo data during recovery. If you had backed up your most frequently accessed

tablespaces three times a week, you can apply a smaller number of changes to roll the restored file forward to the time of the failure.

Performing Backups After Unrecoverable/Unlogged Operations

If users are creating tables or indexes using the UNRECOVERABLE option, make backups after the objects are created. When tables and indexes are created as UNRECOVERABLE, Oracle does not log redo data, which means that you cannot recover these objects from existing backups.

Note: If using RMAN, then you can make an incremental backup.

See Also: *Oracle8i SQL Reference* for information about the UNRECOVERABLE option of the CREATE TABLE ... AS SELECT and CREATE INDEX statements.

Performing Whole Database Backups After Opening with the RESETLOGS Option

After you have opened a database with the RESETLOGS option, Oracle recommends that you immediately perform a whole database backup. If you do not, and a disaster occurs, then you lose all changes made after opening the database.

See Also: "What Is a RESETLOGS Operation?" on page 5-32 for more information about RESETLOGS operations, and "Recovering a Pre-RESETLOGS Backup" on page 5-36 to learn the special circumstances that allow you to recover a pre-RESETLOGS backup.

Archiving Older Backups

You should store older backups for two basic reasons:

- An older backup is necessary for perform incomplete recovery to a time before your most recent backup.
- Your most recent backup is corrupted.

If you want to recover to a non-current time, then you need a database backup that completed before the desired time. For example, if you make backups on the 1st and 14th of February, then decide at the end of the month to recover your database to February 7th, you must use the February 1st backup.

For a database operating in NOARCHIVELOG mode, the backup that you use should be a consistent whole database backup. Of course, you cannot perform media recovery using this backup. For a database operating in ARCHIVELOG mode, your whole database backup:

- Does not need not be consistent because redo is available to recover it.
- Should have completed before the intended recovery time (the control file should reflect the database's structure at the point-in-time of recovery).
- Should have all archived logs necessary to recover the datafiles to the required point-in-time.

For added protection, keep two or more database backups (with associated archived redo logs) previous to the current backup. Thus, if your most recent backups are not usable, you will not lose all of your data.

WARNING: After you open the database with the RESETLOGS option, you cannot use existing backups for subsequent recovery beyond the time when the logs were reset. You should therefore shut down the database and make a consistent whole database backup. Doing so will enable recovery of database changes after using the RESETLOGS option.

Knowing the Constraints for Distributed Database Backups

If your database is a node in a distributed database, all databases in the distributed database system should operate in the same archiving mode. Note the following consequences and constraints:

Mode	Constraint	Consequence
ARCHIVELOG	Closed cleanly.	Backups at each node can be performed autonomously, that is, individually and without time coordination.
NOARCHIVELOG	Closed cleanly.	Consistent whole database backups must be performed at the same global time to plan for global distributed database recovery. For example, if a database in New York is backed up at midnight EST, the database in San Francisco should be backed up at 9 PM PST.

> **See Also:** "Opening the Database After Media Recovery" on page 5-31 to learn about performing media recovery in distributed systems, and *Oracle8i Distributed Database Systems* for concepts and administration relating to distributed systems.

Exporting Data for Added Protection and Flexibility

Because the Oracle Export utility can selectively export specific objects, consider exporting portions or all of a database for supplemental protection and flexibility in a database's backup strategy. This strategy is especially useful for recovery catalog backups when using RMAN.

Note that Database exports are not a substitute for whole database backups and cannot provide the same complete recovery advantages that the built-in functionality of Oracle offers.

> **See Also:** *Oracle8i Utilities* for a complete account of the Export utility.

Avoiding the Backup of Online Redo Logs

Although it may seem that you should back up online redo logs along with the datafiles and control file, this technique is dangerous. You should not back up online redo logs for the following reasons:

- The best method for protecting the online logs against media failure is by multiplexing them, that is, having multiple log members per group, on different disks and disk controllers.
- If your database is in ARCHIVELOG mode, then ARC*n* is already archiving the redo logs.
- If your database is in NOARCHIVELOG mode, then the only type of backups that you should perform are closed, consistent, whole database backups. The files in this type of backup are all consistent and do not need recovery, so the online logs are not needed.

The danger in backing up online redo logs is that you may accidentally restore them while not intending to. A number of situations are possible in which restoring the online logs cause significant problems to the database. Following are two scenarios that illustrate how restoring backed up online logs severely compromises recovery.

Scenario 1: Unintentionally Restoring Online Redo Logs When a crisis occurs, it is easy to make a simple mistake. DBAs and system administrators frequently encounter

dangers during a database restore. When restoring the whole database, you can accidentally restore the online redo logs, thus overwriting the current logs with the older, useless backups. This action forces you to perform an incomplete recovery instead of the intended complete recovery, thereby losing the ability to recover valuable transactions contained in the overwritten redo logs.

Scenario 2: Erroneously Creating Multiple Parallel Redo Log Timelines You can unintentionally create multiple parallel redo log timelines for a single instance database. You can avoid this mistake, however, by making it so that the online logs cannot be restored. You must open the database with the RESETLOGS option, which effectively creates the new redo logs, and also a new database incarnation.

If you face a problem where the best course of action is to restore the database from a consistent backup and not perform any recovery, then you may think it is safe to restore the online logs and thereby avoid opening the database with the RESETLOGS option. The problem is that the database eventually generates a log sequence number that was already generated by the database during the previous timeline.

If you then face another disaster and need to restore from this backup and roll forward, you will find it difficult to identify which log sequence number is the correct one. If you had reset the logs, then you would have created a new incarnation of the database. You could only apply archived redo logs created by this new incarnation to this incarnation.

For example, say that the most recent archived log for database PROD has a log sequence number of 100. Assume that you restore a backup of the database along with backed up online redo logs and then do *not* open with the RESETLOGS option. Assume also that the restored online log is at log sequence 50. Eventually, the database archives a log with the log sequence number of 100—so you now have two copies of log 100 with completely different contents. If you are forced to recover this database, then you may inadvertently restore the wrong series of archived logs, thereby corrupting the database.

Note: Recovery Manager and EBU do not back up online redo logs.

Developing a Recovery Strategy

Oracle provides a variety of procedures and tools to assist you with recovery. To develop an effective recovery strategy, do the following:

Testing Backup and Recovery Strategies

Practice backup and recovery techniques in a test environment before and after you move to a production system. In this way, you can measure the thoroughness of your strategies and minimize problems before they occur in a real situation. Performing test recoveries regularly ensures that your archiving, backup, and recovery procedures work. It also helps you stay familiar with recovery procedures, so that you are less likely to make a mistake in a crisis.

If you use Recovery Manager, use the **duplicate** command to create a test database using backups of your production database. To learn how to duplicate a database, see *Oracle8i Recovery Manager User's Guide and Reference*.

Planning Your Response to Non-Media Failures

Although media recovery is your primary concern when developing your recovery strategy, you should understand the basic types of non-media failures as well as the causes and solutions for each:

Statement Failure

A statement failure is a logical failure in the handling of a statement in an Oracle program. The Oracle database server or the operating system usually returns an error code and a message when a statement failure occurs. Table 3–1 shows typical causes and resolutions for statement failures.

Table 3–1 Typical Causes and Resolutions for Statement Failures

Problem	Solution
A logical error occurred in an application.	Fix the program that generated the error so that its logic flows correctly. You may need to enlist the aid of developers to solve this type of problem.

Table 3–1 Typical Causes and Resolutions for Statement Failures

Problem	Solution
A user attempted to enter illegal data into a table.	Modify the illegal SQL statement and reissue it.
A user attempted an operation with insufficient privileges, for example, attempting to insert data into a table when the user has only SELECT privileges.	Provide the necessary database privileges for the user to complete the statement successfully.
A user attempted to create a table but exceed the allotted quota limit.	Issue an ALTER USER statement to change the quota limit.
A user attempted a table INSERT or UPDATE, causing an extent to be allocated without sufficient free space in the tablespace.	Add space to the tablespace. You can also use the RESIZE and AUTOEXTEND options for datafiles.

User Process Failure

A user process failure is any failure in a user program accessing an Oracle database. User processes can fail for a wide variety of reasons. Some typical scenarios include:

- A user performed an abnormal disconnection in the session.
- The user's session was abnormally terminated. For example, the user rebooted the client while connected to a database in a client-server configuration.
- The user's program raised an address exception that terminated the session.

In most cases, you do not need to act to resolve user process failures: the user process simply fails to function but does not affect Oracle and other user process. The PMON background process is usually sufficient for cleaning up after an abnormally terminated user process.

User Error

Users errors are any mistakes that users make in adding data to or deleting data from the database. Typical causes of user error are:

- A user accidentally drops or truncates a table.
- A user deletes all rows in a table.
- A user commits data, but discovers an error after the data is committed.

If you have a logical backup of a table from which data has been lost, sometimes you can simply import it back into the table. Depending on the scenario, however, you may have to perform some type of incomplete media recovery to correct such errors.

You can perform either database point-in-time recovery (DBPITR) or tablespace point-in-time recovery (TSPITR). The following table explains the difference between these types of incomplete recovery:

Type	Description	Procedure
DBPITR	1. Restore backup database. 2. Roll forward to the time just before the error. 3. Open RESETLOGS.	For operating system recovery, see "Performing Incomplete Media Recovery" on page 5-25. **See Also:** For RMAN recovery, see *Oracle8i Recovery Manager User's Guide and Reference*.
TSPITR	1. Create auxiliary instance. 2. Recover the tablespace on the auxiliary to the time just before the error. 3. Import data back into the primary database.	For operating system TSPITR, see Chapter 7, "Performing Operating System Tablespace Point-in-Time Recovery". **See Also:** For RMAN TSPITR, see *Oracle8i Recovery Manager User's Guide and Reference*.

See Also: "Recovering from User Errors" on page 6-15 for a scenario involving recovery from a user error.

Instance Failure

Instance failure occurs when an instance abnormally terminates. An instance failure can occur because:

- A power outage causes the server to crash.
- The server becomes unavailable because of hardware problems.
- The operating system crashes.
- One of the Oracle background processes fails.
- You issue a SHUTDOWN ABORT statement.

Fortunately, Oracle performs instance recovery automatically: all you need to do is restart the database. Oracle automatically detects that the database was not shut down cleanly, then applies committed and uncommitted redo records in the redo

log to the datafiles and rolls back uncommitted data. Finally, Oracle synchronizes the datafiles and control file and opens the database.

Planning Your Response to Media Failures

Media failure is the biggest threat to your data. A media failure is a physical problem that occurs when a computer unsuccessfully attempts to read from or write to a file necessary to operate the database. Common types of media problems include:

- A disk drive that holds one of the database files experiences a head crash.
- A datafile, online or archived redo log, or control file is accidentally deleted, overwritten, or corrupted.

The technique you use to recover from media failure depends heavily on the type of media failure that occurred. For example, the strategy you use to recover from a corrupted datafile is different from the strategy for recovering from the loss of your control file.

The basic steps for media recovery are:

- Determine which files to recover.
- Determine the type of media recovery required: complete or incomplete, open database or closed database.
- Restore backups or copies of necessary files: datafiles, control files, and the archived redo logs necessary to recover the datafiles.

  Note: If you do not have a backup, then you can still perform recovery if you have the necessary redo log files and the control file contains the name of the damaged file. If you cannot restore a file to its original location, then you must relocate the restored file and inform the control file of the new location.

- Apply redo records (and / or incremental backups when using Recovery Manager) to recover the datafiles.
- Reopen the database. If you perform incomplete recovery, then you must open the database in RESETLOGS mode.

> **See Also:** *Oracle8i Recovery Manager User's Guide and Reference* to learn how to perform media recovery using RMAN, and Chapter 5, "Performing Media Recovery" to learn how to perform media recovery using operating system methods.

Determine Which Files to Recover

The first step is to determine what to recover. Some types of failure are obvious: for example, the hardware crashes and you need to recover the entire database. In other cases, a single datafile becomes corrupted. Often you can use the table V$RECOVER_FILE to determine what requires recovery.

Choose a Type of Recovery

When you perform media recovery, you choose either complete recovery or incomplete recovery. Following is a list of media recovery operations:

- Complete media recovery

  Complete media recovery includes the application of all necessary redo or incremental backups ever generated for the particular incarnation of the database being recovered. Complete media recovery can be performed on offline datafiles while the database is open. Types of complete media recovery are:

  - Closed database recovery
  - Open-database, offline-tablespace recovery
  - Open-database, offline-tablespace, individual datafile recovery

- Incomplete Media Recovery

  Incomplete media recovery, also called point-in-time recovery (PITR), produces a version of the database as it was at some time in the past. Incomplete media recovery must either continue on to become complete media recovery, or be terminated by a RESETLOGS operation that creates a new incarnation of the database. The database must be closed for incomplete media recovery operations. You can perform:

  - *time-based recovery*, which recovers the data up to a specified point in time.
  - *cancel-based recovery*, which recovers until you issue the CANCEL statement.
  - *change-based recovery*, which recovers up to a specified SCN.
  - *log sequence recovery*, which recovers up to a specified log sequence number.

One important and special type media recovery is *tablespace point-in-time recovery* (TSPITR). TSPITR enables you to recover one or more tablespaces to a point-in-time that is different from the rest of the database.

The type of recovery method you use depends on the situation. Table 3–2 displays typical scenarios and strategies.

Table 3–2 Typical Media Failures and Recovery Strategies

Lost Files	Archiving Mode	Status	Strategy
One or more datafiles	NOARCHIVELOG	Closed	Restore whole database from a consistent database backup. The control file and all datafiles are restored from a consistent backup and the database is opened. All changes made after the backup are lost. **Note:** The *only* time you can recover a database in NOARCHIVELOG is when you have not already overwritten the online log files that were current at the time of the most recent backup.
One or more datafiles and an online redo log	NOARCHIVELOG	Closed	Restore whole database from consistent backup. You will lose all changes made since the last backup.
One or more datafiles and all control files	NOARCHIVELOG	Closed	Restore whole database and control file from consistent backup. You will lose all changes made since the last backup.
One or more datafiles	ARCHIVELOG	Open	Perform tablespace or datafile recovery while the database is open. The tablespaces or datafiles are taken offline, restored from backups, recovered, and placed online. No changes are lost and the database remains available during the recovery.
One or more datafiles and an online redo log required for recovery	ARCHIVELOG	Closed	Perform incomplete recovery of the database up to the point of the lost online redo log.

Table 3–2 Typical Media Failures and Recovery Strategies

Lost Files	Archiving Mode	Status	Strategy
One or more datafiles and an archived redo log required for recovery	ARCHIVELOG	Open	Perform TSPITR on the tablespaces containing the lost datafiles up to the point of the latest available redo log.
One or more datafiles and / or all control files	ARCHIVELOG	Not open	Restore the lost files from backups and recover the datafiles. No changes are lost, but the database is unavailable during recovery.
One or more datafiles and / or all control files, as well as an archived or online redo log required for recovery	ARCHIVELOG	Not open	Perform incomplete recovery of the database. You will lose all changes contained in the lost log and in all subsequent logs.

Restore Backups of Datafiles and Necessary Archived Redo Logs

The method you use to restore backups depends on whether you use RMAN or operating system methods to back up your data. If you use operating system methods, then you need to identify which files need to be restored and manually copy the backups to their necessary location. If you use RMAN, then issue a **restore** command and let RMAN take over the transfer of data.

If the database is shut down and you restore one of the datafiles with a backup, either because of a media failure or because for some reason you want to recover the database to a non-current time, Oracle detects an inconsistency between the checkpoint SCN in the datafile headers and the datafile header checkpoint SCNs recorded in the control file at database open time. Oracle then selects the lowest checkpoint SCN recorded in the control file and datafile headers and asks you to begin media recovery starting from a specified log sequence number. You cannot open the database if any of the online datafiles needs media recovery.

There is only one case in which Oracle will tell you that you need to perform media recovery when you do not. If a tablespace is in hot backup mode because you issued the ALTER TABLESPACE ... BEGIN BACKUP statement and the system crashes, then on the next startup Oracle will issue a message stating that media recovery is required. Media recovery is not really required here, however, since you did not restore a backup; in this case, avoid media recovery by issuing the ALTER DATAFILE ... END BACKUP statement. Note that RMAN backups do not have this problem.

> **See Also:** *Oracle8i Recovery Manager User's Guide and Reference* to learn how to restore backups using RMAN, "Restoring Files" on page 5-4 to learn how to restore datafiles using operating system methods.

Begin Media Recovery

You have a choice between two basic methods for recovering physical files. You can:

- Use RMAN to automate recovery.
- Execute SQL or SQL*Plus statements.

Obviously, the recovery method you choose is contingent on which backup method you use. For example, if you backed up your files using:

- The RMAN **backup** command, then you must use the RMAN **restore** and **recover** commands for recovery, since these backups are in an RMAN-specific format.
- The RMAN **copy** command, then you can use either RMAN or operating system methods for recovery.
- Operating system commands, then you must use your operating system utility for restoring files and the RECOVER (SQL*Plus) or ALTER DATABASE RECOVER (SQL) statements for recovering them.

> **Note:** The only exception is for operating system backups that are image copies on disk. If you register these image copies as datafile copies with RMAN, then RMAN can restore them.

Recovering with RMAN RMAN is a powerful tool that can aid in backup and recovery operations. Using RMAN for recovery allows you to:

- Restore and recover both file copies and RMAN-specific backup sets.
- Minimize administration errors by using the recovery catalog.
- Use RMAN's incremental backup feature to minimize recovery time.
- Generate comprehensive reports on previous backups, datafile copies, unrecoverable files, etc.
- Use scripts stored in the file system or recovery catalog to automate jobs.
- Cooperate with a media manager to restore backups from tape.

> **See Also:** *Oracle8i Recovery Manager User's Guide and Reference* to learn how to perform RMAN recovery.

Recovering with the SQL*Plus RECOVER Statement If you do not use RMAN, then you can use operating system methods to restore your backups and SQL*Plus statements to perform media recovery. You can use SQL*Plus statements to:

- Recover both operating system copies and files generated with the RMAN **copy** command.
- Maintain manual control over media recovery.

You can use three basic SQL*Plus statements for recovery:

- RECOVER DATABASE
- RECOVER TABLESPACE
- RECOVER DATAFILE

Note that each of these is also a sub-clause of an ALTER DATABASE statement. Oracle recommends using the SQL*Plus RECOVER statement rather than the ALTER DATABASE statement with the RECOVER clause. For more information about the SQL*Plus RECOVER statement, see *SQL*Plus User's Guide and Reference*.

Each statement uses the same criteria to determine whether files are recoverable. If Oracle cannot get the lock for a file it is attempting to recover, it signals an error. This signal prevents two recovery sessions from recovering the same file and prevents media recovery of a file that is in use.

> **See Also:** "Using Media Recovery Statements" on page 5-7 to learn about the differences between the SQL ALTER DATABASE RECOVER and SQL*Plus RECOVER statements.

Part II

Performing Operating System Backup and Recovery

4

Performing Operating System Backups

If you do not use Recovery Manager, then you can make backups of your database using operating system utilities and recover datafiles using SQL*Plus. This chapter explains how to use operating system methods to back up an Oracle database, and includes the following topics:

- Listing Database Files Before Performing a Backup
- Performing Operating System Backups
- Verifying Backups
- Responding to a Failed Online Tablespace Backup
- Using Export and Import for Supplemental Protection

Listing Database Files Before Performing a Backup

Before taking a backup, identify all the files in your database. Then, ascertain what you need to back up.

To list datafiles, online redo logs, and control files:

1. Start SQL*Plus and query V$DATAFILE to obtain a list of datafiles:

```
SELECT name FROM v$datafile;

NAME
--------------------------------------------------------------------------------
/oracle/dbs/tbs_01.f
/oracle/dbs/tbs_02.f
/oracle/dbs/tbs_03.f
/oracle/dbs/tbs_11.f
/oracle/dbs/tbs_12.f
/oracle/dbs/tbs_21.f
/oracle/dbs/tbs_22.f
/oracle/dbs/tbs_23.f
/oracle/dbs/tbs_24.f
9 rows selected.
```

   You can also join the V$TABLESPACE and V$DATAFILE views to obtain a listing of datafiles along with their associated tablespaces:

```
SELECT t.name "Tablespace", f.name "Datafile"
  FROM v$tablespace t, v$datafile f
  WHERE t.ts# = f.ts#
  ORDER BY t.name;

Tablespace                     Datafile
---------------------------    -------------------------
SYSTEM                         /oracle/dbs/tbs_01.f
SYSTEM                         /oracle/dbs/tbs_02.f
SYSTEM                         /oracle/dbs/tbs_03.f
TBS_1                          /oracle/dbs/tbs_11.f
TBS_1                          /oracle/dbs/tbs_12.f
TBS_2                          /oracle/dbs/tbs_21.f
TBS_2                          /oracle/dbs/tbs_22.f
TBS_2                          /oracle/dbs/tbs_23.f
TBS_2                          /oracle/dbs/tbs_24.f
```

2. Obtain the filenames of online redo log files by using the V$LOGFILE view. For example, issue this query:

```
SELECT member FROM v$logfile;
MEMBER
```

```
--------------------------------------------------------------------------------
/oracle/dbs/t1_log1.f
/oracle/dbs/t1_log2.f
2 rows selected.
```

3. Obtain the filenames of the current control files using the CONTROL_FILES parameter. For example, issue this query:

```
SELECT value FROM v$parameter
  WHERE name = 'control_files';

VALUE
--------------------------------------------------------------------------------
/oracle/dbs/cf1.f, /oracle/dbs/cf2.f
```

4. If you plan to take a control file backup using the ALTER DATABASE statement with the BACKUP CONTROLFILE TO '*filename*' option, save a list of all datafiles and online redo log files with the control file backup.

Performing Operating System Backups

While Recovery Manager is the recommended tool for backing up an Oracle database, you can also make backups using operating system utilities. The utility you choose is dependent on your operating system.

This section describes the various aspects of making operating system backups, and includes the following topics:

- Performing Whole Database Backups
- Performing Tablespace and Datafile Backups
- Performing Control File Backups

Performing Whole Database Backups

Take a whole database backup of all files that constitute a database after the database is shut down to system-wide use in normal priority. *A whole database backup taken while the database is open or after an instance crash or SHUTDOWN ABORT is inconsistent*. In such cases, the files are inconsistent with respect to the checkpoint SCN.

You can take a whole database backup if a database is operating in either ARCHIVELOG or NOARCHIVELOG mode. If you run the database in NOARCHIVELOG mode, however, the backup must be consistent, that is, you must shut down the database cleanly before the backup.

The set of backup files that result from a consistent whole database backup are consistent because all files correspond to the same SCN. You can restore the database without performing recovery. After restoring the backup files, you can perform additional recovery steps to recover the database to a more current time if the database is operated in ARCHIVELOG mode. Also, you can take inconsistent whole database backups if your database is in ARCHIVELOG mode.

Only use a backup control file created during a whole database backup to restore the other files taken in that backup, not for complete or incomplete database recovery. The reason is that Oracle recognizes backup control files created with the ALTER DATABASE BACKUP CONTROLFILE statement as backup control files; operating system copies of control files look like current control files to Oracle. Unless you are making a whole database backup, *always* back up the control file using a SQL statement.

> **See Also:** "Performing Control File Backups" on page 4-13 for more information about backing up control files.

Making Consistent Whole Database Backups

To guarantee that a database's datafiles are consistent, shut down the database with the NORMAL, IMMEDIATE, or TRANSACTIONAL options before making a whole database backup. Never perform a whole database backup after an instance failure or after the database is shut down using a SHUTDOWN ABORT statement unless your database is in ARCHIVELOG mode.

To make a consistent whole database backup:

1. If the database is open, use SQL*Plus to shut down the database with the NORMAL, IMMEDIATE, or TRANSACTIONAL options:

   ```
   SHUTDOWN NORMAL
   SHUTDOWN IMMEDIATE
   SHUTDOWN TRANSACTIONAL
   ```

   Do not make a whole database backup when the instance is aborted or stopped because of a failure. Reopen the database and shut it down cleanly first.

2. Use operating system commands or a backup utility to make backups of all datafiles and all control files specified by the CONTROL_FILES parameter of the initialization parameter file. Also back up the initialization parameter file and other Oracle product initialization files. To find them, do a search for `*.ora` starting in your Oracle home directory and recursively search all of its subdirectories.

> **Note:** If you are forced to perform a restore operation, you must restore the control files to all locations specified in the parameter file. Consequently, it is better to make copies of each multiplexed control file—even if the control files are identical—to avoid problems at restore time.

For example, you might back up the datafiles and control files in the `/disk1/oracle/dbs` directory to `/disk2/backup` as follows:

```
% cp /disk1/oracle/dbs/*.dbf /disk2/backup
% cp /disk1/oracle/dbs/*.cf /disk2/backup
```

3. Restart the database

```
STARTUP
```

> **See Also:** *Oracle8i Administrator's Guide* for more information on starting up and shutting down a database.

Performing Tablespace and Datafile Backups

Only make tablespace and datafile backups when operating in ARCHIVELOG mode. You cannot use individual datafile backups to restore a database operating in NOARCHIVELOG mode because you do not have archived redo logs to recover the datafiles to the same point in time.

This section contains the topics:

- Backing Up Online Tablespaces and Datafiles
- Making Backups in SUSPEND Mode
- Backing Up Offline Tablespaces and Datafiles

Backing Up Online Tablespaces and Datafiles

You can back up all or specified datafiles of an online tablespace while the database is open. When you back up an individual datafile or online tablespace, Oracle stops recording checkpoints in the headers of the online datafiles being backed up.

The ALTER TABLESPACE BEGIN BACKUP statement puts a tablespace into hot backup mode; as a result, Oracle stops recording checkpoints to the tablespace's datafiles. You must put a tablespace in hot backup mode to make operating system

datafile backups when the database is open—except when backing up a read-only tablespace, in which case you can simply back up the online datafiles.

After a hot backup is completed, Oracle advances the file header to the current database checkpoint, but only after you execute the ALTER TABLESPACE END BACKUP statement to take the tablespace out of hot backup mode.

When you restore a datafile, the header has a record of the most recent datafile checkpoint that occurred *before* the online tablespace backup, not any that occurred *during* it. As a result, Oracle asks for the appropriate set of redo log files to apply should recovery be needed.

To back up online read-write tablespaces in an open database:

1. Before beginning a backup of a tablespace, identify all of the tablespace's datafiles using the DBA_DATA_FILES data dictionary view. For example, assume that you want to back up the USERS tablespace. Enter the following:

```
SELECT tablespace_name, file_name
FROM sys.dba_data_files
WHERE tablespace_name = 'USERS';

TABLESPACE_NAME                  FILE_NAME
-------------------------------  --------------------
USERS                            /oracle/dbs/tbs_21.f
USERS                            /oracle/dbs/tbs_22.f
```

   In this example, `/oracle/dbs/tbs_21.f` and `/oracle/dbs/tbs_22.f` are fully specified filenames corresponding to the datafiles of the USERS tablespace.

2. Mark the beginning of the online tablespace backup. For example, the following statement marks the start of an online backup for the tablespace USERS:

```
ALTER TABLESPACE users BEGIN BACKUP;
```

> **WARNING: If you forget to mark the beginning of an online tablespace backup, or neglect to assure that the BEGIN BACKUP statement has completed before backing up an online tablespace, then the backup datafiles are not useful for subsequent recovery operations. Attempting to recover such a backup is risky and can return errors that result in inconsistent data. For example, the attempted recovery operation will issue a "fuzzy files" warning, and lead to an inconsistent database that will not open.**

3. Back up the online datafiles of the online tablespace using operating system commands. For example, UNIX users might enter:

```
% cp /oracle/dbs/tbs_21.f /oracle/backup/tbs_21.backup
% cp /oracle/dbs/tbs_22.f /oracle/backup/tbs_22.backup
```

4. After backing up the datafiles of the online tablespace, indicate the end of the online backup using the SQL statement ALTER TABLESPACE with the END BACKUP option. For example, the following statement ends the online backup of the tablespace USERS:

```
ALTER TABLESPACE users END BACKUP;
```

If you forget to mark the end of an online tablespace backup, and an instance failure or SHUTDOWN ABORT occurs, then Oracle assumes that media recovery (possibly requiring archived redo logs) is necessary at the next instance startup. To avoid performing media recovery in this case, use the following statement, where *filename* is any valid system path name:

```
ALTER DATABASE DATAFILE filename END BACKUP;
```

To back up online read-only tablespaces in an open database:

1. Before beginning a backup of a read-only tablespace, identify all of the tablespace's datafiles using the DBA_DATA_FILES data dictionary view. For example, assume that you want to back up the USERS tablespace. Enter the following:

```
SELECT tablespace_name, file_name
FROM sys.dba_data_files
WHERE tablespace_name = 'USERS';

TABLESPACE_NAME                  FILE_NAME
-------------------------------  --------------------
USERS                            /oracle/dbs/tbs_21.f
USERS                            /oracle/dbs/tbs_22.f
```

   In this example, `/oracle/dbs/tbs_21.f` and `/oracle/dbs/tbs_22.f` are fully specified filenames corresponding to the datafiles of the USERS tablespace.

2. Back up the online datafiles of the online tablespace using operating system commands. You do not have to take the tablespace offline or put the tablespace in hot backup mode because users are automatically prevented from making changes to the read-only tablespace. For example, UNIX users can enter:

```
% cp /oracle/dbs/tbs_21.f /oracle/backup/tbs_21.backup
% cp /oracle/dbs/tbs_22.f /oracle/backup/tbs_22.backup
```

Note: When restoring a backup of a read-only tablespace, take the tablespace offline, restore the datafiles, then bring the tablespace online. A backup of a read-only tablespace is still usable if the read-only tablespace is made read-write after the backup, but the restored backup will require recovery.

See Also: *Oracle8i Reference* for more information about the DBA_DATA_FILES data dictionary view, and *SQL*Plus User's Guide and Reference* for more information about startup and shutdown statements.

Determining Datafile Backup Status To check the backup status of a datafile, query the V$BACKUP view. This view lists all online files and gives their backup status. It is most useful when the database is open. It is also useful immediately after a crash, because it shows the backup status of the files at the time of the crash. Use this information to determine whether you have left tablespaces in hot backup mode.

V$BACKUP is not useful if the control file currently in use is a restored backup or a new control file created after the media failure occurred. A restored or re-created control file does not contain the information Oracle needs to fill V$BACKUP accurately. Also, if you have restored a backup of a file, this file's STATUS in V$BACKUP reflects the backup status of the older version of the file, not the most current version. Thus, this view can contain misleading information about restored files.

For example, the following query displays the current backup status of datafiles:

```
SELECT file#, status FROM v$backup;

FILE#        STATUS
---------   ---------
0011         INACTIVE
0012         INACTIVE
0013         ACTIVE
...
```

In the STATUS column, INACTIVE indicates that the file is not currently being backed up, whereas ACTIVE indicates that the file is currently being backed up.

Backing Up Multiple Online Tablespaces When backing up several online tablespaces, use either of the following procedures:

To back up online tablespaces in parallel:

1. Prepare all online tablespaces for backup by issuing all necessary ALTER TABLESPACE statements at once. For example, put tablespaces TS1, TS2, and TS3 in hot backup mode:

```
ALTER TABLESPACE ts1 BEGIN BACKUP;
ALTER TABLESPACE ts2 BEGIN BACKUP;
ALTER TABLESPACE ts3 BEGIN BACKUP;
```

2. Back up all files of the online tablespaces. For example, a UNIX user might back up `tbs_1.f`, `tbs_2.f`, and `tbs_3.f` as follows:

```
% cp /oracle/dbs/tbs_1.f /oracle/backup/tbs_1.bak
% cp /oracle/dbs/tbs_2.f /oracle/backup/tbs_2.bak
% cp /oracle/dbs/tbs_3.f /oracle/backup/tbs_3.bak
```

3. Indicate that the online backups have been completed:

```
ALTER TABLESPACE ts1 END BACKUP;
ALTER TABLESPACE ts2 END BACKUP;
ALTER TABLESPACE ts3 END BACKUP;
```

To back up online tablespaces serially:

1. Prepare a tablespace for online backup. For example, to put tablespace TBS_1 in hot backup mode enter:

```
SQL> ALTER TABLESPACE tbs_1 BEGIN BACKUP;
```

2. Back up the datafiles in the tablespace. For example, enter:

```
% cp /oracle/dbs/tbs_1.f /oracle/backup/tbs_1.bak
```

3. Take the tablespace out of hot backup mode. For example, enter:

```
SQL> ALTER TABLESPACE tbs_1 END BACKUP;
```

4. Repeat this procedure for each remaining tablespace until you have backed up all the desired tablespaces.

Oracle recommends the serial option because it minimizes the time between ALTER TABLESPACE ... BEGIN / END BACKUP statements. During online backups, more redo information is generated for the tablespace.

Making Backups in SUSPEND Mode

Some third-party tools allow you to mirror a set of disks or logical devices, that is, maintain an exact duplicate of the primary data in another location, and then *split*

the mirror. Splitting the mirror involves separating the copies so that you can use them independently.

Using the Oracle8*i* SUSPEND/RESUME functionality, you can suspend I/O to the database, then split the mirror and make a backup of the split mirror. This feature, which complements the hot backup functionality, allows you to quiesce the database so that no new I/O can be performed. You can then access the suspended database to make backups without I/O interference.

> **Note:** Some RAID devices benefit from suspending writes while the split operation is occurring; your RAID vendor can advise you on whether your system would benefit from this feature.

Understanding the Suspend/Resume Feature The ALTER SYSTEM SUSPEND statement suspends the database by halting I/Os to datafile headers and data as well as control files. When the database is suspended, all pre-existing I/O operations can complete; however, any new database access attempts are queued.

The SUSPEND and RESUME statements operate on the database and not just the instance. If the SUSPEND statement is entered on one system in an OPS configuration, then the internal locking mechanisms propagate the halt request across instances, thereby quiescing all active instances in a given cluster.

Making Backups in a Suspended Database After a successful database suspension, you can back up the database to disk or break the mirrors. Because suspending a database does not guarantee immediate termination of I/O, Oracle recommends that you precede the SUSPEND statement with a BEGIN BACKUP statement to place the tablespaces in hot backup mode.

You must use conventional operating system backup methods to back up split mirrors. RMAN cannot make database backups or copies because these operations require reading the datafile headers. After the database backup is finished or the mirrors are re-silvered, then you can resume normal database operations using the RESUME statement.

Backing up a suspended database without splitting mirrors can cause an extended database outage because the database is inaccessible during this time. If backups are taken by splitting mirrors, however, then the outage is nominal. The outage time depends on the size of cache to flush, the number of datafiles, and the time required to break the mirror.

Note the following restrictions:

- In an OPS environment, you should not start a new instance while the original nodes are suspended.
- No checkpoint is initiated by the SUSPEND or RESUME statements.
- You cannot issue SHUTDOWN with IMMEDIATE or NORMAL options while the database is suspended.
- Issuing SHUTDOWN ABORT on a database that was already suspended reactivates the database. This operation prevents media recovery or instance recovery from hanging.

To make a split mirror backup in SUSPEND mode:

1. Place the database tablespaces in hot backup mode using the ALTER TABLESPACE ... BEGIN BACKUP statement. For example, to place tablespace USERS in hot backup mode enter:

```
ALTER TABLESPACE users BEGIN BACKUP;
```

2. If your mirror system has problems with splitting a mirror while disk writes are occurring, issue the following:

```
ALTER SYSTEM SUSPEND;
```

3. Check to make sure that the database is suspended:

```
SELECT database_status FROM v$instance;

DATABASE_STATUS
-----------------
SUSPENDED
```

4. Split the mirrors at the operating system or hardware level.
5. Issue the following:

```
ALTER SYSTEM RESUME;
```

6. Check to make sure that the database is active:

```
SELECT database_status FROM v$instance;

DATABASE_STATUS
-----------------
ACTIVE
```

7. Take the specified tablespaces out of hot backup mode. For example, to take tablespace USERS out of hot backup mode enter:

```
ALTER TABLESPACE users END BACKUP;
```

8. Copy the control file and archive the online redo logs as usual for a backup.

WARNING: Do not use the SUSPEND statement as a substitute for placing a tablespace in hot backup mode.

See Also: *Oracle8i Administrator's Guide* for more information about the SUSPEND/RESUME feature, *Oracle8i SQL Reference* for more information about the ALTER SYSTEM statement with the RESUME and SUSPEND options.

Backing Up Offline Tablespaces and Datafiles

You can back up all or some of the datafiles of an individual tablespace while the tablespace is offline. All other tablespaces of the database can remain open and available for system-wide use. You must have the MANAGE TABLESPACE system privilege to take tablespaces offline and online.

Note: You cannot take the SYSTEM tablespace or any tablespace with active rollback segments offline. The following procedure cannot be used for such tablespaces.

To back up offline tablespaces:

1. Before beginning a backup of a tablespace, identify the tablespace's datafiles using the DBA_DATA_FILES table. For example, assume that you want to back up the USERS tablespace. Enter the following:

```
SELECT tablespace_name, file_name
FROM sys.dba_data_files
WHERE tablespace_name = 'USERS';

TABLESPACE_NAME                 FILE_NAME
------------------------------  -----------------
USERS                           /oracle/dbs/users.f
```

In this example, `/oracle/dbs/users.f` is a fully specified filename corresponding to the datafile in the USERS tablespace.

2. Take the tablespace offline using normal priority if possible. Normal priority is recommended because it guarantees that you can subsequently bring the tablespace online without the requirement for tablespace recovery. For example, the following statement takes a tablespace named USERS offline normally:

   ```
   ALTER TABLESPACE users OFFLINE NORMAL;
   ```

   After you take a tablespace offline with normal priority, all datafiles of the tablespace are closed.

3. Back up the offline datafiles. For example, a UNIX user might enter the following to back up datafile `users.f`:

   ```
   % cp /disk1/oracle/dbs/users.f /disk2/backup/users.backup
   ```

4. Bring the tablespace online. For example, the following statement brings tablespace USERS back online:

   ```
   ALTER TABLESPACE users ONLINE;
   ```

   Note: If you took the tablespace offline using temporary or immediate priority, then you must not bring the tablespace online unless you perform tablespace recovery.

   After you bring a tablespace online, it is open and available for use.

Performing Control File Backups

Back up the control file of a database after making a structural modification to a database operating in ARCHIVELOG mode. To back up a database's control file, you must have the ALTER DATABASE system privilege.

You have these options when backing up the control file:

- Backing Up the Control File to a Physical File
- Backing Up the Control File to a Trace File

Backing Up the Control File to a Physical File

The primary method for backing up the control file is to use a SQL statement to generate a binary file.

To back up the control file after a structural change:

1. Make the desired change to the database. For example, you might create a new datafile:

   ```
   ALTER DATABASE CREATE DATAFILE '/oracle/dbs/tbs_20.f' AS '/oracle/dbs/tbs_4.f';
   ```

2. Back up the database's control file. The following SQL statement backs up a database's control file to `/oracle/backup/cf.bak`:

   ```
   ALTER DATABASE BACKUP CONTROLFILE TO '/oracle/backup/cf.bak' REUSE;
   ```

   The REUSE option allows you to have the new control file overwrite a control file that currently exists.

Backing Up the Control File to a Trace File

The TRACE option of the ALTER DATABASE BACKUP CONTROLFILE statement helps you manage and recover your control file. The TRACE option prompts Oracle to write SQL statements to the database's trace file rather than generate a physical backup. The statements in the trace file start the database, re-create the control file, and recover and open the database appropriately.

Each SQL statement in the trace file is commented. Thus, you can copy the statements from the trace file into a script file, edit them as necessary, and use the script to recover the database if all copies of the control file are lost (or to change the value of control file parameters such as MAXDATAFILES). The trace file is located in the location specified by the USER_DUMP_DEST initialization parameter.

To back up the control file to a trace file, mount the database and issue the following statement:

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

Creating a Trace File: Scenario Assume that you want to generate a script that re-creates the control file for the SALES database. The database has these characteristics:

- Three threads are enabled, of which thread 2 is public and thread 3 is private.
- The redo logs are multiplexed into three groups of two members each.
- The database has these datafiles:
  - `/diska/prod/sales/db/filea.dbf` (offline datafile in online tablespace)
  - `/diska/prod/sales/db/database1.dbf` (online)

- `/diska/prod/sales/db/fileb.dbf` (only file in read-only tablespace)

You issue the following statement to create the trace file:

```
ALTER DATABASE BACKUP CONTROLFILE TO TRACE NORESETLOGS;
```

You then edit the trace file to create a script that creates a new control file based on the control file that was current when you generated the trace file. To avoid recovering offline normal or read-only tablespaces, omit them from the CREATE CONTROLFILE statement. At database open time, the dictionary check code will mark these files as MISSING. The RENAME statement renames them back to their filenames.

For example, the script might read as follows:

```
# The following statements will create a new control file and use it to open the database.
# No data other than log history will be lost. Additional logs may be required for media
# recovery of offline datafiles. Use this only if the current version of all online logs
# are available.

STARTUP NOMOUNT
CREATE CONTROLFILE REUSE DATABASE SALES NORESETLOGS ARCHIVELOG
     MAXLOGFILES 32
     MAXLOGMEMBERS 2
     MAXDATAFILES 32
     MAXINSTANCES 16
     MAXLOGHISTORY 1600
LOGFILE
     GROUP 1
       '/diska/prod/sales/db/log1t1.dbf',
       '/diskb/prod/sales/db/log1t2.dbf'
     )  SIZE 100K
    GROUP 2
       '/diska/prod/sales/db/log2t1.dbf',
        '/diskb/prod/sales/db/log2t2.dbf'
    ) SIZE 100K,
    GROUP 3
       '/diska/prod/sales/db/log3t1.dbf',
       '/diskb/prod/sales/db/log3t2.dbf'
    ) SIZE 100K
DATAFILE
    '/diska/prod/sales/db/database1.dbf',
    '/diskb/prod/sales/db/filea.dbf'
;

# This datafile is offline, but its tablespace is online. Take the datafile offline
# manually.
ALTER DATABASE DATAFILE '/diska/prod/sales/db/filea.dbf' OFFLINE;
```

```
# Recovery is required if any datafiles are restored backups,
# or if the most recent shutdown was not normal or immediate.
RECOVER DATABASE;

# All redo logs need archiving and a log switch is needed.
ALTER SYSTEM ARCHIVE LOG ALL;

# The database can now be opened normally.
ALTER DATABASE OPEN;

# The backup control file does not list read-only and normal offline tablespaces so that
# Oracle can avoid performing recovery on them. Oracle checks the data dictionary and
# finds information on these absent files and marks them 'MISSINGxxxx'. It then renames
# the missing files to acknowledge them without having to recover them.
ALTER DATABASE RENAME FILE 'MISSING0002'
     TO '/diska/prod/sales/db/fileb.dbf';
```

Using the statement without NORESETLOGS produces the same output. Using the statement with RESETLOGS produces a similar script that includes statements that recover and open the database, but resets the redo logs upon startup.

Verifying Backups

You should periodically verify your backups to ensure that they are usable for recovery. This section contains the following topics:

- Testing the Restore of Backups
- Using the DBVERIFY Utility

Testing the Restore of Backups

The best way to test the usability of backups is to restore them to a separate host and attempt to open the database, performing media recovery if necessary. This option requires that you have a separate computer available for the restore procedure.

> **See Also:** "Restoring Files" on page 5-4 to learn how to restore files, and "Performing Complete Media Recovery" on page 5-19 to learn how to recover files.

Using the DBVERIFY Utility

DBVERIFY is an external command-line utility that performs a physical data structure integrity check on an offline database. Use DBVERIFY primarily when you need to ensure that a backup database or datafile is valid before it is restored or as a diagnostic aid when you have encountered data corruption problems.

The name and location of DBVERIFY is dependent on your operating system. For example, to perform an integrity check on datafile `tbs_52.f` on UNIX, you can execute the `dbv` command as follows:

```
% dbv file=tbs_52.f

DBVERIFY: Release 8.1.5.0.0

(c) Copyright 1998 Oracle Corporation.  All rights reserved.

DBVERIFY - Verification starting : FILE = tbs_52.f

DBVERIFY - Verification complete

Total Pages Examined         : 250
Total Pages Processed (Data) : 4
Total Pages Failing   (Data) : 0
Total Pages Processed (Index): 15
Total Pages Failing   (Index): 0
Total Pages Processed (Other): 29
Total Pages Empty            : 202
Total Pages Marked Corrupt   : 0
Total Pages Influx           : 0
```

> **See Also:** *Oracle8i Utilities* for more information about using DBVERIFY.

Responding to a Failed Online Tablespace Backup

The following situations can cause a tablespace backup to fail and be incomplete:

- You did not indicate the end of the online tablespace backup operation using the ALTER TABLESPACE statement with the END BACKUP option, and the database was subsequently shut down with the ABORT option.
- An instance or SHUTDOWN ABORT interrupted the backup.

Upon detecting an incomplete online tablespace backup at startup, Oracle assumes that media recovery is necessary for startup to proceed.

For example, Oracle may display:

```
SQL> startup
ORACLE instance started.
Total System Global Area                        19839308 bytes
Fixed Size                                         63820 bytes
Variable Size                                   11042816 bytes
Database Buffers                                 8192000 bytes
Redo Buffers                                      540672 bytes
Database mounted.
ORA-01113: file 12 needs media recovery
ORA-01110: data file 12: '/oracle/dbs/tbs_41.f'
```

To avoid performing media recovery on a tablespace:

1. Use the V$BACKUP view to list the datafiles of the tablespaces that were being backed up before the database was restarted:

```
SQL>  SELECT * FROM v$backup WHERE status = 'ACTIVE';
FILE#      STATUS             CHANGE#    TIME
---------- ------------------ ---------- ---------
        12 ACTIVE                  20863 25-NOV-98
        13 ACTIVE                  20863 25-NOV-98
        20 ACTIVE                  20863 25-NOV-98
 3 rows selected.
```

2. Issue the ALTER DATABASE DATAFILE ... END BACKUP statement to end the hot backup. For example, to take datafiles 12, 13, and 20 out of hot backup mode enter:

```
ALTER DATABASE DATAFILE 12,13,20 END BACKUP;
```

> **WARNING: Do not use ALTER DATABASE DATAFILE ... END BACKUP if you have restored any of the affected files from a backup.**

3. Open the database:

```
ALTER DATABASE OPEN;
```

To recover the database without using the END BACKUP statement:

1. Mount the database:

```
STARTUP MOUNT;
```

2. Recover the database:

```
RECOVER DATABASE;
```

3. Use the V$BACKUP view to confirm that there are no active datafiles:

```
SQL>  SELECT * FROM v$backup WHERE status = 'ACTIVE';
FILE#      STATUS            CHANGE#    TIME
---------- ----------------- ---------- ---------
0 rows selected.
```

See Also: Chapter 5, "Performing Media Recovery" for information on recovering a database.

Using Export and Import for Supplemental Protection

Export and Import are utilities that move Oracle data in and out of Oracle databases. Export writes data from an Oracle database to an operating system file in a special binary format. Import reads Export files and restores the corresponding information into an existing database. Although Export and Import are designed for moving Oracle data, you can also use them to supplement backups of data.

This section describes the Import and Export utilities, and includes the following topics:

- Using Export
- Using Import

See Also: *Oracle8i Utilities* for information about the Export and Import utilities.

Using Export

The Export utility allows you to back up your database while it is open and available for use. It writes a read-consistent view of the database's objects to an operating system file. System audit options are not exported.

WARNING: If you use Export to perform a backup, you must export all data in a logically consistent way so that the backup reflects a single point in time. No one should make changes to the database while the Export takes place. Ideally, you should run the database in restricted mode while you export the data, so no regular users can access the data.

Table 4–1 lists available export modes.

Table 4–1 Export Modes

Mode	Description
User	Exports all objects owned by a user.
Table	Exports all or specific tables owned by a user.
Full Database	Exports all objects of the database.

Following are descriptions of Export types:

Incremental Exports — Only database data that has changed since the last incremental, cumulative, or complete export is exported. An incremental export exports the object's definition and all its data. Incremental exports are typically performed more often than cumulative or complete reports.

For example, if tables A, B, and C exist, and only table A's information has been modified since the last incremental export, only table A is exported.

Cumulative Exports — Only database data that has been changed since the last cumulative or complete export is exported.

Perform this type of export on a limited basis, such as once a week, to condense the information contained in numerous incremental exports.

For example, if tables A, B, and C exist, and only table A's and table B's information has been modified since the last cumulative export, only the changes to tables A and B are exported.

Complete Exports — All database data is exported.

Perform this type of export on a limited basis, such as once a month, to export all data contained in a database.

Using Import

The Import utility allows you to restore the database information held in previously created Export files. It is the complement utility to Export.

To recover a database using Export files and the Import utility:

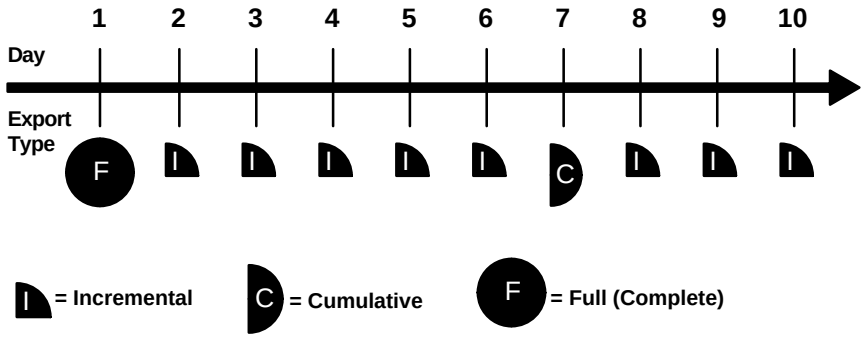
1. Re-create the database structure, including all tablespaces and users.

Note: These re-created structures should not have objects in them.

2. Import the appropriate Export files to restore the database to the most current state possible. Depending on how your Export schedule is performed, imports of varying degrees will be necessary to restore a database.

Assume that the schedule illustrated in Figure 4–1 is used in exporting data from an Oracle database

Figure 4–1 A Typical Export Schedule



A complete export was taken on Day 1, a cumulative export was taken every week, and incremental exports were taken daily. Follow these steps to recover:

1. Recreate the database, including all tablespaces and users.
2. Import the complete database export taken on Day 1.
3. Import the cumulative database export taken on Day 7.
4. Import the incremental database exports taken on Days 8, 9, and 10.

5

Performing Media Recovery

This chapter describes how to recover a database, and includes the following topics:

- Determining Which Files to Recover
- Restoring Files
- Understanding Basic Media Recovery Procedures
- Performing Complete Media Recovery
- Performing Incomplete Media Recovery
- Opening the Database After Media Recovery

Determining Which Files to Recover

You can often use the table V$RECOVER_FILE to determine which files to recover. This view lists all files that need to be recovered, and explains why they need to be recovered.

The following query displays the file ID numbers of datafiles that require media recovery as well as the reason for recovery (if known) and the SCN / time when recovery needs to begin:

```
SQL> SELECT * FROM v$recover_file;

FILE#      ONLINE  ERROR              CHANGE#    TIME
---------- ------- ------------------ ---------- ---------
        14 ONLINE                             0
        15 ONLINE  FILE NOT FOUND             0
        21 OFFLINE OFFLINE NORMAL             0
```

> **Note:** The view is not useful if the control file currently in use is a restored backup or a new control file created since the media failure occurred. A restored or re-created control file does not contain the information Oracle needs to fill V$RECOVER_FILE accurately.

Query V$DATAFILE and V$TABLESPACE to obtain filenames and tablespace names for datafiles requiring recovery. For example, enter:

```
SQL> SELECT d.name, t.name
  2  FROM v$datafile d, v$tablespace t
  3  WHERE t.ts# = d.ts#
  4  AND d.file# in (14,15,21);  # use values obtained from V$RECOVER_FILE query

NAME                             TABLESPACE_NAME
-------------------------------- ---------------
/oracle/dbs/tbs_14.f             TBS_1
/oracle/dbs/tbs_15.f             TBS_2
/oracle/dbs/tbs_21.f             TBS_3
```

You can combine these queries in the following SQL*Plus script (sample output shown below):

```
COL df# FORMAT 999
COL df_name FORMAT a20
COL tbsp_name FORMAT a10
COL status FORMAT a7
COL error FORMAT a10
```

```
SELECT r.file# AS df#, d.name AS df_name, t.name AS tbsp_name,
       d.status, r.error, r.change#, r.time
FROM v$recover_file r, v$datafile d, v$tablespace t
WHERE t.ts# = d.ts#
AND d.file# = r.file#
/

SQL> @script

 DF# DF_NAME              TBSP_NAME  STATUS  ERROR          CHANGE# TIME
---- -------------------- ---------- ------- ---------- ---------- ----------
  12 /oracle/dbs/tbs_41.f TBS_4      OFFLINE OFFLINE             0
                                             NORMAL

  13 /oracle/dbs/tbs_42.f TBS_4      OFFLINE OFFLINE             0
                                             NORMAL

  20 /oracle/dbs/tbs_43.f TBS_4      OFFLINE OFFLINE             0
                                             NORMAL
```

Besides determining which files to recover, you must also know which files you should *not* recover. The following have special implications for media recovery:

- Unrecoverable Tables and Indexes
- Read-Only Tablespaces

Unrecoverable Tables and Indexes

You can create tables and indexes using the CREATE TABLE AS SELECT statement. You can also specify that Oracle create them as *unrecoverable*. When you create a table or index as unrecoverable, Oracle does not generate redo log records for the operation. Thus, you cannot recover objects created unrecoverable, even if you are running in ARCHIVELOG mode.

> **Note:** If you cannot afford to lose tables or indexes created unrecoverable, then take a backup after the unrecoverable table or index is created.

Be aware that when you perform media recovery, and some tables or indexes are created as recoverable while others are unrecoverable, the unrecoverable objects are marked logically corrupt by the RECOVER operation. Any attempt to access the unrecoverable objects returns an ORA-01578 error message. Drop the unrecoverable objects and re-create them if needed.

Because it is possible to create a table unrecoverable and then create a recoverable index on that table, the index is not marked as logically corrupt after you perform media recovery. The table was unrecoverable (and thus marked as corrupt after recovery), however, so the index points to corrupt blocks. The index must be dropped, and the table and index must be re-created if necessary.

> **See Also:** *Oracle8i Standby Database Concepts and Administration* for information about the impact of unrecoverable operations on a standby database.

Read-Only Tablespaces

Media recovery with the USING BACKUP CONTROLFILE option checks for read-only files. You cannot recover a read-only file. To avoid this error, take datafiles from read-only tablespaces offline before doing recovery with a backup control file.

Use the correct version of the control file for the recovery. If the tablespace will be read-only when the recovery is complete, then the control file must be from a time when the tablespace was read-only. Similarly, if the tablespace will be read-write at the end of recovery, it should be read-write in the control file.

If the appropriate control file is unavailable, execute a CREATE CONTROLFILE statement as described in "Losing All Copies of the Current Control File" on page 6-13. If you need to re-create a control file for a database with read-only tablespaces, issue the following to obtain the procedure that you need to follow:

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

The procedure is similar to the procedure for offline normal tablespaces, except that you need to bring the tablespace online after the database is open.

> **See Also:** "Backing Up the Control File to a Trace File" on page 4-14 to learn about taking trace backups of the control file.

Restoring Files

If you determine that media recovery is necessary, restore the files necessary to perform it. Learn how to execute the following tasks:

- Restoring Backup Datafiles
- Re-Creating Datafiles when Backups Are Unavailable
- Restoring Necessary Archived Redo Log Files

Restoring Backup Datafiles

If a media failure permanently damages one or more datafiles of a database, you must restore backups of the damaged datafiles before you can recover the damaged files. If you cannot restore a damaged datafile to its original location (for example, you must replace a disk, so you restore the files to an alternate disk), then you must indicate the new locations of these files to the control file of the associated database.

To restore backup datafiles to their default location:

1. Determine which datafiles to recover using the techniques described in "Determining Which Files to Recover" on page 5-2.
2. Copy backups of the damaged datafiles to their default location using operating system commands. For example, to restore `tbs_14.f` on UNIX you might issue:

   ```
   % cp /disk2/backup/tbs_14.bak /disk1/oracle/dbs/tbs_14.f
   ```

Re-Creating Datafiles when Backups Are Unavailable

If a datafile is damaged and no backup of the file is available, you can still recover the datafile if:

- All archived log files written since the creation of the original datafile are available.
- The control file contains the name of the damaged file (that is, the control file is current, or is a backup taken after the damaged datafile was added to the database).

To re-create a datafile for recovery:

1. Create a new, empty datafile to replace a damaged datafile that has no corresponding backup. For example, assume that the datafile `disk1:users1` has been damaged, and no backup is available. The following statement re-creates the original datafile (same size) on `disk2`:

   ```
   ALTER DATABASE CREATE DATAFILE 'disk1:users1' AS 'disk2:users1';
   ```

   This statement creates an empty file that matches the lost file. Oracle looks at information in the control file and the data dictionary to obtain size information. The old datafile is renamed as the new datafile.
2. Perform media recovery on the empty datafile. For example, enter:

   ```
   RECOVER DATAFILE 'disk2:users1'
   ```

3. All archived redo logs written since the original datafile was created must be mounted and reapplied to the new, empty version of the lost datafile during recovery.

> **Note:** You cannot re-create any of the datafiles for the SYSTEM tablespace by using the CREATE DATAFILE clause of the ALTER DATABASE statement because the necessary redo data is not available.

Restoring Necessary Archived Redo Log Files

All archived redo log files required for the pending media recovery eventually need to be on disk so that they are readily available to Oracle.

To restore necessary archived redo logs:

1. To determine which archived redo log files you need, query V$LOG_HISTORY and V$RECOVERY_LOG. You will need all redo information from the time the datafile was added to the database if no backup of the datafile is available.

View	Description
V$LOG_HISTORY	Lists all of the archived logs, including their probable names, given the current archived log file naming scheme as set by the initialization parameter LOG_ARCHIVE_FORMAT.
V$RECOVERY_LOG	Lists only the archived redo logs that Oracle needs to perform recovery. It also includes the probable names of the files, using LOG_ARCHIVE_FORMAT.

2. If space is available, restore the required archived redo log files to the location specified by LOG_ARCHIVE_DEST_1 or LOG_ARCHIVE_DEST. Oracle locates the correct log automatically when required during media recovery.

   For example, enter:

   ```
   % cp /disk2/arc_backup/*.arc /disk1/oracle/dbs/arc_dest
   ```

3. If sufficient space is not available at the location indicated by the destination initialization parameter, restore some or all of the required archived redo log files to an alternate location. Specify the location before or during media recovery using the LOGSOURCE parameter of the SET statement in SQL*Plus

or the RECOVER ... FROM parameter of the ALTER DATABASE statement in SQL. For example, enter:

```
SET LOGSOURCE /disk2/temp   # set location using SET statement
ALTER DATABASE RECOVER FROM "/disk2/temp" DATABASE;  # set in RECOVER statement
```

4. After an archived log is applied, and after making sure that a copy of each archived log group still exists in offline storage, delete the restored copy of the archived redo log file to free disk space. For example, after making the log directory your working directory, enter:

```
% rm *.arc
```

See Also: *Oracle8i Reference* for more information about the data dictionary views.

Understanding Basic Media Recovery Procedures

Before beginning recovery, familiarize yourself with the following topics:

- Using Media Recovery Statements
- Applying Archived Redo Logs
- Recovering a Database in NOARCHIVELOG Mode
- Recovering a Database in ARCHIVELOG Mode
- Performing Media Recovery in Parallel

Using Media Recovery Statements

Oracle uses these basic media recovery SQL*Plus statements, which differ only in the way the system determines the set of files to be recovered:

- RECOVER DATABASE
- RECOVER TABLESPACE
- RECOVER DATAFILE

Each statement uses the same criteria to determine whether files are recoverable. Oracle prevents two recovery sessions from recovering the same file and prevents media recovery of a file that is in use.

You can also use the SQL statement ALTER DATABASE RECOVER, although Oracle strongly recommends you use the SQL*Plus RECOVER statement instead so that Oracle will prompt you for the names of the archived redo logs.

> **See Also:** *SQL*Plus User's Guide and Reference* for more information about SQL*Plus RECOVER statements, and *Oracle8i SQL Reference* for more information about the ALTER DATABASE RECOVER statement.

RECOVER DATABASE Statement

RECOVER DATABASE performs media recovery on all online datafiles that require redo to be applied. For example, issue the following at the SQL prompt to recover the whole database:

```
RECOVER DATABASE
```

If you shut down all instances cleanly, and did not restore any backups, issuing RECOVER DATABASE returns an error indicating that no recovery is required. It also fails if any instances have the database open, since they have the datafile locks. To perform media recovery on an entire database, the database must be mounted EXCLUSIVE and closed.

RECOVER TABLESPACE Statement

RECOVER TABLESPACE performs media recovery on all datafiles in the tablespaces listed. For example, enter the following at the SQL prompt to recover tablespace TBS_1:

```
RECOVER TABLESPACE tbs_1
```

The tablespaces must be offline to perform the recovery. Oracle indicates an error if none of the files require recovery.

RECOVER DATAFILE Statement

RECOVER DATAFILE lists the datafiles to be recovered. For example, enter the following at the SQL prompt to recover datafile `/oracle/dbs/tbs_22.f`:

```
RECOVER DATAFILE '/oracle/dbs/tbs_22.f'
```

The database can be open or closed, provided that you can acquire the media recovery locks. If the database is open in any instance, then datafile recovery can only recover offline files.

> **See Also:** *Oracle8i SQL Reference* for more information about media recovery statements.

Applying Archived Redo Logs

During complete or incomplete media recovery, Oracle applies redo log files to the datafiles during the roll forward phase of media recovery. Because rollback data is recorded in the redo log, rolling forward regenerates the corresponding rollback segments. Rolling forward proceeds through as many redo log files as necessary to bring the database forward in time.

As a log file is needed, Oracle suggests the name of the file. For example, if you are using SQL*Plus, it returns the following lines and prompts:

```
ORA-00279: Change #### generated at DD/MM/YY HH:MM:SS needed for thread#
ORA-00289: Suggestion : logfile
ORA-00280: Change #### for thread # is in sequence #
Specify log: [<RET> for suggested | AUTO | FROM logsource | CANCEL ]
```

Similar messages are returned when you use an ALTER DATABASE ... RECOVER statement. However, no prompt is displayed.

Suggested Archived Redo Log Filenames

Oracle suggests archived redo log filenames by concatenating the current values of the initialization parameters LOG_ARCHIVE_DEST_1 or LOG_ARCHIVE_DEST and LOG_ARCHIVE_FORMAT and using information from the control file. For example, the following are possible settings for archived logs:

```
LOG_ARCHIVE_DEST_1 = /oracle/arc_dest/arc
LOG_ARCHIVE_FORMAT = r_%t_%s.arc

SQL> SELECT name FROM v$archived_log;

NAME
------------------------------
/oracle/arc_dest/arcr_1_467.arc
/oracle/arc_dest/arcr_1_468.arc
/oracle/arc_dest/arcr_1_469.arc
/oracle/arc_dest/arcr_1_470.arc
```

Thus, if all the required archived log files are mounted at the LOG_ARCHIVE_DEST_1 or LOG_ARCHIVE_DEST destination, and the value for LOG_ARCHIVE_FORMAT is never altered, Oracle can suggest and apply log files to complete media recovery automatically.

To restore archived redo logs to a non-default location:

1. Change the value for this parameter to a new location. For example, enter:

```
LOG_ARCHIVE_DEST_1 = /oracle/new_location
```

2. Move the log files to the new location. For example, enter:

```
% cp /oracle/arc_dest/* /oracle/new_location
```

3. Start a new instance and mount the database:

```
STARTUP MOUNT
```

4. Initiate beginning media recovery as usual. For example, enter:

```
RECOVER DATABASE
```

In some cases, you may want to override the current setting for the destination parameter as a source for redo log files. For example, assume that a database is open and an offline tablespace must be recovered, but not enough space is available to mount the necessary redo log files at the location specified by the destination parameter.

To recover using logs in a non-default location:

1. Mount the archived redo logs to an alternate location. For example, enter:

```
% cp /disk1/oracle/arc_dest/* /disk2/temp
```

2. Specify the alternate location to Oracle for the recovery operation. Use the LOGSOURCE parameter of the SET statement or the RECOVER ... FROM parameter of the ALTER DATABASE statement. For example, enter:

```
SET LOGSOURCE "/disk2/temp"
```

3. Recover the offline tablespace:

```
RECOVER TABLESPACE offline_tbsp
```

Note: Overriding the redo log source does not affect the archive redo log destination for filled online groups being archived.

Consider overriding the current setting for the destination parameter when not enough space is available to mount all the required log files at any one location. In this case, you can set the log file source to an operating system variable (such as a logical or an environment variable) that acts as a search path to several locations.

See Also: Such functionality is operating system-dependent. See your operating system-specific Oracle documentation for more information.

Applying Logs Automatically Using the SQL*Plus RECOVER Statement

When using SQL*Plus, use the following statement to automate the application of the default filenames of archived redo logs needed during recovery:

```
SET AUTORECOVERY ON
```

No interaction is required when you issue the RECOVER statement, provided that the necessary files are in the correct locations with the correct names.

The filenames used when you use SET AUTORECOVERY ON are derived from the values of the initialization parameters LOG_ARCHIVE_DEST or LOG_ARCHIVE_DEST_1 in conjunction with LOG_ARCHIVE_FORMAT. If you execute SET AUTORECOVERY OFF, which is the default option, then you must enter the filenames manually, or accept the suggested default filename.

To automate the application of archived redo logs:

1. Restore a backup of the offline datafiles. This example restores a consistent backup of the whole database:

   ```
   % cp /oracle/work/BACKUP/tbs* /oracle/dbs
   ```

2. Make sure the database is mounted. For example, if the database is shut down, enter:

   ```
   SQL> STARTUP MOUNT
   ```

3. Turn on autorecovery:

   ```
   SQL> SET AUTORECOVERY ON
   Autorecovery                    ON
   ```

4. Recover the desired datafiles. This example recovers the whole database:

   ```
   SQL> RECOVER DATABASE
   ```

5. Oracle automatically suggests and applies the necessary archived logs:

   ```
   ORA-00279: change 53577 generated at 01/26/99 19:20:58 needed for thread 1
   ORA-00289: suggestion : /oracle/work/arc_dest/arcr_1_802.arc
   ORA-00280: change 53577 for thread 1 is in sequence #802
   Log applied.
   ORA-00279: change 53584 generated at 01/26/99 19:24:05 needed for thread 1
   ```

```
ORA-00289: suggestion : /oracle/work/arc_dest/arcr_1_803.arc
ORA-00280: change 53584 for thread 1 is in sequence #803
ORA-00278: log file "/oracle/work/arc_dest/arcr_1_802.arc" no longer needed for this
recovery
Log applied.
ORA-00279: change 53585 generated at 01/26/99 19:24:14 needed for thread 1
ORA-00289: suggestion : /oracle/work/arc_dest/arcr_1_804.arc
ORA-00280: change 53585 for thread 1 is in sequence #804
ORA-00278: log file "/oracle/work/arc_dest/arcr_1_803.arc" no longer needed for this
recovery
Log applied.
Media recovery complete.
```

If you use an OPS configuration, and you are performing incomplete recovery or using a backup control file, then Oracle can only compute the name of the first archived redo log file from the *first* thread. You may have to apply the first log file from the other threads. Once the first log file in a given thread has been supplied, Oracle can suggest the names of the subsequent logfiles in those threads.

> **See Also:** Your operating system-specific Oracle documentation for examples of log file application.

Applying Logs Individually Using ALTER DATABASE RECOVER

When you perform media recovery using SQL statements, Oracle does not display a prompt for log files after media recovery is started. Instead, you must provide the correct log file using an ALTER DATABASE RECOVER LOGFILE statement. For example, if a message suggests `log1.arc`, apply the suggestion using the following statement:

```
ALTER DATABASE RECOVER LOGFILE 'log1.arc';
```

As a result, recovering a tablespace requires several statements, as indicated in the following example (DBA input is boldfaced; variable information is italicized.):

```
SQL>ALTER DATABASE RECOVER TABLESPACE users;
ORA-00279: Change #### generated at DD/MM/YY HH:MM:SS needed for thread #
ORA-00289: Suggestion : logfile1
ORA-00280: Change #### for thread # is in sequence #
SQL>ALTER DATABASE RECOVER LOGFILE 'logfile1';
ORA-00279: Change #### generated at DD/MM/YY HH:MM:SS needed for thread # <D%0>
ORA-00289: Suggestion : logfile2
ORA-00280: Change #### for thread # is in sequence #
SQL> ALTER DATABASE RECOVER LOGFILE 'logfile2';
. . .
Repeat until all logs are applied.)
Statement processed.
SQL> ALTER TABLESPACE users ONLINE;
```

```
Statement processed.
```

Applying Logs Automatically Using ALTER DATABASE RECOVER

In this example, assume that the backup files have been restored, and that the user has administrator privileges. As in the method you used with SQL*Plus, automatic application of the redo logs can be started with the following statements, before and during recovery, respectively:

```
ALTER DATABASE RECOVER AUTOMATIC ...;
ALTER DATABASE RECOVER AUTOMATIC LOGFILE suggested_log_filename;
```

An example of the first statement follows:

```
SQL> ALTER DATABASE RECOVER AUTOMATIC TABLESPACE users;
Statement processed.
SQL> ALTER TABLESPACE users ONLINE;
Statement processed.
```

In this example, it is assumed that the backup files have been restored, and that the user has administrator privileges.

An example of the ALTER DATABASE RECOVER AUTOMATIC LOGFILE statement follows:

```
SQL> ALTER DATABASE RECOVER TABLESPACE users;
ORA-00279: Change #### generated at DD/MM/YY HH:MM:SS needed for thread #
ORA-00289: Suggestion : logfile1
ORA-00280: Change #### for thread # is in sequence #
SQL> ALTER DATABASE RECOVER AUTOMATIC LOGFILE 'logfile1';
Statement processed.
SQL> ALTER TABLESPACE users ONLINE;
Statement processed.
```

In this example, assume that the backup files have been restored, and that the user has administrator privileges.

Note: After issuing the ALTER DATABASE RECOVER statement, you can view all files that have been considered for recovery in the V$RECOVERY_FILE_STATUS view. You can access status information for each file in the V$RECOVERY_STATUS view. These views are not accessible after you terminate the recovery session.

See Also: *Oracle8i Reference* for information about the content of all recovery-related views.

Successful Application of Redo Logs

If you are using SQL*Plus's recovery options (not SQL statements), each time Oracle finishes applying a redo log file, the following message is returned:

```
Log applied.
```

Oracle then prompts for the next log in the sequence or, if the most recently applied log is the last required log, terminates recovery.

Unsuccessful Application of Redo Logs

If the suggested file is incorrect or you provide an incorrect filename, Oracle returns an error message. For example, you may see something similar to the following:

```
ORA-00308: cannot open archived log "/oracle/work/arc_dest/arcr_1_811.arc"
ORA-27037: unable to obtain file status
SVR4 Error: 2: No such file or directory
Additional information: 3
```

Recovery cannot continue until the required redo log file is applied. If Oracle returns an error message after supplying a redo log filename, the following scenarios are possible:

Error	Possible Cause	Solution
ORA-27037: unable to obtain file status	Entered wrong filename. Log is missing.	Re-enter correct filename. Restore backup archived redo log.
ORA-27047: unable to read the header block of file	The log may have been partially written or become corrupted.	If you can locate an uncorrupted or complete copy of the log, apply that copy; you do not need to restart recovery. If no copy of the log exists and you know the time of the last valid redo entry, perform incomplete recovery; in this case, restart recovery from the beginning, including restoring backups.

Interrupting the Application of Redo Logs

If you start a media recovery operation and must then interrupt it, for example, because a recovery operation must end for the night and resume the next morning, interrupt recovery at any time by taking either of the following actions:

- Enter the word CANCEL when prompted for a redo log file.

- Use your operating system's interrupt signal if you must abort when recovering an individual datafile, or when automated recovery is in progress.

After recovery is canceled, it must be completed before opening a database for normal operation. To resume recovery, restart it. Recovery resumes where it left off when it was canceled.

There are several reasons why, after starting recovery, you may want to restart. For example, if you want to restart with a different backup or want to use the same backup but need to change the end time to an earlier point in time than you initially specified, then the entire operation must recommence by restoring a backup. Failure to do so may result in "file inconsistent" error messages when attempting to open the database.

Recovering a Database in NOARCHIVELOG Mode

If a database is in NOARCHIVELOG mode and a media failure damages some or all of the datafiles, the only option for recovering the database is usually to restore the most recent whole database backup. If you are using Export to supplement regular backups, then you can instead restore the database by importing an exported backup of the database.

The disadvantage of NOARCHIVELOG mode is that to recover your database from the time of the most recent full backup up to the time of the media failure, you have to re-enter manually all of the changes executed in that interval. If your database was in ARCHIVELOG mode, however, the redo log covering this interval would have been available as archived log files or online log files. Using archived redo logs would have enabled you to use complete or incomplete recovery to reconstruct your database, thereby minimizing the amount of lost work.

If you have a database damaged by media failure and operating in NOARCHIVELOG mode, and you want to restore from your most recent consistent whole database backup (your only option at this point), follow the steps below.

To restore the most recent whole database backup to the default location:

1. If the database is open, abort the instance:

   ```
   SHUTDOWN ABORT
   ```

2. Correct the media problem so that the backup database files can be restored to their original locations.
3. Restore the most recent whole database backup using operating system commands. Restore all of the datafiles and control files of the whole database

backup, not just the damaged files. This example restores a whole database backup:

```
% cp /oracle/work/BACKUP/tbs* /oracle/dbs  # restores datafiles
% cp /oracle/work/BACKUP/cf.f /oracle/dbs  # restores control file
```

4. Mimic incomplete database recovery by issuing the following statement:

```
ALTER DATABASE RECOVER DATABASE UNTIL CANCEL;
```

5. Open the database and reset the current redo log sequence to 1:

```
ALTER DATABASE OPEN RESETLOGS;
```

A RESETLOGS operation invalidates all redo in the online logs. Restoring from a whole database backup and then resetting the log discards all changes to the database made from the time the backup was taken to the time of the failure.

To restore the most recent whole database backup to a new location:

1. If the database is open, shut it down:

```
SHUTDOWN NORMAL
```

2. If the hardware problem has not been corrected and some or all of the database files must be restored to alternative locations, restore the most recent whole database backup to a new location. Restore all of the datafiles and control files of the whole database backup, not just the damaged files. For example, enter:

```
% cp /disk2/BACKUP/tbs* /disk3/oracle/dbs
% cp /disk2/BACKUP/cf.f /disk3/oracle/dbs
```

3. If necessary, edit the restored parameter file to indicate the new location of the control files.

```
CONTROL_FILES = "/disk3/oracle/dbs/cf.f"
```

4. Start an instance using the restored and edited parameter file and mount, but do not open, the database. For example, this statements mounts the database using the initialization file `initPROD1.ora`:

```
STARTUP MOUNT pfile=initPROD1.ora
```

5. If the restored datafile filenames will be different, rename the restored datafiles in the control file. For example, you might enter:

```
ALTER DATABASE RENAME FILE "/disk1/oracle/dbs/tbs1.f" TO "/disk3/oracle/dbs/tbs1.f";
```

> **See Also:** *Oracle8i SQL Reference* for more information about ALTER DATABASE RENAME FILE.

6. If applicable, rename the online redo log files. For example, enter:

```
ALTER DATABASE RENAME FILE "/disk1/oracle/dbs/log1.f" TO "/disk3/oracle/dbs/log1.f";
```

7. Mimic incomplete database recovery by issuing the following statement:

```
ALTER DATABASE RECOVER DATABASE UNTIL CANCEL;
```

8. Mimic incomplete database recovery by issuing the following statement:

```
ALTER DATABASE RECOVER CANCEL;
```

9. Open the database and reset the current redo log sequence to 1:

```
ALTER DATABASE OPEN RESETLOGS;
```

   A RESETLOGS operation invalidates all redo in the online logs. Restoring from a whole database backup and then resetting the log discards all changes to the database made from the time the backup was taken to the time of the failure.

   > **See Also:** *Oracle8i Administrator's Guide* for more information about renaming and relocating datafiles.

Recovering a Database in ARCHIVELOG Mode

To begin media recovery operations when your database is running in ARCHIVELOG mode, use one of the following options:

- The ALTER DATABASE RECOVER statement
- The SQL*Plus RECOVER statement (recommended)

To start any type of media recovery, you must adhere to the following restrictions:

- You must have administrator privileges.
- All recovery sessions must be compatible.
- One session cannot start complete media recovery while another performs incomplete media recovery.
- You cannot start media recovery if you are connected to the database via a multi-threaded server process.

> **See Also:** *SQL*Plus User's Guide and Reference*

Performing Media Recovery in Parallel

Use *parallel block recovery* to tune the roll forward phase of media recovery. In parallel block recovery, Oracle uses a "division of labor" approach to allocate different processes to different data blocks while rolling forward, thereby making the procedure more efficient. For example, if the redo log contains a substantial number of entries, spawned process 1 takes responsibility for one part of the log file, process 2 takes responsibility for another part, process 3 takes responsibility for a third part, etc.

> **Note:** Typically, recovery is I/O-bound on reads to data blocks. Consequently, parallelism at the block level may only help recovery performance if it increases total I/Os, for example, by bypassing operating system restrictions on asynchronous I/Os. Systems that have efficient asynchronous I/O typical see little improvement from using parallel block recovery.

Use the following SQL*Plus RECOVER statement to perform parallel media recovery:

```
RECOVER PARALLEL ... ;
```

The PARALLEL clause of the RECOVER statement has the following options:

DEGREE *integer*	Specifies the number of recovery processes used to apply redo entries to datafiles on each instance.
DEGREE DEFAULT	Indicates that twice the number of datafiles being recovered is the number of recovery processes to use.
INSTANCES *integer*	Specifies the number of instances to use for parallel recovery. The number of recovery processes specified with DEGREE is used on each instance. Thus, the total number of recovery processes is the integer specified with DEGREE multiplied by the integer specified with INSTANCES. INSTANCES is only pertinent for the Oracle Parallel Server.
INSTANCES DEFAULT	Has operating system-specific consequences. For more information about the default behavior of the INSTANCES DEFAULT specification, see the Oracle8i Parallel Server Documentation Set: Oracle8i Parallel Server Concepts; Oracle8i Parallel Server Setup and Configuration Guide; Oracle8i Parallel Server Administration, Deployment, and Performance manual.

For example, to specify that 5 recovery processes should operate during recovery, specify as follows:

```
RECOVER DEGREE 5 ... ;
```

In a different scenario, assume that you are recovering 10 datafiles. Issue the following statement to specify that 20 processes should perform recovery:

```
RECOVER DEGREE DEFAULT;
```

> **Note:** The RECOVERY_PARALLELISM initialization parameter specifies the number of concurrent recovery processes for instance or crash recovery *only*. Media recovery is not affected by this parameter.

See Also:

- *Oracle8i Designing and Tuning for Performance* for more information on parallel recovery
- *Oracle8i Reference* for more information about the RECOVERY_PARALLELISM parameter
- *SQL*Plus User's Guide and Reference* for more information about the SQL*Plus RECOVER statement

Performing Complete Media Recovery

When you perform complete recovery, you can either recover the whole database at once or recover individual tablespaces or datafiles. Because you do not have to open the database with the RESETLOGS option after complete recovery as you do after incomplete recovery, you have the option of recovering some datafiles at one time and the remaining datafiles later.

This section describes the steps necessary to complete media recovery operations, and includes the following topics:

- Performing Closed Database Recovery
- Performing Open Database Recovery

> **See Also:** Chapter 3, "Developing a Backup and Recovery Strategy" to familiarize yourself with fundamental recovery concepts and strategies

Performing Closed Database Recovery

This section describes steps to perform closed database recovery of either all damaged datafiles in one operation, or individual recovery of each damaged datafile in separate operations.

Perform the media recovery in these stages:

1. Shut down the database and correct the media damage if possible.
2. Restore the necessary files.
3. Recover the database.

To prepare for closed database recovery:

1. If the database is open, shut it down using the ABORT option:

   ```
   SHUTDOWN ABORT
   ```

2. If you are recovering from a media error, correct it if possible.
3. If the hardware problem that caused the media failure was temporary, and the data was undamaged (for example, a disk or controller power failure), simply start the database and resume normal operations:

   ```
   STARTUP
   ```

To restore the necessary files:

1. Determine which datafiles to recover using the techniques described in "Determining Which Files to Recover" on page 5-2.
2. If files are permanently damaged, identify the most recent backups for the damaged files. Restore *only* the datafiles damaged by the media failure: do not restore any undamaged datafiles or any online redo log files.

   For example, if `/oracle/dbs/tbs_10.f` is the damaged file, you may consult your records and determine that `/oracle/backup/tbs_10.backup` is the most recent backup. If you do not have a backup of a specific datafile, you may be able to create an empty replacement file that can be recovered.
3. Use an operating system utility to restore the files to their default location or to a new location. For example, a UNIX user restoring `/oracle/dbs/tbs_10.f` to its default location might enter:

   ```
   % cp /oracle/backup/tbs_10.backup /oracle/dbs/tbs_10.f
   ```

   Follow these guidelines when determining where to restore datafile backups:

If...	Then...
The hardware problem is repaired and you can restore the datafiles to their default locations	Restore the datafiles to their default locations and begin media recovery.
The hardware problem persists and you cannot restore datafiles to their original locations	Restore the datafiles to an alternative storage device. Indicate the new location of these files to the control file. Use the operation described in "Renaming and Relocating Datafiles" in the *Oracle8i Administrator's Guide*, as necessary.

To recover the restored datafiles:

1. Connect to Oracle with administrator privileges, then start a new instance and mount, but do not open, the database. For example, enter:

   ```
   STARTUP MOUNT
   ```

2. Obtain the datafile names of all datafiles by checking the list of datafiles that normally accompanies the current control file or querying the V$DATAFILE view. For example, enter:

   ```
   SELECT name FROM v$datafile;
   ```

3. Ensure that all datafiles of the database are online. For example, to guarantee that a datafile named `/oracle/dbs/tbs_10.f` is online, enter the following:

   ```
   ALTER DATABASE DATAFILE '/oracle/dbs/tbs_10.f' ONLINE;
   ```

   If a specified datafile is already online, Oracle ignores the statement. If you prefer, create a script to bring all datafiles online at once as in the following:

   ```
   SPOOL onlineall.sql
   SELECT 'ALTER DATABASE DATAFILE '''||name||''' ONLINE;' FROM v$datafile;
   SPOOL OFF
   @onlineall
   ```

4. Issue the statement to recover the database, tablespace, or datafile. For example, enter:

   ```
   RECOVER DATABASE   # recovers whole database
   RECOVER TABLESPACE users   # recovers specific tablespace
   RECOVER DATAFILE '/oracle/dbs/tbs_10';   # recovers specific datafile
   ```

   Follow these guidelines when deciding which statement to execute:

To...	Then...
Recover all damaged files in one step	Execute RECOVER DATABASE (recommended) or ALTER DATABASE RECOVER DATABASE
Recover an individual tablespace	Execute RECOVER TABLESPACE (recommended) or ALTER DATABASE RECOVER TABLESPACE
Recover an individual damaged datafile	Execute RECOVER DATAFILE (recommended) or ALTER DATABASE RECOVER DATAFILE
Parallelize recovery of the whole database or an individual datafile	See "Performing Media Recovery in Parallel" on page 5-18

5. If you choose not to automate the application of archived redo logs, accept or reject each required redo log file that Oracle prompts you for. If you automated recovery, Oracle applies the necessary logs automatically. Oracle continues until all required archived and online redo log files have been applied to the restored datafiles.
6. Oracle notifies you when media recovery is complete. If no archived redo log files are required for complete media recovery, Oracle applies all necessary online redo log files and terminates recovery.
7. Open the database:

```
ALTER DATABASE OPEN;
```

See Also: "Performing Complete Media Recovery" on page 5-19 for more information about applying redo log files

Performing Open Database Recovery

It is possible for a media failure to occur while the database remains open, leaving the undamaged datafiles online and available for use. Oracle automatically takes the damaged datafiles offline—but not the tablespaces that contain them—if DBWR fails to be able to write to them. Queries that cannot read damaged files receive errors, but Oracle does not take the files offline for this reason alone.

This procedure cannot be used to perform complete media recovery on the datafiles of the SYSTEM tablespace. If the media failure damages any datafiles of the SYSTEM tablespace, Oracle automatically shuts down the database.

Perform media recovery in these stages:

1. Prepare the database for recovery by making sure it is open and taking the affected tablespaces offline.

2. Restore the necessary files.
3. Recover the database.

> **See Also:** "Performing Closed Database Recovery" on page 5-19 for procedures for proceeding with complete media recovery of SYSTEM tablespaces datafiles

To prepare for open database recovery when the database is shut down:

1. Start a new instance, and mount and open the database. For example, enter:

   ```
   STARTUP
   ```

2. After the database is open, take all tablespaces that contain damaged datafiles offline. For example, if tablespace TBS_1 contains damaged datafiles, enter:

   ```
   ALTER TABLESPACE tbs_1 OFFLINE TEMPORARY;
   ```

3. Correct the hardware problem that caused the media failure. If the hardware problem cannot be repaired quickly, proceed with database recovery by restoring damaged files to an alternative storage device.

To prepare for recovery in an open database:

1. If the database is open when you discover that recovery is required, take all tablespaces containing damaged datafiles offline. For example, if tablespace TBS_1 contains damaged datafiles, enter:

   ```
   ALTER TABLESPACE tbs_1 OFFLINE TEMPORARY;
   ```

2. Correct the hardware problem that caused the media failure. If the hardware problem cannot be repaired quickly, proceed with database recovery by restoring damaged files to an alternative storage device.

To restore datafiles in an open database:

1. If files are permanently damaged, restore the most recent backup files of *only* the datafiles damaged by the media failure. Do not restore undamaged datafiles, online redo log files, or control files. If the hardware problem has been repaired and the datafiles can be restored to their original locations, do so. If the hardware problem persists, restore the datafiles to an alternative storage device of the database server.

> **Note:** If you do not have a backup of a specific datafile, you can use ALTER DATABASE CREATE DATAFILE to create an empty replacement file, which can be recovered.

2. If you restored one or more damaged datafiles to alternative locations, indicate the new locations of these files to the control file of the associated database by using the procedure in the *Oracle8i Administrator's Guide*.

To recover offline tablespaces in an open database:

1. Connect to the database with administrator privileges. For example, connect as SYS to database PROD1:

   ```
   % sqlplus sys/oracle@prod1
   ```

2. Start offline tablespace recovery of all damaged datafiles in one or more offline tablespaces using one step:

   ```
   RECOVER TABLESPACE tbs_1  # begins recovery on datafiles in tbs_1
   ```

   > **Note:** For maximum performance, use parallel recovery to recover the datafiles. See"Performing Media Recovery in Parallel" on page 5-18.

3. Oracle begins the roll forward phase of media recovery by applying the necessary redo log files (archived and online) to reconstruct the restored datafiles. Unless the applying of files is automated using SET AUTORECOVERY ON, Oracle prompts for each required redo log file.

   Oracle continues until all required archived redo log files have been applied to the restored datafiles. The online redo log files are then automatically applied to the restored datafiles to complete media recovery.

   If no archived redo log files are required for complete media recovery, Oracle does not prompt for any. Instead, all necessary online redo log files are applied, and media recovery is complete.

4. When the damaged tablespaces are recovered up to the moment that media failure occurred, bring the offline tablespaces online. For example, to bring tablespace TBS_1 online, issue:

   ```
   ALTER TALBESPACE tbs_1 ONLINE;
   ```

See Also: *Oracle8i Administrator's Guide* for more information about creating datafiles.

Performing Incomplete Media Recovery

This section describes the steps necessary to complete the different types of incomplete media recovery operations, and includes the following topics:

- Performing Cancel-Based Recovery
- Performing Time-Based Recovery
- Performing Change-Based Recovery

Note that if your database is affected by seasonal time changes (for example, daylight savings time), you may experience a problem if a time appears twice in the redo log and you want to recover to the second, or later time. To deal with time changes, perform cancel-based or change-based recovery to the point in time where the clock is set back, then continue with the time-based recovery to the exact time.

Performing Cancel-Based Recovery

This section describes how to perform cancel-based media recovery in these stages:

1. Prepare for recovery by backing up the database and correct any media failures.
2. Restore backup control files (if necessary) and backup datafiles.
3. Perform media recovery on the restored backup using the RECOVER DATABASE statement, terminating it with a CANCEL.

To prepare for cancel-based recovery:

1. If the database is still open and incomplete media recovery is necessary, abort the instance:

   ```
   SHUTDOWN ABORT
   ```

2. Make a whole backup of the database—all datafiles, a control file, and the parameter files of the database—as a precautionary measure in case an error occurs during the recovery procedure.
3. If a media failure occurred, correct the hardware problem that caused the failure. If the hardware problem cannot be repaired quickly, proceed with database recovery by restoring damaged files to an alternative storage device.

To restore the files necessary for cancel-based recovery:

1. If the current control files do not match the physical structure of the database at the intended time of recovery, for example, if a datafile was added after the point in time to which you intend to recover, then restore a backup of the control file.

   The restored control file should reflect the database's physical file structure, that is, contain the names of datafiles and online redo log files, at the point at which incomplete media recovery is intended to finish. Review the list of files that correspond to the current control file as well as each control file backup to determine the correct control file to use.

   If necessary, replace all current control files of the database with the correct control file backup. Alternatively, create a new control file.

   > **Note:** If a database control file cannot function or be replaced with a control file backup, take it out of the CONTROL_FILES parameter list in the parameter file associated with the database.

2. Restore backups taken as part of a full or partial backup of *all* the datafiles of the database. You must have taken all backup files used to replace existing datafiles before the intended time of recovery. For example, if you intend to recover to redo log sequence number 38, then restore all datafiles with backups completed before redo log sequence number 38.
3. If you do not have a backup of a specific datafile, create an empty replacement file that can be recovered. If you added a datafile after the intended time of recovery, you do not need to restore a backup for this file since it will no longer be used for the database after recovery is complete.
4. If you solved the hardware problem that caused a media failure and can restore all datafiles to their original locations, then restore the files. If a hardware problem persists, restore damaged datafiles to an alternative storage device.

   > **Note:** Files in read-only tablespaces should be taken offline if you are using a control file backup. Otherwise, recovery will try to update the headers of the read-only files.

To perform cancel-based recovery:

1. Start SQL*Plus and connect to Oracle with administrator privileges. For example, enter:

   ```
   % sqlplus sys/change_on_install@prod1
   ```

2. Start a new instance and mount the database:

   ```
   STARTUP MOUNT
   ```

3. If you restored one or more damaged datafiles to alternative locations, indicate the new locations of these files to the control file of the associated database.

4. Begin cancel-based recovery:

   ```
   RECOVER DATABASE UNTIL CANCEL
   ```

   If you are using a backup control file with this incomplete recovery, specify the USING BACKUP CONTROLFILE option in the RECOVER statement.

   ```
   RECOVER DATABASE UNTIL CANCEL USING BACKUP CONTROLFILE
   ```

   > **Note:** If you do not specify the UNTIL CANCEL clause on the RECOVER statement, you will not be able to open the database until a complete recovery is done.

5. Oracle applies the necessary redo log files to reconstruct the restored datafiles. Unless the application of files is automated, Oracle supplies the name it expects to find from LOG_ARCHIVE_DEST_1 or LOG_ARCHIVE_DEST and requests you to stop or proceed with applying the log file. Note that if the control file is a backup file, you must supply names of online logs.

   > **Note:** If you use an OPS configuration, and you are performing incomplete recovery or using a backup control file, then Oracle can only compute the name of the first archived redo log file from the *first* thread. The first redo log file from the other threads must be supplied by the user. Once the first log file in a given thread has been supplied, Oracle can suggest the names of the subsequent log files in those threads.

6. Continue applying redo log files until the most recent, undamaged redo log file has been applied to the restored datafiles.

7. Cancel recovery after Oracle has applied the redo log file just prior to the damaged file:

```
CANCEL
```

Oracle returns a message indicating whether recovery is successful. Note that if you cancel recovery before it is complete and then try to open the database, you will get an ORA-1113 error if more recovery is necessary for the file.

Performing Time-Based Recovery

This section describes how to perform the time-based media recovery procedure in these stages:

1. Back up the database as a precaution and correct any media failures.
2. Restore backup control files (if necessary) and backup datafiles.
3. Perform media recovery on the restored backup using the RECOVER DATABASE statement with the UNTIL TIME option.

Note: If you are performing time-based, incomplete recovery using a backup control file and have read-only tablespaces, contact Oracle Support before attempting this procedure.

To prepare for time-based recovery:

Follow the same preparation procedure described in the section "Performing Cancel-Based Recovery" on page 5-28.

To restore the files necessary for time-based recovery and bring them online:

1. If the current control files do not match the physical structure of the database at the intended time of recovery, restore a backup control file that reflects the database's physical file structure at the point at which incomplete media recovery should finish. To determine which control file backup to use:
   - Review the list of files that corresponds to the current control file and each control file backup to determine the correct control file to use.
   - If necessary, replace all current control files of the database with the correct control file backup.
   - Alternatively, create a new control file to replace the missing one.

Note: If a database control file cannot function or be replaced with a control file backup, take it out of the CONTROL_FILES parameter list in the parameter file associated with the database.

2. Restore backups of *all* the datafiles of the database. All backups used to replace existing datafiles must have been taken before the intended time of recovery. For example, if you intend to recover to January 2 at 2:00 p.m., then restore all datafiles with backups completed before this time. Follow these guidelines:

If...	Then...
You do not have a backup of a datafile	Create an empty replacement file, which can be recovered.
A datafile was added after the intended time of recovery	Do not restore a backup of this file, since it will no longer be used for the database after recovery completes.
The hardware problem causing the failure has been solved and all datafiles can be restored to their default locations	Restore the files and skip Step 5 of this procedure.
A hardware problem persists	Restore damaged datafiles to an alternative storage device.

Note: Files in read-only tablespaces should be offline if you are using a control file backup. Otherwise, the recovery will try to update the headers of the read-only files.

3. Start SQL*Plus and connect to Oracle with administrator privileges. For example, enter:

```
% sqlplus sys/change_on_install@prod1
```

4. Start a new instance and mount the database:

```
STARTUP MOUNT
```

5. If one or more damaged datafiles were restored to alternative locations in Step 2, indicate the new locations of these files to the control file of the associated database. For example, enter:

```
ALTER DATABASE RENAME FILE "/oracle/dbs/df2.f" TO "/oracle/newloc/df2.f";
```

6. Obtain the names of all datafiles requiring recovery by:
   - Checking the list of datafiles that normally accompanies the control file being used.
   - Querying the V$DATAFILE view.
7. Make sure that all datafiles of the database are online. All datafiles of the database must be online unless an offline tablespace was taken offline normally. For example, to guarantee that a datafile named `user1` (a fully specified filename) is online, enter the following statement:

   ```
   ALTER DATABASE DATAFILE 'users1' ONLINE;
   ```

   If a backup of the control file is being used with this incomplete recovery (that is, a control file backup or re-created control file was restored), indicate this in the dialog box or command used to start recovery. If a specified datafile is already online, Oracle ignores the statement.

To perform time-based recovery:

1. Issue the RECOVER DATABASE UNTIL TIME statement to begin time-based recovery. The time is always specified using the following format, delimited by single quotation marks: 'YYYY-MM-DD:HH24:MI:SS'. The following statement recovers the database up to a specified time using a control file backup:

   ```
   RECOVER DATABASE UNTIL TIME '1992-12-31:12:47:30' USING BACKUP CONTROLFILE
   ```

2. Apply the necessary redo log files to reconstruct the restored datafiles. Unless the application of files is automated, Oracle supplies the name it expects to find from LOG_ARCHIVE_DEST_1 or LOG_ARCHIVE_DEST and requests you to stop or proceed with applying the log file. If the control file is a backup, you must supply names of online logs.
3. Apply redo log files until the last required redo log file has been applied to the restored datafiles. Oracle automatically terminates the recovery when it reaches the correct time, and returns a message indicating whether recovery is successful.

Performing Change-Based Recovery

This section describes how to perform recovery to a specified SCN in these stages:

1. Back up the database as a precaution and correct any media failures.
2. Restore backup control files (if necessary) and backup datafiles.

3. Perform media recovery on the restored backup using the RECOVER DATABASE statement with the UNTIL CHANGE option.

To prepare for change-based recovery:

Follow the same preparation procedure described in the section "Performing Cancel-Based Recovery" on page 5-28.

To restore files necessary for change-based recovery:

Follow the same restore procedure described in the section "Performing Time-Based Recovery" on page 5-28.

To perform change-based recovery:

1. Begin change-based recovery, specifying the SCN for recovery termination. The SCN is specified as a decimal number without quotation marks. For example, to recover through SCN 100 issue:

   ```
   RECOVER DATABASE UNTIL CHANGE 100;
   ```

2. Oracle begins the roll forward phase of media recovery by applying the necessary redo log files (archived and online) to reconstruct the restored datafiles. Unless the application of files is automated, Oracle supplies the name it expects to find from LOG_ARCHIVE_DEST_1 or LOG_ARCHIVE_DEST and requests you to stop or proceed with applying the log file. If the control file is a backup file, you must supply names of online logs. Oracle continues to apply redo log files.
3. Continue applying redo log files until the last required redo log file has been applied to the restored datafiles. Oracle automatically terminates the recovery when it reaches the correct SCN, and returns a message indicating whether recovery is successful.

Opening the Database After Media Recovery

Whenever you perform incomplete recovery or perform recovery using a backup control file, you must reset the online redo logs when you open the database. The new version of the reset database is called a new *incarnation*. All archived redo logs generated after the point of the RESETLOGS on the old incarnation are invalid in the new incarnation.

If you perform complete recovery, then you do not have to open the database with the RESETLOGS option: you simply open the database as normal. All previous

backups and archived logs created during the lifetime of this incarnation of the database are still valid.

This section contains the following topics:

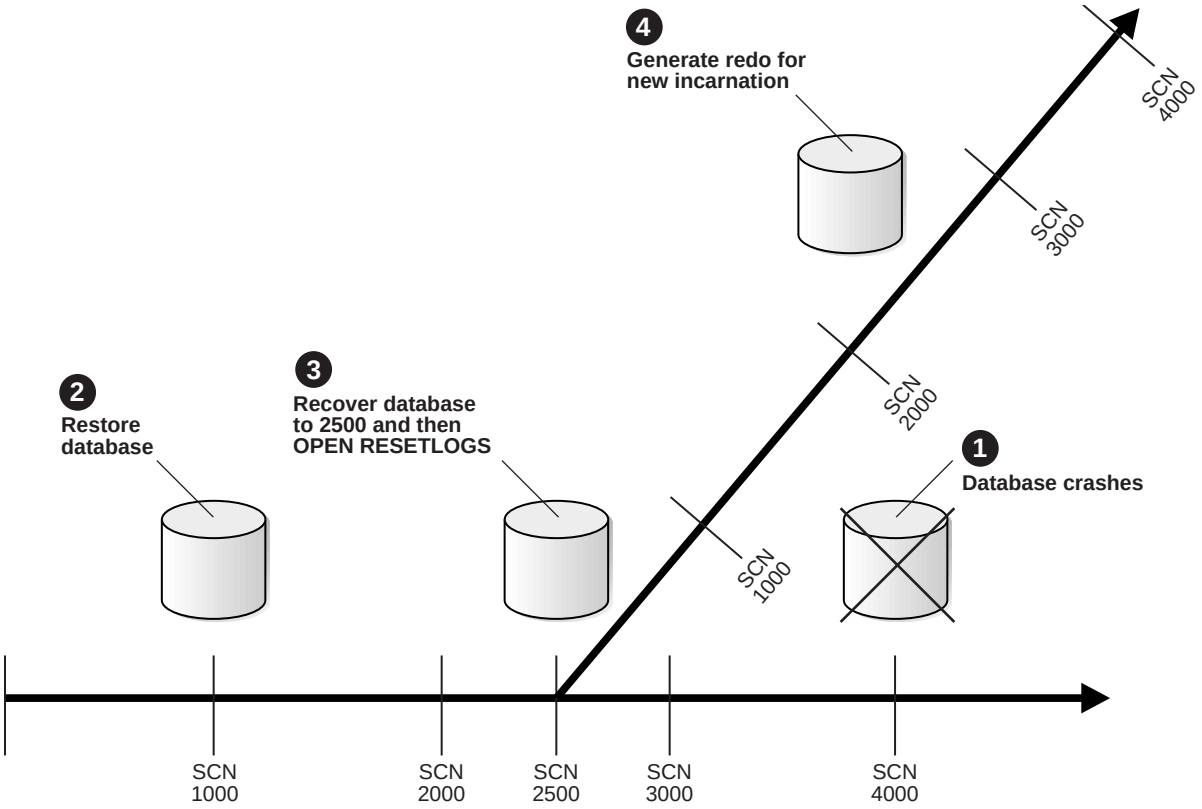
What Is a RESETLOGS Operation?

Whenever you open the database with the RESETLOGS option, all datafiles get a new RESETLOGS SCN and timestamp. Archived redo logs also have these two values in their header. Because Oracle will not apply an archived redo log to a datafile unless the RESETLOGS SCN and timestamps match, the RESETLOGS operations prevents you from corrupting your datafiles with old archived logs.

Figure 5–1 shows the case of a database that can only be recovered to SCN 2500 because an archived redo log is missing. At SCN 4000, the database crashes. You restore the SCN 1000 backup and prepare for complete recovery. Unfortunately, one of your archived redo logs is corrupted. The log before the missing log contains SCN 2500, so you recover to this point and open with the RESETLOGS option.

As the diagram illustrates, you generate new changes in the new incarnation of the database, eventually reaching SCN 4000. The changes between SCN 2500 and SCN 4000 for the new incarnation of the database are completely different from the changes between SCN 2500 and SCN 4000 for the old incarnation. Oracle does not allow you to apply logs from an old incarnation to the new incarnation. You cannot restore backups from before SCN 2500 in the old incarnation to the new incarnation.

Figure 5–1 Creating a New Database Incarnation



Determining Whether to Reset the Online Redo Logs

The RESETLOGS option is *required* after incomplete media recovery or recovery using a backup control file. Resetting the redo log:

- Discards any redo information that was not applied during recovery, ensuring that it will never be applied.
- Re-initializes the control file information about online redo logs and redo threads.
- Clears the contents of the online redo logs.
- Creates the online redo log files if they do not currently exist.

- Resets the log sequence number to 1.

> **WARNING: Resetting the redo log discards all changes to the database made since the first discarded redo information. Updates entered after that time must be re-entered manually.**

Use the following rules when deciding whether to specify RESETLOGS or NORESETLOGS:

- *Always* specify the RESETLOGS option after incomplete media recovery. For example, you must have specified a previous time or SCN, not one in the future.
- Specify the NORESETLOGS option after performing complete media recovery (unless you used a backup control file). This rule applies when you intentionally performed complete recovery and when you performed incomplete recovery but actually recovered all changes in the redo logs anyway.
- Always specify the RESETLOGS option if you used a backup of the control file in recovery, regardless of whether you performed complete or incomplete recovery.
- Do not specify the RESETLOGS option if you are using the archived logs of the database for a standby database. If you must reset the online logs, then you have to re-create the standby database.

Executing the ALTER DATABASE OPEN Statements

To preserve the log sequence number when opening a database after media recovery, execute the following statement:

```
ALTER DATABASE OPEN NORESETLOGS;
```

To reset the log sequence number when opening a database after recovery, execute the following statement:

```
ALTER DATABASE OPEN RESETLOGS;
```

If you open with the RESETLOGS option, Oracle returns different messages depending on whether recovery was complete or incomplete. If the recovery was complete, the following message appears in the `alert.log` file:

```
RESETLOGS after complete recovery through change scn
```

If the recovery was incomplete, this message is reported in the ALERT file:

```
RESETLOGS after incomplete recovery UNTIL CHANGE scn
```

If you attempt to reset the log when you should not, or if you neglect to reset the log when you should, Oracle returns an error and does not open the database. Correct the error and try again.

Following Up After a RESETLOGS Operation

This section describes actions that you should perform after opening the database in RESETLOGS mode:

- Making a Whole Database Backup
- Checking the Alert Log

Making a Whole Database Backup Immediately shut down the database normally and make a full database backup. Otherwise, you cannot recover changes made after you reset the logs. Until you take a full backup, the only way to recover is to repeat the procedures you just finished, up to resetting the logs. You do not need to back up the database if you did not reset the log sequence.

In general, backups made before a RESETLOGS operation are not allowed in the new incarnation. There is, however, an exception to the rule: you can restore a pre-RESETLOGS backup *only if* Oracle does not need to access archived redo logs from before the RESETLOGS to perform recovery.

See Also: "Recovering a Pre-RESETLOGS Backup" on page 5-36.

Checking the Alert Log After opening the database using the RESETLOGS option, check the `alert.log` to see whether Oracle detected inconsistencies between the data dictionary and the control file, for example, a datafile that the data dictionary includes but does not list in the new control file.

If a datafile exists in the data dictionary but not in the new control file, Oracle creates a placeholder entry in the control file under MISSING*nnnn* (where *nnnn* is the file number in decimal). MISSING*nnnn* is flagged in the control file as being offline and requiring media recovery.

The actual datafile corresponding to MISSING*nnnn* can be made accessible by renaming MISSING*nnnn* so that it points to the datafile only if the datafile was read-only or offline normal. If, on the other hand, MISSING*nnnn* corresponds to a datafile that was not read-only or offline normal, then the rename operation cannot be used to make the datafile accessible, because the datafile requires media recovery

that is precluded by the results of RESETLOGS. In this case, you must drop the tablespace containing the datafile.

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

Recovering a Pre-RESETLOGS Backup

In pre-Oracle8 releases, DBAs typically backed up online logs when performing cold consistent backups to avoid opening the database with the RESETLOGS option (if they were planning to restore immediately).

A classic example of this technique was disk maintenance, which required the database to be backed up, deleted, the disks reconfigured, and the database restored. DBAs realized that by not restarting in RESETLOGS mode, they would not have to perform a whole database backup immediately after the database was restored. This backup was required since it was impossible to perform recovery using a backup taken before using RESETLOGS—especially if any errors occurred after resetting the logs.

Restoring Pre-RESETLOGS Backups

It is possible to restore the following types of pre-RESETLOGS backups in a new incarnation:

- Backups of a tablespace made after it was made read-only (only if it was not made read-write again before the RESETLOGS)
- Backups of a tablespace after it was taken offline-normal (only if it was not brought online again before the RESETLOGS)
- Consistent backups of read-write tablespaces made after recovery ends and before you open RESETLOGS, that is, you do not perform further recovery or alter the datafiles between the backup and the RESETLOGS—but only if you have a control file that is valid *after* you open the database with RESETLOGS

You are prevented from restoring backups of read-write tablespaces that were *not* made immediately before the RESETLOGS. This restriction applies even if no changes were made to the datafiles in the read-write tablespace between the backup and the RESETLOGS. Because the checkpoint in the datafile header of a backup will be older than the checkpoint in the control file, Oracle has to search the archived logs to determine whether changes need to be applied—and the pre-RESETLOGS archived logs are not valid in the new incarnation.

Restoring a Pre-RESETLOGS Backup: Scenario

The following scenario illustrates a situation when you can use a pre-RESETLOGS backup. Suppose you wish to perform hardware striping reconfiguration, which requires the database files to be backed up and deleted, the hardware reconfigured, and the database restored.

On Friday night you perform the following actions:

1. Cleanly shut down the database:

   ```
   SHUTDOWN IMMEDIATE
   ```

2. Perform a whole database backup. For example, enter

   ```
   % cp /oracle/dbs/* /oracle/backup
   ```

   Note: At this point you must not reopen the database.

3. Perform operating system maintenance.
4. Restore the datafiles and control files from the backup that you just made. For example, enter:

   ```
   % cp /oracle/backup/* /oracle/dbs
   ```

5. Mount the database:

   ```
   STARTUP MOUNT
   ```

6. Initiate cancel-based recovery:

   ```
   RECOVER DATABASE UNTIL CANCEL
   ```

7. Open the database with the RESETLOGS option:

   ```
   ALTER DATABASE OPEN RESETLOGS;
   ```

On Saturday morning the scheduled batch jobs run, generating archived redo logs. If a hardware error occurs on Saturday night that requires you to restore the whole database, then you can restore the backup taken immediately before opening the database with the RESETLOGS option, and roll forward using the logs produced on Saturday.

On Saturday night you do the following:

1. Abort the instance (if it still exists):

   ```
   SHUTDOWN ABORT
   ```

2. Restore all damaged files from the backup made on Friday night:

```
% cp /oracle/backup/* /oracle/dbs
```

> **Note:** If you have the current control file, *do not* restore it; otherwise you must restore a control file that was valid after opening the database with RESETLOGS.

3. Begin complete recovery, applying all the archived logs produced on Saturday. Use SET AUTORECOVERY ON to automate the log application.

```
SET AUTORECOVERY ON
RECOVER DATABASE
```

4. Open the database:

```
STARTUP
```

In this scenario, if you had opened the database after the Friday night backup and before opening the database with RESETLOGS, or, did not have a control file from after opening the database, you *would not* be able to use the Friday night backup to roll forward. You must have a backup after opening the database with the RESETLOGS option in order to be able to recover.

6

Media Recovery Scenarios

This chapter describes how to recover from common media failures, and includes the following topics:

Understanding the Types of Media Failures

Media failures fall into two general categories: *permanent* and *temporary*. Use different recovery strategies depending on the type of failure.

Permanent media failures are serious hardware problems that cause permanent loss of data on the disk. Lost data cannot be recovered except by repairing or replacing the failed storage device and restoring backups of the files stored on the damaged storage device.

Temporary media failures are hardware problems that make data temporarily inaccessible, but do not corrupt the data. Following are two examples of temporary media failures:

- A disk controller fails. Once the disk controller is replaced, Oracle can access the data on the disk.
- Power to a storage device is cut off. Once the power is returned, the storage device and all associated data is accessible again.

Recovering After the Loss of Datafiles

If a media failure affects datafiles, the appropriate recovery procedure depends on:

- The archiving mode of the database: ARCHIVELOG or NOARCHIVELOG.
- The type of media failure.
- The files affected by the media failure.

The following sections explain the appropriate recovery strategies for the database mode:

- Losing Datafiles in NOARCHIVELOG Mode
- Losing Datafiles in ARCHIVELOG Mode

Losing Datafiles in NOARCHIVELOG Mode

If either a permanent or temporary media failure affects *any* datafiles of a database operating in NOARCHIVELOG mode, then Oracle automatically shuts down the

database. Depending on the type of media failure, you can use one of the following recovery methods:

If the media failure is...	Then...
Temporary	Correct the hardware problem and restart the database. Usually, instance recovery is possible, and all committed transactions can be recovered using the online redo log.
Permanent	Follow the procedure "Recovering a Database in NOARCHIVELOG Mode" on page 5-15.

Losing Datafiles in ARCHIVELOG Mode

If either a permanent or temporary media failure affects the datafiles of a database operating in ARCHIVELOG mode, then the following scenarios can occur.

Damaged Datafiles	Database Status	Solution
Datafiles in the SYSTEM tablespace or datafiles with active rollback segments.	Oracle shuts down.	If the hardware problem is temporary, then fix it and restart the database. Usually, instance recovery recovers lost transactions. If the hardware problem is permanent, follow the procedure in "Performing Closed Database Recovery" on page 5-19.
Non-SYSTEM datafiles or datafiles that do not contain active rollback segments.	Oracle takes affected datafiles offline, but the database stays open.	If the unaffected portions of the database must remain available, then do not shut down the database. Take tablespaces containing problem datafiles offline using the temporary option, then follow the procedure in "Performing Open Database Recovery" on page 5-22.

Recovering Through an ADD DATAFILE Operation

If database recovery rolls forward through an ADD DATAFILE operation, then Oracle stops recovery when applying the ADD DATAFILE redo record and lets you confirm the location of the added file.

For example, suppose you create a new tablespace containing two datafiles: `/db/db2.f` and `/db/db3.f`. If you later perform media recovery through the CREATE TABLESPACE operation, Oracle may signal the following error when applying the CREATE TABLESPACE redo data:

```
ORA-00283: recovery session canceled due to errors
ORA-01244: unnamed datafile(s) added to controlfile by media recovery
ORA-01110: data file 3: '/db/db2.f'
ORA-01110: data file 2: '/db/db3.f'
```

To recover through an ADD DATAFILE operation:

1. View the files added by selecting from V$DATAFILE:

```
SELECT file#, name FROM v$datafile;

FILE#         NAME
-------------------------------------
1             /db/db1.f
2             /db/UNNAMED00002
3             /db/UNNAMED00003
```

2. If multiple unnamed files exist, determine which unnamed file corresponds to which datafile using one of these methods:
   - Open the `alert.log`, which contains messages about the original file location for each unnamed file.
   - Derive the original file location of each unnamed file from the error message and V$DATAFILE: each unnamed file corresponds to the file in the error message with the same file number.
3. Issue the ALTER DATABASE RENAME FILE statement to rename the datafiles. For example, enter:

```
ALTER DATABASE RENAME FILE '/db/UNNAMED00002' TO '/db/db3.f';
ALTER DATABASE RENAME FILE '/db/UNNAMED00003' TO '/db/db2.f';
```

4. Continue recovery by issuing the previous recovery statement. For example, enter:

```
RECOVER DATABASE
```

Recovering Transported Tablespaces

The *transportable tablespace* feature of Oracle allows a user to transport a set of tablespaces from one database to another. Transporting a tablespace into a database is like creating a tablespace with pre-loaded data. Using this feature is often an advantage because:

- It is faster than import / export or load / unload because it involves only copying datafiles and integrating metadata.

- You can use it to move index data, which allows you to avoid having to rebuild indexes.

Like normal tablespaces, transportable tablespaces are recoverable. While you can recover normal tablespaces without a backup, you must have a version of the transported datafiles in order to recover a plugged-in tablespace.

To recover a transportable tablespace, restore a backup of the transported datafiles and issue normal recovery commands. The backup can be the initial version of the transported datafiles or any backup taken after the tablespace is transported. Just as when recovering through a CREATE TABLESPACE operation, Oracle may signal `ORA-01244` when recovering through a transportable tablespace operation. In this case, rename the unnamed files to the correct locations using the procedure in "Recovering Through an ADD DATAFILE Operation" on page 6-3.

> **See Also:** *Oracle8i Administrator's Guide* for detailed information about using the transportable tablespace feature.

Recovering After the Loss of Online Redo Log Files

If a media failure has affected the online redo logs of a database, then the appropriate recovery procedure depends on:

- The configuration of the online redo log: mirrored or non-mirrored.
- The type of media failure: temporary or permanent.
- The types of online redo log files affected by the media failure: current, active, unarchived, or inactive (see Table 2–1 for a description of these log states).

The following sections describe the appropriate recovery strategies for these situations:

- Recovering After Losing a Member of a Multiplexed Online Redo Log Group
- Recovering After the Loss of All Members of an Online Redo Log Group

Recovering After Losing a Member of a Multiplexed Online Redo Log Group

If the online redo log of a database is multiplexed, and at least one member of each online redo log group is not affected by the media failure, Oracle allows the database to continue functioning as normal. Oracle writes error messages to the LGWR trace file and the `alert.log` of the database.

Solve the problem by taking one of the following actions:

- If the hardware problem is temporary, then correct it. LGWR accesses the previously unavailable online redo log files as if the problem never existed.
- If the hardware problem is permanent, then drop the damaged member and add a new member using the procedure below.

> **Note:** The newly added member provides no redundancy until the log group is reused.

To replace a damaged member of a redo log group:

1. Locate the filename of the damaged member in V$LOGFILE. The status is INVALID if the file is inaccessible:

```
SELECT group#, status, member FROM v$logfile;

GROUP#    STATUS       MEMBER
-------   -----------  --------------------
0001                    /oracle/dbs/log1a.f
0001                    /oracle/dbs/log1b.f
0002                    /oracle/dbs/log2a.f
0002      INVALID       /oracle/dbs/log2b.f
0003                    /oracle/dbs/log3a.f
0003                    /oracle/dbs/log3b.f
```

2. Drop the damaged member. For example, to drop member `log2b.f` from group 2, issue:

```
ALTER DATABASE DROP LOGFILE MEMBER '/oracle/dbs/log2b.f';
```

3. Add a new member to the group. For example, to add `log2c.f` to group 2, issue:

```
ALTER DATABASE ADD LOGFILE MEMBER '/oracle/dbs/log2c.f' TO GROUP 2;
```

   If the file you want to add already exists, then it must be the same size as the other group members, and you must specify REUSE:

```
ALTER DATABASE ADD LOGFILE MEMBER '/oracle/dbs/log2b.f' REUSE TO GROUP 2;
```

Recovering After the Loss of All Members of an Online Redo Log Group

If a media failure damages all members of an online redo log group, different scenarios can occur, depending on the type of online redo log group affected by the failure and the archiving mode of the database.

If the damaged log group is inactive, then it is not needed for instance recovery; if it is active, then it is needed for instance recovery.

If the group is...	Then...	And you should...
Inactive	It is not needed for instance recovery	Clear the archived or unarchived group.
Active	It is needed for instance recovery	Attempt to issue a checkpoint and clear the log; if impossible, then you must restore a backup and perform incomplete recovery up to the most recent available log.
Current	It is the log that Oracle is currently writing to	Attempt to clear the log; if impossible, then you must restore a backup and perform incomplete recovery up to the most recent available log.

Your first task is to determine whether the damaged group is active or inactive.

To determine whether the damaged groups are active:

1. Locate the filename of the lost redo log in V$LOGFILE and then look for the group number corresponding to it. For example, enter:

```
SELECT group#, status, member FROM v$logfile;

GROUP#    STATUS       MEMBER
-------   -----------  --------------------
0001                    /oracle/dbs/log1a.f
0001                    /oracle/dbs/log1b.f
0002      INVALID       /oracle/dbs/log2a.f
0002      INVALID       /oracle/dbs/log2b.f
0003                    /oracle/dbs/log3a.f
0003                    /oracle/dbs/log3b.f
```

2. Determine which groups are active. For example, enter:

```
SELECT group#, members, status, archived FROM v$log;
```

```
GROUP#  MEMBERS          STATUS     ARCHIVED
------  -------          ---------  -----------
 0001   2                INACTIVE   YES
 0002   2                ACTIVE     NO
 0003   2                CURRENT    NO
```

3. If the affected group is inactive, follow the procedure in "Losing an Inactive Online Redo Log Group" on page 6-8. If the affected group is active as in the above example, then follow the procedure in "Losing an Active Online Redo Log Group" on page 6-10.

Losing an Inactive Online Redo Log Group

If all members of an online redo log group with INACTIVE status are damaged, then the procedure depends on whether you can fix the media problem that damaged the inactive redo log group.

Type of Media Failure	Procedure
Temporary	Fix the problem. LGWR can reuse the redo log group when required.
Permanent	The damaged inactive online redo log group eventually halts normal database operation. Reinitialize the damaged group manually using ALTER DATABASE CLEAR LOGFILE as described below.

You can clear an active redo log group when the database is open or closed. The procedure depends on whether the damaged group has been archived.

To clear an inactive, online redo log group that has been archived:

1. If the database is shut down, start a new instance and mount the database, but do not open it:

   ```
   STARTUP MOUNT
   ```

2. Reinitialize the damaged log group. For example, to clear redo log group 2, issue:

   ```
   ALTER DATABASE CLEAR LOGFILE GROUP 2;
   ```

To clear an inactive, online redo log group that has not been archived:

Clearing an unarchived log allows it to be reused without archiving it. This action makes backups unusable if they were started before the last change in the log,

unless the file was taken offline prior to the first change in the log. Hence, if you need the cleared log file for recovery of a backup, you cannot recover that backup.

1. If the database is shut down, then start a new instance and mount the database, but do not open it:

   ```
   STARTUP MOUNT
   ```

2. Clear the log using the UNARCHIVED keyword. For example, to clear log group 2, issue:

   ```
   ALTER DATABASE CLEAR LOGFILE UNARCHIVED GROUP 2;
   ```

   If there is an offline datafile that requires the cleared unarchived log to bring it online, then the keywords UNRECOVERABLE DATAFILE are required. The datafile and its entire tablespace have to be dropped because the redo necessary to bring it online is being cleared, and there is no copy of it. For example, enter:

   ```
   ALTER DATABASE CLEAR LOGFILE UNARCHIVED GROUP 2 UNRECOVERABLE DATAFILE;
   ```

3. Immediately back up the database using an operating system utility. Now you can use this backup for complete recovery without relying on the cleared log group. For example, enter:

   ```
   % cp /disk1/oracle/dbs/*.f /disk2/backup
   ```

4. Back up the database's control file using the ALTER DATABASE statement. For example, enter:

   ```
   ALTER DATABASE BACKUP CONTROLFILE TO '/oracle/dbs/cf_backup.f';
   ```

Failure of CLEAR LOGFILE Operation The ALTER DATABASE CLEAR LOGFILE statement can fail with an I/O error due to media failure when it is not possible to:

- Relocate the redo log file onto alternative media by re-creating it under the currently configured redo log file name.
- Reuse the currently configured log file name to recreate the redo log file because the name itself is invalid or unusable (for example, due to media failure).

In these cases, the CLEAR LOGFILE statement (before receiving the I/O error) would have successfully informed the control file that the log was being cleared and did not require archiving. The I/O error occurred at the step in which CLEAR LOGFILE attempts to create the new redo log file and write zeros to it.

Losing an Active Online Redo Log Group

If the database is still running and the lost active log is *not* the current log, then issue the ALTER SYSTEM CHECKPOINT statement. If successful, your active log is rendered inactive, and you can follow the procedure in "Losing an Inactive Online Redo Log Group" on page 6-8. If unsuccessful, or if your database has halted, perform one of these procedures, depending on the archiving mode.

Note that the current log is the one LGWR is currently writing to. If a LGWR I/O fails, then LGWR terminates and the instance crashes. In this case, you must restore a backup, perform incomplete recovery, and open the database with the RESETLOGS option.

To recover from loss of an active online redo log group in NOARCHIVELOG mode:

1. If the media failure is temporary, correct the problem so that Oracle can reuse the group when required.
2. Restore the database from a whole database backup using an operating system utility. For example, enter:

   ```
   % cp /disk2/backup/*.f /disk1/oracle/dbs
   ```

3. Mount the database:

   ```
   STARTUP MOUNT
   ```

4. Open the database using the RESETLOGS option:

   ```
   ALTER DATABASE OPEN RESETLOGS;
   ```

5. Shut down the database normally:

   ```
   SHUTDOWN IMMEDIATE
   ```

6. Make a whole database backup. For example, enter:

   ```
   % cp /disk1/oracle/dbs/*.f /disk2/backup
   ```

To recover from loss of an active online redo log group in ARCHIVELOG mode:

1. If the media failure is temporary, then correct the problem so that Oracle can reuse the group when required.
2. Perform incomplete media recovery. Use the procedure given in "Performing Incomplete Media Recovery" on page 5-25, recovering up through the log before the damaged log.

3. Ensure that the current name of the lost redo log can be used for a newly created file. If not, rename the members of the damaged online redo log group to a new location. For example, enter:

```
ALTER DATABASE RENAME FILE "/oracle/dbs/log_1.rdo" TO "/temp/log_1.rdo";
ALTER DATABASE RENAME FILE "/oracle/dbs/log_2.rdo" TO "/temp/log_2.rdo";
```

4. Open the database using the RESETLOGS option:

```
ALTER DATABASE OPEN RESETLOGS;
```

> **Note:** All updates executed from the endpoint of the incomplete recovery to the present must be re-executed.

Loss of Multiple Redo Log Groups

If you have lost multiple groups of the online redo log, then use the recovery method for the most difficult log to recover. The order of difficulty, from most difficult to least, follows:

1. The current online redo log
2. An active online redo log
3. An unarchived redo log
4. An inactive online redo log

Recovering After the Loss of Archived Redo Log Files

If the database is operating in ARCHIVELOG mode, and the only copy of an archived redo log file is damaged, then the damaged file does not affect the present operation of the database. The following situations can arise, however, depending on when the redo log was written and when you backed up the datafile.

If you backed up...	Then...
All datafiles *after* the filled online redo log group (which is now archived) was written	The archived version of the filled online redo log group is not required for complete media recovery operation.
A given datafile *before* the filled online redo log group was written	If the corresponding datafile is damaged by a permanent media failure, use the most recent backup of the damaged datafile and perform incomplete recovery up to the damaged log.

WARNING: If you know that an archived redo log group has been damaged, immediately back up all datafiles so that you will have a whole database backup that does not require the damaged archived redo log.

Recovering After the Loss of Control Files

If a media failure has affected the control files of a database (whether control files are multiplexed or not), the database continues to run until the first time that an Oracle background process needs to access the control files. At this point, the database and instance are automatically shut down.

If the media failure is temporary and the database has not yet shut down, avoid the automatic shutdown of the database by immediately correcting the media failure. If the database shuts down before you correct the temporary media failure, however, then you can restart the database after fixing the problem and restoring access to the control files.

The appropriate recovery procedure for media failures that permanently prevent access to control files of a database depends on whether you have multiplexed the control files. The following sections describe the appropriate procedures:

- Losing a Member of a Multiplexed Control File
- Losing All Copies of the Current Control File

Losing a Member of a Multiplexed Control File

Use the following procedures to recover a database if all the following conditions are met:

- A permanent media failure has damaged one or more control files of a database.
- At least one control file has *not* been damaged by the media failure.

Note: If all control files of a multiplexed control file configuration have been damaged, follow the procedure in "Losing All Copies of the Current Control File" on page 6-13.

To restore a control file to its default location:

1. If the instance is still running, abort it:

   ```
   SHUTDOWN ABORT
   ```

2. Correct the hardware problem that caused the media failure. If you cannot repair the hardware problem quickly, you can proceed with database recovery by restoring damaged control files to an alternative storage device.
3. Use an intact multiplexed copy of the database's current control file to copy over the damaged control files. For example, to replace `bad_cf.f` with `good_cf.f`, you might enter:

   ```
   % cp /oracle/good_cf.f /oracle/dbs/bad_cf.f
   ```

4. Start an instance and open the database:

   ```
   STARTUP
   ```

To restore a control file to its non-default location:

1. If the instance is still running, abort it:

   ```
   SHUTDOWN ABORT
   ```

2. If you cannot correct the hardware problem that caused the media failure, copy the intact control file to alternative locations. For example, to rename `good_cf.f` as `new_cf.f` you might issue:

   ```
   % cp /oracle/dbs/good_cf.f /oracle/dbs/new_cf.f
   ```

3. Edit the parameter file of the database so that the CONTROL_FILES parameter reflects the current locations of all control files and excludes all control files that were not restored. For example, to add `new_cf.f` you might enter:

   ```
   CONTROL_FILES = '/oracle/dbs/good_cf.f', '/oracle/dbs/new_cf.f'
   ```

4. Start a new instance and open the database:

   ```
   STARTUP
   ```

Losing All Copies of the Current Control File

If all control files of a database have been lost or damaged by a permanent media failure, but all online redo logfiles remain intact, then you can recover the database by creating a new control file.

Depending on the existence and currency of a control file backup, you have the following options for generating the text of the CREATE CONTROLFILE statement

Table 6–1 Options for Creating the Control File

If you...	Then...
Executed ALTER DATABASE BACKUP CONTROLFILE TO TRACE NORESETLOGS after you made the last structural change to the database, and if you have saved the SQL command trace output	Use the CREATE CONTROLFILE statement from the trace output as-is.
Performed your most recent execution of ALTER DATABASE BACKUP CONTROLFILE TO TRACE before you made a structural change to the database	Edit the output of ALTER DATABASE BACKUP CONTROLFILE TO TRACE to reflect that change. For example, if you recently added a datafile to the database, add that datafile to the DATAFILE clause of the CREATE CONTROLFILE statement.
Have not backed up the control file using the TO TRACE option, but used the TO *filename* option of ALTER DATABASE BACKUP CONTROLFILE	Use the control file copy to obtain SQL output. Copy the backup control file and execute STARTUP MOUNT before ALTER DATABASE BACKUP CONTROLFILE TO TRACE NORESETLOGS. If the control file copy predated a recent structural change, edit the TO TRACE output to reflect the structural change.
Do not have a control file backup in either TO TRACE format or TO *filename* format	Generate the CREATE CONTROLFILE statement manually (see *Oracle8i SQL Reference*).

Note: If your character set is not the default US7ASCII, then you must specify the character set as an argument to the CREATE CONTROLFILE statement.

To create a new control file:

1. Create the control file using the CREATE CONTROLFILE statement with the NORESETLOGS option (see Table 6–1 for options). For example, enter:

```
CREATE CONTROLFILE REUSE DATABASE SALES NORESETLOGS ARCHIVELOG
    MAXLOGFILES 32
    MAXLOGMEMBERS 2
    MAXDATAFILES 32
    MAXINSTANCES 16
```

```
     MAXLOGHISTORY 1600
LOGFILE
     GROUP 1
       '/diska/prod/sales/db/log1t1.dbf',
       '/diskb/prod/sales/db/log1t2.dbf'
     )  SIZE 100K
    GROUP 2
       '/diska/prod/sales/db/log2t1.dbf',
        '/diskb/prod/sales/db/log2t2.dbf'
    ) SIZE 100K,
DATAFILE
    '/diska/prod/sales/db/database1.dbf',
    '/diskb/prod/sales/db/filea.dbf'
;
```

2. Recover the database as normal:

```
RECOVER DATABASE
```

> **See Also:** "Backing Up the Control File to a Trace File" on page 4-14.

Recovering from User Errors

An accidental or erroneous operational or programmatic change to the database can cause loss or corruption of data. Recovery may require a return to a state prior to the error.

> **Note:** If you have granted powerful privileges (such as DROP ANY TABLE) to only selected, appropriate users, user errors that require database recovery are minimized.

To recover a table that has been accidentally dropped:

1. If possible, keep the database that experienced the user error online and available for normal use. Back up all datafiles of the existing database in case an error is made during the remaining steps of this procedure.
2. Restore a database backup to an alternative location, then perform incomplete recovery using a restored backup control file to the point just before the table was dropped (see "Performing Incomplete Media Recovery" on page 5-25 for the procedure).

3. Export the lost data from the temporary, restored version of the database using the Oracle utility Export. In this case, export the accidentally dropped table.

   Note: System audit options are exported.

4. Import the exported data into the permanent copy of the database using the Oracle Import utility.
5. Delete the files of the temporary, reconstructed copy of the database to conserve space.

   See Also: *Oracle8i Utilities* for more information about the Import and Export utilities.

Performing Media Recovery in a Distributed Environment

The manner in which you perform media recovery depends on whether your database participates in a distributed database system. The Oracle distributed database architecture is autonomous. Therefore, depending on the type of recovery operation selected for a single, damaged database, you may have to coordinate recovery operations globally among all databases in the distributed database system.

Table 6–2 summarizes different types of recovery operations and whether coordination among nodes of a distributed database system is required.

Table 6–2 Recovery Operations in a Distributed Database Environment

If you are...	Then...
Restoring a whole backup for a database that was never accessed from a remote node	Use non-coordinated, autonomous database recovery.
Restoring a whole backup for a database that was accessed by a remote node	Shut down all databases and restore them using the same coordinated full backup.
Performing complete media recovery of one or more databases in a distributed database	Use non-coordinated, autonomous database recovery.
Performing incomplete media recovery of a database that was never accessed by a remote node	Use non-coordinated, autonomous database recovery.
Performing incomplete media recovery of a database that was accessed by a remote node	Use coordinated, incomplete media recovery to the same global point in time for all databases in the distributed database.

Coordinating Time-Based and Change-Based Distributed Database Recovery

In special circumstances, one node in a distributed database may require recovery to a past time. To preserve global data consistency, it is often necessary to recover all other nodes in the system to the same point in time. This operation is called *coordinated, time-based, distributed database recovery*. The following tasks should be performed with the standard procedures of time-based and change-based recovery described in this chapter.

1. Recover the database that requires the recovery operation using time-based recovery. For example, if a database needs to be recovered because of a user error (such as an accidental table drop), recover this database first using time-based recovery. Do not recover the other databases at this point.
2. After you have recovered the database and opened it using the RESETLOGS option, look in the `alert.log` of the database for the RESETLOGS message.

   If the message is, "**RESETLOGS after complete recovery through change xxx**", then you have applied all the changes in the database and performed a complete recovery. Do not recover any of the other databases in the distributed system, or you will unnecessarily remove changes in them. Recovery is complete.

If the message is, "**RESETLOGS after incomplete recovery UNTIL CHANGE xxx**", you have successfully performed an incomplete recovery. Record the change number from the message and proceed to the next step.

3. Recover all other databases in the distributed database system using change-based recovery, specifying the change number (SCN) from Step 2.

Recovering a Database with Snapshots

If a master database is independently recovered to a past time (that is, coordinated, time-based distributed database recovery is not performed), any dependent remote snapshot that was refreshed in the interval of lost time will be inconsistent with its master table. In this case, the administrator of the master database should instruct the remote administrators to perform a complete refresh of any inconsistent snapshot.

7

Performing Operating System Tablespace Point-in-Time Recovery

This chapter describes how to perform O/S tablespace point-in-time recovery (TSPITR), and includes the following topics:

Introduction to O/S Tablespace Point-in-Time Recovery

Tablespace Point-in-Time Recovery (TSPITR) enables you to quickly recover one or more non-SYSTEM tablespaces to a time that is different from that of the rest of the database. Like a table export, TSPITR enables you to recover a consistent data set; however, the data set is the entire tablespace rather than just one object.

TSPITR is most useful for recovering:

- An erroneous DROP TABLE or TRUNCATE TABLE operation.
- A table that is logically corrupted.
- An incorrect batch job or other DML statement that has affected only a subset of the database.
- A logical schema to a point different from the rest of the physical database when multiple schemas exist in separate tablespaces of one physical database.
- A tablespace in a VLDB (very large database) when TSPITR is more efficient than restoring the whole database from a backup and rolling it forward (see "Planning for Tablespace Point-in-Time Recovery" on page 7-4 before making any decisions).

This section contains the following topics:

TSPITR Advantages

Prior to Oracle8, point-in-time recovery could only be performed on a subset of a database by:

1. Creating a copy of the database.
2. Rolling the copied database forward to the desired point in time.
3. Exporting the desired objects from the copied database.
4. Dropping the relevant objects from the production database.
5. Importing the objects into the production database.

There was a performance overhead associated with exporting and importing large objects, however, which created a need for a new method. TSPITR enables you to do the following:

1. Make a temporary copy of the database, called a *clone database*.
2. Recover a subset of a clone database.
3. Copy the relevant datafiles from the recovered database to the production database using an operating system utility.
4. Export data dictionary metadata about the datafile's content (for example, the recovered segments within the file) from the clone database to the production database. The copied file is also added to the production database through a special import option.

TSPITR Methods

You can perform O/S TSPITR in two different ways:

Method	Consequence
Traditional O/S TSPITR	You must follow special procedures for creating clone initialization parameter files, mounting the clone database, etc. The procedures provide error checks to prevent the corruption of the primary database on the same computer while recovering the clone database.
TSPITR using the transportable tablespace feature	This method differs from standard O/S TSPITR mainly in using transported tablespaces to perform the last step of TSPITR. You must set the COMPATIBLE initialization parameter to 8.1 or higher to use this method.

The major difference between the two methods is that performing TSPITR through transportable tablespaces relaxes some of O/S TSPITR's special procedures. For example, if you restore backups to a different host separate from the primary database, then you can start the clone database as if it were the primary database using the normal database MOUNT statement instead of the clone database MOUNT statement.

> **See Also:** *Oracle8i Administrator's Guide* for more information about the transportable tablespace feature.

TSPITR Terminology

Familiarize yourself with the following terms and abbreviations, which are used throughout this chapter:

TSPITR
Tablespace point-in-time recovery

Clone Database
The copied database used for recovery in TSPITR. It has various substantive differences from a regular database.

Recovery Set
Tablespaces that require point-in-time recovery to be performed on them.

Auxiliary Set
Any other items required for TSPITR, including:

- Backup control file
- System tablespaces
- Datafiles containing rollback segments
- Temporary tablespace (optional)

A small amount of space is required by export for sort operations. If a copy of the temporary tablespace is not included in the auxiliary set, then provide sort space either by creating a new temporary tablespace after the clone has been started or by setting AUTOEXTEND to ON on the SYSTEM tablespace files.

Transportable Tablespace
A feature that enables you to take a tablespace from one database and plug it into another database. For more information, see "Recovering Transported Tablespaces" on page 6-4. For a detailed account, see the *Oracle8i Administrator's Guide*.

Planning for Tablespace Point-in-Time Recovery

TSPITR is a complicated procedure and requires careful planning. Before proceeding you should read this chapter thoroughly.

WARNING: You should not perform TSPITR for the first time on a production system, or during circumstances where there is a time constraint.

TSPITR Limitations

The primary issue you should consider is the possibility of application-level inconsistencies between tables in recovered and unrecovered tablespaces due to implicit rather than explicit referential dependencies. Understand these dependencies and find the means to resolve any possible inconsistencies before proceeding.

This section deals with the following topics:

- General Restrictions
- Data Consistency and TSPITR

General Restrictions

TSPITR has several restrictions. You *cannot* do the following:

- Recover a SYSTEM tablespace.
- Recover dropped tablespaces.
- Recover a tablespace that has been dropped and re-created with the same name.
- Remove a datafile that has been added to the wrong tablespace. If the file was added after the point to which the tablespace is being recovered, then the file will still be part of the tablespace (and be empty) after TSPITR is complete.
- Execute DML statements on the clone database—the clone database is for recovery only.
- Use existing backups of the recovery set datafiles for recovery after TSPITR completes. Instead, you must take fresh backups of the recovered files. If you attempt to recover using a backup taken prior to performing TSPITR, then recovery fails.
- Recover optimizer statistics for objects that have had statistics calculated on them; statistics must be re-calculated after performing TSPITR.
- Include any of the following object types within the TSPITR recovery set:
  - Replicated master tables
  - Snapshot logs
  - Snapshot tables

  If any of these objects are included, you must drop them before TSPITR.

Data Consistency and TSPITR

TSPITR provides views that can detect any data relationships between objects that are in the tablespaces being recovered and objects in the rest of the database. TSPITR cannot successfully complete unless you manage these relationships, either by removing or suspending the relationship or by including the related object within the recovery set.

See Also: "Step 2: Research and Resolve Dependencies on the Primary Database" on page 7-7.

TSPITR Requirements

Satisfy the following requirements before performing TSPITR.

- Ensure that all files constituting the recovery set tablespaces are in the recovery set on the clone database, otherwise the export phase of TSPITR fails.
- Create the control file backup in the auxiliary set using the following SQL statement:

  ```
  ALTER DATABASE BACKUP CONTROLFILE TO 'controlfile_name';
  ```

  This control file backup must be created at a later time than the backup that is being used. If it is not, then you may encounter an error message (`ORA-01152, file 1 was not restored from a sufficiently old backup`).
- Allocate enough disk space to accommodate the clone database.
- Provide enough real memory to start the clone instance.

See Also: "Step 4: Prepare the Clone Parameter Files" on page 7-10.

Preparing the Databases for TSPITR

This section describes how to prepare the clone database for TSPITR, and includes the following steps:

Step 1: Determine Whether Objects Will Be Lost

When TSPITR is performed on a tablespace, any objects created after the recovery time are lost. To see which objects will be lost, query the TS_PITR_OBJECTS_TO_BE_DROPPED view on the primary database. The contents of the view are described in Table 7–1:

Table 7–1 TS_PITR_OBJECTS_TO_BE_DROPPED View

Column Name	Meaning
OWNER	Owner of the object to be dropped.
NAME	The name of the object that will be lost as a result of undergoing TSPITR
CREATION_TIME	Creation timestamp for the object.
TABLESPACE_NAME	Name of the tablespace containing the object.

When querying this view, supply all the elements of the date field, otherwise the default setting is used. Also, use the TO_CHAR and TO_DATE functions. For example, with a recovery set consisting of TS1 and TS2, and a recovery point in time of '1997-06-02:07:03:11', issue the following:

```
SELECT owner, name, tablespace_name, to_char(creation_time, 'YYYY-MM-DD:HH24:MI:SS'),
FROM ts_pitr_objects_to_be_dropped
WHERE tablespace_name IN ('TS1','TS2')
AND creation_time > to_date('97-JUN-02:07:03:11','YY-MON-  DD:HH24:MI:SS')
ORDER BY tablespace_name, creation_time;
```

> **See Also:** *Oracle8i Reference* for more information about the TS_PITR_OBJECTS_TO_BE_DROPPED view.

Step 2: Research and Resolve Dependencies on the Primary Database

Use the TS_PITR_CHECK view to identify relationships between objects that overlap the recovery set boundaries. If this view returns rows when queried, investigate and correct the problem. Proceed with TSPITR *only* when TS_PITR_CHECK view returns no rows. Record all actions performed during this step so that you can retrace these relationships after completing TSPITR.

You must do the following, or TS_PITR_CHECK view returns rows:

- Fully contain all partitions and sub-partitions of a partitioned table in the recovery set. If you need to recover only one or more of the partitions of a

partitioned table, convert them to stand-alone tables (see "Performing Partial TSPITR of Partitioned Tables" on page 7-15).

- Fully contain the following in the recovery set:
  - Tables (and their indexes, partitioned or non-partitioned)
  - Clusters (and their indexes, partitioned or non-partitioned)
  - Primary key and foreign key relationships
  - All elements of a LOB (LOB segment, LOB index, and LOB locator)
- Exclude the following object types from the recovery set:
  - Replicated master tables
  - Snapshot logs
  - Snapshot tables

Supply a four-line predicate detailing the recovery set tablespace to query the TS_PITR_CHECK view. For example, with a recovery set consisting of TS1 and TS2, the SELECT statement against TS_PITR_CHECK would be as follows:

```
SELECT * FROM sys.ts_pitr_check
WHERE (ts1_name IN ('TS1','TS2') AND ts2_name NOT IN ('TS1','TS2'))
OR (ts1_name NOT IN ('TS1','TS2') AND ts2_name IN ('TS1','TS2'));
```

Because of the number and width of the columns in the TS_PITR_CHECK view, you may want to format the columns as follows:

```
column OBJ1_OWNER heading "own1"
column OBJ1_OWNER format a4
column OBJ1_NAME heading "name1"
column OBJ1_NAME format a5
column OBJ1_SUBNAME heading "subname1"
column OBJ1_SUBNAME format a8
column OBJ1_TYPE heading "obj1type"
column OBJ1_TYPE format a8 word_wrapped
column TS1_NAME heading "ts1_name"
column TS1_NAME format a8
column OBJ2_NAME heading "name2"
column OBJ2_NAME format a5
column OBJ2_SUBNAME heading "subname2"
column OBJ2_SUBNAME format a8
column OBJ2_TYPE heading "obj2type"
column OBJ2_TYPE format a8 word_wrapped
column OBJ2_OWNER heading "own2"
column OBJ2_OWNER format a4
column TS2_NAME heading "ts2_name"
```

```
column TS2_NAME format a8
column CONSTRAINT_NAME heading "cname"
column CONSTRAINT_NAME format a5
column REASON heading "reason"
column REASON format a57 word_wrapped
```

If the partitioned table TP has two partitions, P1 and P2, which exist in tablespaces TS1 and TS2 respectively, and there is a partitioned index defined on TP called TPIND, which has two partitions ID1 and ID2 (that exist in tablespaces ID1 and ID2 respectively), you would get the following output when TS_PITR_CHECK is queried against tablespaces TS1 and TS2 (assuming appropriate formatting):

```
own1   name1 subname1 obj1type ts1_name name2 subname2 obj2type own2 ts2_name cname reason
---    ----  -------   -------  -------- -----  -------  -------- ---  -------- ---   ------
SYSTEM  TP   P1        TABLE     TS1     TPIND IP1      INDEX    PARTITION PARTITION  SYS
ID1 Partitioned Objects not fully contained in the recovery set

SYSTEM  TP   P1        TABLE     TS1     TPIND IP2      INDEX    PARTITION PARTITION  SYS
ID2 Partitioned Objects not fully contained in the recovery set
```

The table SYSTEM.TP has a partitioned index TPIND that consists of two partitions, IP1 in tablespace ID1 and IP2 in tablespace ID2. Either drop TPIND or include ID1 and ID2 in the recovery set.

> **See Also:** *Oracle8i Reference* for more information about the TS_PITR_CHECK view.

Step 3: Prepare the Primary Database

Perform the following tasks:

1. Archive the current online redo log:

   ```
   ALTER SYSTEM ARCHIVE LOG CURRENT;
   ```

2. Take offline any rollback segments in the recovery set (you do not have to take auxiliary set rollback segments offline):

   ```
   ALTER ROLLBACK SEGMENT segment_name OFFLINE;
   ```

3. Take the recovery set tablespaces on the primary database offline normal. Use the OFFLINE FOR RECOVER option if you cannot write to the file due to I/O errors or if the file is unavailable. You can use OFFLINE FOR RECOVER for performance reasons, for example, if you have a large number of datafiles and you do not care about updating the file headers since they are being recovered back to a point in time anyway:

```
ALTER TABLESPACE tablespace_name OFFLINE FOR RECOVER;
```

This statement prevents changes being made to the recovery set before TSPITR is complete.

Note: If there is a subset of data that is not physically or logically corrupt that you want to query within the recovery set tablespaces, alter the recovery set tablespaces on the primary database as READ ONLY for the duration of the recovery of the clone. Take the recovery set tablespaces offline before integrating the clone files with the primary database (see "Step 5: Copy the Recovery Set Clone Files to the Primary Database" on page 7-13).

See Also: *Oracle8i SQL Reference* for more information about the ALTER SYSTEM and ALTER ROLLBACK SEGMENT statements.

Step 4: Prepare the Clone Parameter Files

Create a brand new initialization parameter file rather than copying and then editing the production database initialization parameter file. Save memory by using low settings for parameters such as:

- DB_BLOCK_BUFFERS
- SHARED_POOL_SIZE
- LARGE_POOL_SIZE.

If the production parameter files are used for the clone database, however, reducing these parameters can prevent the clone database from starting when other parameters are set too high—for example, the parameter ENQUEUE_RESOURCES, which allocates memory from within the shared pool.

Set the following parameters in the clone initialization parameter file:

Parameter	Purpose
CONTROL_FILES	Identifies clone control files. Set to the name and location of the clone control files.
LOCK_NAME_SPACE	Allows the clone database to start even though it has the same name as the primary database. Set to a unique value, for example, = CLONE. **Note:** Do not change the DB_NAME parameter.

Parameter	Purpose
DB_FILE_NAME_CONVERT	Converts datafile filenames. Set to new values if necessary.
LOG_FILE_NAME_CONVERT	Renames redo logs files. For example, if the datafiles of the primary database reside in the directory `/ora/primary`, and the clone resides in `/ora/clone`, set DB_FILE_NAME_CONVERT to "primary","clone". **Note:** You can also rename the redo logs with the ALTER DATABASE RENAME FILE statement. See "Step 5: Prepare the Clone Database" on page 7-11.

Step 5: Prepare the Clone Database

Perform the following tasks to prepare the clone database for TSPITR:

1. Restore the auxiliary set and the recovery set to a location different from that of the primary database.

   Note: It is possible, although not recommended, to place the recovery set files over their corresponding files on the primary database. For more information see "Performing Partial TSPITR of Partitioned Tables" on page 7-15.

2. Configure your environment so that you can start up the clone database. For example, on UNIX, set ORACLE_SID to the name of the clone.
3. Start the clone database without mounting it, specifying the parameter file if necessary:

   ```
   STARTUP NOMOUNT PFILE=/path/initCLONE.ora;
   ```

4. Mount the clone database:

   ```
   ALTER DATABASE MOUNT CLONE DATABASE;
   ```

   At this point, the database is automatically taken out of ARCHIVELOG mode because it is a clone. All files are offline.

5. If you did *not* set DB_FILE_NAME_CONVERT and LOG_FILE_NAME_CONVERT, then rename the files to reflect their new locations:

   ```
   ALTER DATABASE RENAME FILE 'name_of_file_in_primary_location'
   TO 'name_of_corresponding_file_in_clone_location';
   ```

If you did set DB_FILE_NAME_CONVERT and LOG_FILE_NAME_CONVERT but there are files that have been restored to different locations, then rename them.

6. Even if you have set DB_FILE_NAME_CONVERT and LOG_FILE_NAME_CONVERT, do not assume that all the files of the clone database are in the specified locations—some clone files may have been restored to different locations due to constraints of disk space. Bring online all recovery set and auxiliary set files using the following SQL statement:

```
ALTER DATABASE DATAFILE 'datafile_name' ONLINE;
```

Note: the export phase of TSPITR will not work if all the files of each recovery set tablespace are not online.

Performing TSPITR

This section describes how to execute TSPITR, and includes the following steps:

- Step 1: Recover the Clone Database
- Step 2: Open the Clone Database
- Step 3: Prepare the Clone Database for Export
- Step 4: Export the Metadata
- Step 5: Copy the Recovery Set Clone Files to the Primary Database
- Step 6: Import the Metadata into the Primary Database
- Step 7: Prepare the Primary Database for Use
- Step 8: Back Up the Recovered Tablespaces in the Primary Database

Step 1: Recover the Clone Database

Recover the clone database to the desired point by specifying the USING BACKUP CONTROLFILE option. Use any form of incomplete recovery as follows:

```
RECOVER DATABASE USING BACKUP CONTROLFILE UNTIL TIME 'YYYY-MM-DD:HH24:MI:SS';
RECOVER DATABASE USING BACKUP CONTROLFILE UNTIL CANCEL;
```

If the clone database files are not online, Oracle issues an error message.

Step 2: Open the Clone Database

Open the clone database with the RESETLOGS option using the following statement:

```
ALTER DATABASE OPEN RESETLOGS;
```

Because the database is a clone database, only the SYSTEM rollback segment is brought online at this point, which prevents you from executing DML statements against any user tablespace. Any attempt to bring a user rollback segment online fails and generates an error message.

Step 3: Prepare the Clone Database for Export

Prepare the clone database for export using the TS_PITR_CHECK view and resolving the dependencies just as you did for the primary database (see "Step 2: Research and Resolve Dependencies on the Primary Database" on page 7-7). Only when TS_PITR_CHECK returns no rows will the export phase of TSPITR complete.

Step 4: Export the Metadata

Export the metadata for the recovery set tablespaces using the following statement:

```
exp sys/password point_in_time_recover=y
recovery_tablespaces=tablespace_1,tablespace_2,tablespace_n
```

If the export phase fails and generates an error message, then:

1. Re-query TS_PITR_CHECK.
2. Resolve the problem.
3. Re-run the export.

Perform the export phase of TSPITR as the user SYS, otherwise the export fails.

Shut down the clone database after a successful export:

```
SHUTDOWN IMMEDIATE
```

Step 5: Copy the Recovery Set Clone Files to the Primary Database

If any recovery set tablespaces are read-only on the primary database, then you should take them offline. Use an operating system utility to copy the recovery set files from the clone database to the primary database, taking care not to overwrite any auxiliary set files on the primary database.

Step 6: Import the Metadata into the Primary Database

Import the recovery set metadata into the primary database using the following statement:

```
imp sys/password point_in_time_recover=true
```

This import also updates the copied file's file headers and integrates them with the primary database.

Note: Object name conflicts may arise if objects of the same name exist already in primary database. Resolve these conflicts explicitly.

See Also: *Oracle8i Designing and Tuning for Performance* for more information about Export.

Step 7: Prepare the Primary Database for Use

To prepare the primary database for use, follow these steps:

1. Bring the recovery set tablespaces online in the primary database.
2. Change the recovery set tablespaces to read-write (if they had been altered to read-only, see "Step 3: Prepare the Primary Database" on page 7-9).
3. Undo all the steps taken to resolve dependencies. For example, rebuild indexes or re-enable constraints (see "Step 2: Research and Resolve Dependencies on the Primary Database" on page 7-7).
4. If statistics existed on the recovery set objects before TSPITR was performed, you need to recalculate them. For partitioned tables, you have to exchange the stand-alone tables into the partitions of their partitioned tables (for more information, see "Performing Partial TSPITR of Partitioned Tables" on page 7-15).

Step 8: Back Up the Recovered Tablespaces in the Primary Database

After TSPITR on a tablespace is complete, use an operating system utility to back up the tablespace.

WARNING: You must back up the tablespace, because otherwise you might lose it. For example, a media failure occurs, but the archived redo logs from the last backup of the database do not logically link to the recovered tablespaces. If you attempt to recover any recovery set tablespaces from a backup taken before TSPITR, the procedure fails.

Performing Partial TSPITR of Partitioned Tables

This section describes how to perform partial TSPITR of partitioned tables that have a range that has not changed or expanded, and includes the following steps:

- Step 1: Create a Table on the Primary Database for Each Partition Being Recovered
- Step 2: Drop the Indexes on the Partition Being Recovered
- Step 3: Exchange Partitions with Stand-Alone Tables
- Step 4: Take the Recovery Set Tablespace Offline
- Step 5: Create Tables at Clone Database
- Step 6: Drop Indexes on Partitions Being Recovered
- Step 7: Exchange Partitions with Stand-Alone Tables
- Step 8: Export the Clone Database
- Step 9: Copy the Recovery Set Datafiles to the Primary Database
- Step 10: Import into the Primary Database
- Step 11: Bring Recovery Set Tablespace Online
- Step 12: Exchange Partitions with Stand-Alone Tables
- Step 13: Back Up the Recovered Tablespaces in the Primary Database

Note: Often you have to recover the dropped partition along with recovering a partition whose range has expanded. See "Performing TSPITR of Partitioned Tables When a Partition Has Been Dropped" on page 7-18.

Step 1: Create a Table on the Primary Database for Each Partition Being Recovered

This table should have the exact same column names and column datatypes as the partitioned table you are recovering. Create the table as follows:

```
CREATE TABLE new_table AS
  SELECT * FROM partitioned_table
  WHERE 1=2;
```

These tables are used to swap each recovery set partition (see "Step 3: Exchange Partitions with Stand-Alone Tables" on page 7-16).

Step 2: Drop the Indexes on the Partition Being Recovered

Drop the indexes on the partition you wish to recover, or create identical, non-partitioned indexes that exist on the partition you wish to recover. If you drop the indexes on the partition being recovered, then you need to drop them on the clone database (see "Step 6: Drop Indexes on Partitions Being Recovered" on page 7-17). Rebuild the indexes after TSPITR is complete.

Step 3: Exchange Partitions with Stand-Alone Tables

Exchange each partition in the recovery set with its associated stand-alone table (created in Step 1) by issuing the following statement:

```
ALTER TABLE table_name EXCHANGE PARTITION partition_name WITH TABLE table_name;
```

Step 4: Take the Recovery Set Tablespace Offline

On the primary database, take each recovery set tablespace offline:

```
ALTER TABLESPACE tablespace_name OFFLINE IMMEDIATE;
```

This prevents any further changes to the recovery set tablespaces on the primary database.

Step 5: Create Tables at Clone Database

After recovering the clone and opening it with the RESETLOGS option, create a table that has the same column names and column data types as the partitioned table you are recovering. Create a table for each partition you wish to recover. These tables are used later to swap each recovery set partition.

Step 6: Drop Indexes on Partitions Being Recovered

Drop the indexes on the partition you wish to recover, or create identical, non-partitioned indexes that exist on the partition you wish to recover (on the table created in Step 1).

Step 7: Exchange Partitions with Stand-Alone Tables

For each partition in the clone database recovery set, exchange the partitions with the stand-alone tables (created in Step 5) by issuing the following statement:

```
ALTER TABLE partitioned_table_name EXCHANGE PARTITION partition_name
WITH TABLE table_name;
```

Step 8: Export the Clone Database

Execute export against the clone database for the recovery set tablespaces using the following statement:

```
exp sys/password point_in_time_recover=y
recovery_tablespaces=tablespace_1,tablespace_2,tablespace_n
```

If the export phase fails with the error message `ORA 29308 view TS_PITR_CHECK failure`, re-query TS_PITR_CHECK, resolve the problem, and re-run the export. Perform the export phase of TSPITR as the user SYS, otherwise the export fails with the error message `ORA-29303: user does not login as SYS`. Shut down the clone database after a successful export.

Step 9: Copy the Recovery Set Datafiles to the Primary Database

If any recovery set tablespaces are READ ONLY on the primary database, change them to OFFLINE. Copy the recovery set datafiles from the clone database to the primary database, taking care not to overwrite auxiliary set files on the primary database.

Step 10: Import into the Primary Database

Import the recovery set metadata into the primary database using the following command:

```
imp sys/password point_in_time_recover=true
```

This import also updates the copied file's file headers and integrates them with the primary database.

Step 11: Bring Recovery Set Tablespace Online

At the primary database, bring each recovery set tablespace online:

```
ALTER TABLESPACE tablespace_name ONLINE;
```

Step 12: Exchange Partitions with Stand-Alone Tables

For each recovered partition on the primary database, swap its associated stand-alone table using the following statement:

```
ALTER TABLE table_name EXCHANGE PARTITION partition_name WITH TABLE table_name;
```

If the associated indexes have been dropped, re-create them.

Step 13: Back Up the Recovered Tablespaces in the Primary Database

Back up the recovered tablespaces on the primary database. Failure to do so results in loss of data in the event of media failure.

WARNING: You must back up the tablespace, because otherwise you might lose it. For example, a media failure occurs, but the archived redo logs from the last backup of the database do not logically link to the recovered tablespaces. If you attempt to recover any recovery set tablespaces from a backup taken before TSPITR, the procedure fails.

Performing TSPITR of Partitioned Tables When a Partition Has Been Dropped

This section describes how to perform TSPITR on partitioned tables when a partition has been dropped, and includes the following steps:

Step 1: Find the Low and High Range of the Partition that Was Dropped

When a partition is dropped, the range of the partition above it expands downwards. Therefore, there may be records in the partition above that should actually be in the dropped partition after it has been recovered. To ascertain this, issue the following statement at the primary database:

```
SELECT * FROM partitioned_table
  WHERE relevant_key
  BETWEEN low_range_of_partition_that_was_dropped
  AND high_range_of_partition_that_was_dropped;
```

Step 2: Create a Temporary Table

If any records are returned, create a temporary table in which to store these records so that if necessary they can be inserted into the recovered partition later.

Step 3: Delete Records From Partitioned Table

Delete all the records stored in the temporary table from the partitioned table.

Step 4: Take Recovery Set Tablespaces Offline

At the primary database, take each recovery set tablespace offline:

```
ALTER TABLESPACE tablespace_name OFFLINE IMMEDIATE;
```

Step 5: Create Tables at Clone Database

After opening the clone with the RESETLOGS option, create a table that has the exact same column names and column datatypes as the partitioned table you are recovering. Create a table for each partition you wish to recover. These tables will be used later to swap each recovery set partition.

Step 6: Drop Indexes on Partitions Being Recovered

Drop the indexes on the partition you wish to recover, or create identical, non-partitioned indexes that exist on the partition you wish to recover.

Step 7: Exchange Partitions with Stand-Alone Tables

For each partition in the clone recovery set, exchange the partitions into the stand-alone tables created in Step 5 by issuing the following statement:

```
ALTER TABLE partitioned_table_name EXCHANGE PARTITION partition_name
WITH TABLE table_name;
```

Step 8: Export the Clone Database

Execute export against the clone database for the recovery set tablespaces using the following statement:

```
exp sys/password point_in_time_recover=y
recovery_tablespaces=tablespace_1,tablespace_2,tablespace_n
```

If the export phase fails with the error message `ORA 29308 view TS_PITR_CHECK failure`, re-query TS_PITR_CHECK, resolve the problem, and re-run the export. You need to perform the export phase of TSPITR as the user SYS, otherwise the export fails with the error message `ORA-29303: user does not login as SYS`. Shut down the clone database after a successful export.

Step 9: Copy the Recovery Set Datafiles to the Primary Database

If any recovery set tablespaces are READ ONLY on the primary database, you should change them to OFFLINE. Copy the recovery set datafiles from the clone

database to the primary database, taking care not to overwrite any auxiliary set files on the primary database.

Step 10: Import into the Primary Database

Import the recovery set metadata into the primary database using the following command:

```
imp sys/password point_in_time_recover=true;
```

This import also updates the copied file's file headers and integrates them with the primary database.

Step 11: Bring Recovery Set Tablespace Online

Online each recovery set tablespace at the primary database by issuing the following statement:

```
ALTER TABLESPACE tablespace_name ONLINE;
```

Step 12: Insert Stand-Alone Tables into Partitioned Tables

At this point you must insert the stand-alone tables into the partitioned tables; you can do this by first issuing the following statement:

```
ALTER TABLE table_name SPLIT PARTITION partition_name AT (key_value) INTO
(PARTITION partition_1_name TABLESPACE tablespace_name,
PARTITION partition_2_name TABLESPACE tablespace_name);
```

Note that at this point, partition 2 is empty because keys in that range have already been deleted from the table.

Issue the following statement to swap the stand-alone table into the partition:

```
ALTER TABLE EXCHANGE PARTITION partition_name WITH TABLE table_name;
```

Now insert the records saved in Step 2 into the recovered partition (if desired).

Note: If the partition that has been dropped is the last partition in the table, add it using the ALTER TABLE ADD PARTITION statement.

Step 13: Back Up the Recovered Tablespaces in the Primary Database

Back up the recovered tablespaces in the primary database. Failure to do so results in loss of data in the event of media failure.

WARNING: You must back up the tablespace, because otherwise you might lose it. For example, a media failure occurs, but the archived redo logs from the last backup of the database do not logically link to the recovered tablespaces. If you attempt to recover any recovery set tablespaces from a backup taken before TSPITR, the procedure fails.

Note: As described in "TSPITR Limitations" on page 7-5, TSPITR cannot be used to recover a tablespace that has been dropped. Therefore, if the associated tablespace of the partition has been dropped as well as the partition, you cannot recover that partition using TSPITR. You have to perform ordinary export/import recovery. Specifically, you have to:

- Make a copy of the database
- Roll it forward
- Open the database
- Exchange the partition for a stand-alone table
- Make a table-level export of the stand-alone table

Import the table into the primary database and insert it into the partitioned table using the ALTER TABLE SPLIT PARTITION or ALTER TABLE ADD PARTITION statements.

Performing TSPITR of Partitioned Tables When a Partition Has Split

This section describes how to recover partitioned tables when a partition has been split, and includes the following sections:

- Step 1: Drop the Lower of the Two Partitions at the Primary Database
- Steps 2-13: Follow Same Steps as for Partial TSPITR of Partitioned Tablespaces

Step 1: Drop the Lower of the Two Partitions at the Primary Database

For each partition you wish to recover whose range has been split, drop the lower of the two partitions so that the higher expands downwards. In other words, the higher partition has the same range as before the split. For example, if P1 was split into partitions P1A and P1B, then P1B must be dropped, meaning that partition P1A now has the same range as P1.

For each partition that you wish to recover whose range has split, create a table that has exactly the same column names and column datatypes as the partitioned table you are recovering:

```
CREATE TABLE new_table
AS SELECT * FROM partitioned_table
WHERE 1=2;
```

These tables will be used to exchange each recovery set partition in Step 3.

Steps 2-13: Follow Same Steps as for Partial TSPITR of Partitioned Tablespaces

Follow steps 2-13 in the procedure for "Performing Partial TSPITR of Partitioned Tables" on page 7-15.

TSPITR Tuning Considerations

This section describes tuning issues relevant to TSPITR, and includes the following topics:

- Recovery Set Location Considerations
- Backup Control File Considerations

Recovery Set Location Considerations

If space is at a premium, it is possible to recover the recovery set files "in place". In other words, recover them over their corresponding files on the primary database.

Note that the recommended practice is to restore the files to a separate location and then copy across before the import phase of TSPITR is complete (see "Step 6: Import the Metadata into the Primary Database" on page 7-14).

Advantages and Disadvantages of Recovering to a Separate Location

The advantages of recovering to a separate location are:

- Greater availability and flexibility. If recovery is abandoned at a point before integrating the recovery set with the primary database, then there is no need to restore the recovery set files on the primary database and recover them using normal means.
- The recovery set tablespaces can be accessible on the primary database while recovery occurs on the clone. For example, there may be a subset of undamaged data within the recovery set tablespaces that you wish to access (see "Step 3: Prepare the Primary Database" on page 7-9). If so, change the recovery set tablespaces to READ ONLY on the primary database. If the files are recovered in place, this option is not available.

The disadvantage of recovering to a separate location is that more space is required for the clone database.

Advantages and Disadvantages of Recovering in Place

The advantage of recovering in place is that the amount of space taken up by the recovery set files is saved. After recovery of the clone is complete, there is no need to copy the recovery set files over to the primary database.

The disadvantage is that if the recovery is abandoned at a point before integrating the recovery set with the primary database (see "Step 6: Import the Metadata into the Primary Database" on page 7-14), then you must restore the overwritten recovery set files of the primary database from a backup and recover by normal means, prolonging data unavailability. You cannot query any undamaged data within the recovery set tablespaces during recovery.

Backup Control File Considerations

The error `ORA-01152 file 1 was not restored from a sufficiently old backup` appears when no recovery is performed on the clone before grafting it to the primary. For example, if a backup is taken at time A, and a database at time B requires TSPITR to be done on a particular tablespace to take that tablespace to time A, what actually happens is that the clone database is opened RESETLOGS without

any recovery having been done. When recovering the clone, the SQL*Plus statements would be:

```
RECOVER DATABASE USING BACKUP CONTROLFILE UNTIL CANCEL;
CANCEL;
OPEN DATABASE RESETLOGS;
```

At this point no redo logs have been applied, but we wish to open the database. However, since we save checkpoints to the control file in Oracle 8, it is a requirement for clone and standby databases that the backup control files need to be taken at a point after the rest of the backup was taken. Unless this is the case, Oracle issues `ORA-01152 file 1 was not restored from a sufficiently old backup` at open time, not because file 1 is too recent (because it is synchronized with the rest of the database), but because it is more recent than the control file.

Note: A RESETLOGS would work with a regular database if a clean, consistent backup and an old backup control file is used. Otherwise, the behavior would not be compatible with existing backup scripts.

Performing TSPITR Using Transportable Tablespaces

You can use the *transportable tablespace* feature to perform tablespace point-in-time recovery. This method is similar to the O/S TSPITR described in previous sections, except you use the transportable tablespace feature to move recovered tablespaces from the clone database to the primary database. To learn how to transport tablespaces between databases, see the *Oracle8i Administrator's Guide*.

The major difference between O/S TSPITR and TSPITR through transportable tablespaces is that for the former you must follow the special procedures for creating clone initialization parameter files, mounting the clone database, etc. O/S TSPITR assumes that the user may place the clone database on the same computer as the primary database; the special clone database commands provide error checks to prevent the corruption of the primary database on the same computer while recovering the clone database.

Performing TSPITR through transportable tablespaces relaxes this requirement. If you restore backups to a different computer separate from the primary database, you can start the clone database as if it were the primary database, using the normal database MOUNT statement instead of the clone database MOUNT statement. If you restore backups on the same computer as the primary database, however,

follow the special procedure to create the clone database as described in O/S TSPITR, since this procedure helps prevent accidental corruption of the primary database while recovering the clone database on the same computer.

TSPITR through transportable tablespaces provides basically the same functionality as O/S TSPITR, but is more flexible since:

- You can recover dropped tablespaces, which you cannot do using O/S TSPITR.
- You can transport the recovered tablespaces from the clone database to a different database to test the procedure before making permanent changes to the primary database.

To perform TSPITR using the transportable tablespace feature:

1. Restore the backup to construct the clone database. Create the clone database on the same computer as the primary database or on a different computer.
2. If you create the clone database using the special clone database procedure, place all recovery set and auxiliary set files online:

   ```
   ALTER DATABASE DATAFILE 'datafile_name' ONLINE;
   ```

   If you create the clone database as a normal database (on a computer different from the primary database), take all datafiles not in the recovery and auxiliary set offline:

   ```
   ALTER DATABASE DATAFILE 'datafile_name' OFFLINE;
   ```

3. Recover the clone database to the specified point in time.
4. Open the clone database with the RESETLOGS option.
5. Make the tablespaces in the recovery set read-only by issuing the ALTER TABLESPACE ... READ ONLY statement.
6. Generate the transportable set by running EXPORT. Include all tablespaces in the recovery set.
7. In the primary database, drop the tablespaces in the recovery set through the DROP TABLESPACE statement.
8. Plug in the transportable set into the primary database by running IMPORT.
9. If necessary, make the recovered tablespaces read write by issuing the ALTER TABLESPACE READ WRITE statement.

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